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The side effect of commonly used chemical pesticides on entomopathogenic *Beauveria bassiana* and *Bacillus thuringiensis* as biopesticides

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Abstract:

Biopesticides are considered to be the best alternative to chemical pesticides that are highly effective, target specific and reduce environmental risks. Compatibility of bio and chemical pesticides is very important for effective pest management. The aim of this work is to study the side effect of used pesticides on the viability of spores (active ingredient) in biopesticides. The tolerance of *Beauveria bassiana* and *Bacillus thuringiensis* to eleven commonly used pesticides as indoxacarb, dimethoate, chlorfenapyre, abamectin, lambda-cyhalothrin, chlorpyrifos, deltamethrin, profenofos, cypermethrin, methomyl and hexaflumuron were tested in the laboratory. The results indicated that chlorfenapyre and abamectin were more compatible with *B. bassiana*. Also, there were not any side effect between them and the fungus. Also, when used the mixtures of *B. bassiana* and chlorfenapyre or abamectin to control the red spider mites, *Tetranychus urticae* Koch (Acari: Tetranychidae) were more toxic than use them individually. On the other hand, chlorfenapyre, cypermethrin and methomyl had not any inhibition effect to *B. thuringiensis* compared with other compounds. The obtained results may be useful in the development of Integrated Pest Management strategies using beneficial control agents like microorganisms with chemical pesticides.

Introduction

Biopesticides, in particular when accomplished by entomopathogens, is a method that should be considered as an important factor in Integrated Pest Management (IPM) programs for pest population density reduction (Amutha *et al*., 2010). The biopesticides, especially *Beauveria bassiana* and *Bacillus thuringiensis* are important natural control agents against many insect pests. Many species of fungi, approximately 1,200 species are described as insect pathogens. From these, seven species are used to control plant pest insects in augmentative

biopesticide (Van Lenteren *et al.*, 2017). More than 200 insect species from nine orders of insects, especially Lepidoptera and Coleoptera have been recorded as hosts of the entomopathogenic fungus, *B. bassiana* (De la Rosa *et al*., 2000). *B. bassiana* spores are found naturally in some plants and soils and are regarded as safe biopesticide (Uma Devi *et al*., 2008).

Also, *B. thuringiensis* (*Bt*) is a microbe naturally found in soil. It makes proteins that are toxic to insects. There are many types of Bt. each type targets different group from insects. These insect groups include beetles, mosquitoes, black flies, caterpillars, and moths. There are about one hundred and eighty successful commercial products from Bt in the world (De Maagd *et al*., 2003; Schnepf *et al*., 1998 and Van Franken huyzen, 2009).

The compatibility between microbial pesticides and chemical pesticides requires more studies. The collected data from such studies would enable farmers to select appropriate compounds and schedule microbial and chemical pesticide treatments so that benefits from compatible sets can be accrued and with noncompatible pairs, the deleterious effect of the chemical on the microbe in the biopesticide can be minimized (Butt *et al*., 2001; Inglis *et al*., 2001 and Lacey *et al*., 2001). A microbial pesticide compatible with a commonly used chemical pesticide can be used simultaneously or sequentially with it. To harness the benefits of entomopathogens their compatibility with insecticides becomes decisive for combined use, while the potential inhibitory effects of insecticides on the entomopathogenic fungus or bacteria cannot be ignored. Using incompatible insecticides may suppression the development and reproduction of these pathogens, affecting IPM. IPM programs it is essential to know the influence of compatibility between entomopathogenic fungi or bacteria and pesticides used in crop protection. If *B. bassiana* or *B. thuringiensis* has to be incorporated into a pest management program it is essential to determine the effects of pesticides on it.

It is important to study the side effects of pesticides on beneficial microorganisms for IPM. It is known that pesticides can have different effects on growth, sporulation and pathogenicity of entomopathogens (Tkaczuk, 2001; Rashid *et al*., 2010; Hernandez *et al*., 2012; Tkaczuk *et al*., 2012, 2015 and Pelizza *et al*., 2015). Using biopesticides compatible with classic chemical pesticides is recommended in integrated pest management (IPM) as an effective and environmental sound strategy.

The red spider mites, *Tetranychus urticae* Koch (Acari: Tetranychidae) is causing great damage to different agricultural crops. Both chemical and biocontrol must start at low densities for effective control of this pest (Blindeman and Van Labeke ,2003). The main objective of this study is to evaluate the side effects of some common pesticides on the growth and sporulation of entomopathogens, *B. bassiana* and *B. thuringiensis* as well as to the compatibility between them in IPM programs.

Materials and methods

The present study was conducted at Plant Protection Research Institute, Agriculture Research Center, Egypt. Experiments were carried out under laboratory conditions.

1.Tested pesticides:

Eleven commonly used pesticides in Egypt were obtained from Central Laboratory for Pesticides, Agriculture Research Center, Egypt (Table, 1). The side effect of these chemical pesticides was tested on the viability of active ingredient of biopesticides Biovar and Dipel (*B. bassiana* and *B. thuringiensis*, respectively).

2.Tested biopesticides:

B. bassiana and *B. thuringiensis* strains which are used in pesticide formulations Dipel DF and Biovar were used in this study. These strains were

obtained from the Plant Protection Research Institute, Agriculture Research Center, Egypt. These strains were refreshed by re-grown on culture media as Potato Dextrose Agar (PDA) for *B. bassiana* and Nutrient Agar (NA) for *B. thuringiensis*.

Table (1): The chemical pesticides which were tested

Trade name	Active ingredient	Field recommended dose
Camfal EC 15%	Indoxacarb	25 ml / 100 L
Dematox EC 40%	Dimethoate	150 ml / 100 L
Macet SC 10%	Abamectin	15 ml / 100 L
Challenger super SC 24%	Chlorfenapyre	60 ml / 100 L
Lamdathrin EC 5%	Lambda-cyhalothrin	20 ml / 100 L
Kafrothrin EC 2.5 %	Deltamethrin	350 ml/fd
Super-methrin EC 25 %	Cypermethrin	600 ml / fd
Helban EC 48%	Chlorpyrifos	1L/fd
Aktacron EC 72%	Profenofos	750ml / fd
Newmel SP 90%	Methomyl	300 gm/ fd
CamEron EC 10%	Hexaflumuron	200ml/ fd

3. Sensitivity of *Beauveria bassiana* to selected pesticides:

The Potato Dextrose Agar medium (PDA) was autoclaved at 121°C for 15 min. When the medium reached 50–60°C precisely measured doses of pesticides were added and thoroughly mixed. The treated medium was poured into Petri dishes and allowed to solidify. An agar disc of 10 days old colony of *B. bassiana* was cut by 6 mm diameter cork borer and transferred into the center of the treated PDA plates. Also, agar disc of *B. bassiana* grown on medium without pesticides as the control. Then Petri dishes were incubated at 25°C. Colony growth was observed every day until 14 days of culturing by measuring the colony diameter. Each treatment was performed in four replications. The results were recorded as the percentage growth inhibition of *B. bassiana* by insecticide-treated PDA (Hokkanen and Kotiluoto, 1992).

$$X = \frac{Y - Z}{Y} \times 100$$

Where: X = Growth inhibition percentage
Y= Growth diameter in control
Z = Growth diameter in treatment

4. Sensitivity of *Bacillus thuringiensis* to selected pesticides:

The sensitivity of *B. thuringiensis* to selected pesticides was measured by plate diffusion method, according to Collins and Lyne (1985) with cultures grown to logarithmic growth phase in nutrient broth medium (NB) for *B. thuringiensis.* Bacterial suspension (2 ml) was mixed carefully with 20 ml of nutrient agar medium in Petri dishes. Wells (8 mm diameter) were punched in the agar using the stainless-steel borer and were filled with 0.1 ml of the selected pesticides concentration. The plates were incubated for 48 hrs at 28 oC and the diameter of resulting clear zones of inhibition was measured using three replicates according to Toda *et al.* (1989).

5. Compatibility test:

The compatibility of the chemical pesticide which has not any side effect on *B. bassiana* and *B. thuringiensis* was tested in vitro against red spider mites (*T. urticae*). Four different treatments were conducted to test their efficacy against the red spider mite, *T. urticae* under laboratory conditions as leaf disk dip bioassay method as following: a) recommended field dose of the chemical pesticide only; b) recommended field dose of

chemical pesticide with *B. bassiana* (1×10^8 conidia/ml); **c)** *B. bassiana* (1×10^8 conidia/ml) only; d) control, without any compounds. Mortality was recorded daily until the death of all the tested organisms (Ullah and Lim, 2015 and Pree *et al*., 1989). The percentage of mortalities was corrected using Abbott's (1925) formula.

Results and discussion

Compatibility is the capacity to mix different pesticides without physical or chemical interactions or changes, leading to the enhancement of their biological effects. The sensitivity of *B. bassiana* and *B. thuringiensis* to the tested pesticide in this study showed in Table (2). The growth of *B. bassiana* was inhibited by all pesticides except indoxacarb, abamectin, chlorfenapyre, lambda-cyhalothrin, and methomyl. Abamectin and chlorofenapyr had not any inhibition of colony growth. Indoxacarb proved relatively slightly inhibition (33%), lambda-cyhalothrin and methomyl had moderately inhibition of colony growth were reached 56% and 50% respectively. Other pesticides were highly toxic of *B. bassiana* were reached to 100% inhibition of colony growth. On the other hand, *B. thuringiensis* was more sensitive to all tested pesticides except chlorofenapyr, cypermethrin, and methomyl.

The side effect of chemical pesticides on the entomopathogen (*B. bassiana* and *B. thuringiensis*) have been studied by Tkaczuk *et al*. (2015), Narkhede *et al*. (2017), Amutha *et al.* (2010) and Fiedler and Sosnowska (2017). In the present study abamectin and chlorfenapyre showed no toxic effect to *B. bassiana*. In earlier reports, abamectin was found to be compatible with *B. bassiana* at recommended field dose (Fiedler and Sosnowska, 2017).

Table 2. Sensitivity of *Beauveria bassiana* and *Bacillus thuringiensis* to the tested pesticides.

Pesticides	Colony growth of *B. bassiana*				Inhibition zone diameter (cm) of treated *B. thuringiensis* after 3 days
	Growth diameter (mm)			Inhibition percentage after 15 days	
	4 days	7 days	15 days		
Indoxacarb	0	9	20	33	3.0
Dimethoate	0	0	0	100	2.2
Abamectin	12	17	30	00	1.7
Chlorfenapyre	14	18	30	00	0.0
Lambda-cyhalothrin	0	10	13	56	3.5
Deltamethrin	0	0	0	100	3.5
Cypermethrin	0	0	0	100	0.0
Chlorpyrifos	0	0	0	100	2.4
Profenofos	0	0	0	100	1.8
Methomyl	0	10	15	50	0.0
Hexaflumuron	0	0	0	100	4.0
Control	16	20	30	00	00

In the present study, among the tested pesticides relatively low inhibition of the fungus growth showed based on indoxacarb where the fungus did not grow until four days after treatment and started to grow after five days. But Amutha *et al.* (2010) were found that the indoxacarb was more toxic on the fungus growth until 14 days of treatment. Also, in this study, lambda-cyhalothrin and methomyl have moderately effect on mycelial growth where the growth was slow until 7 days after treatment compared with control but the fungus growth was increased after seven days and reached to about 50% compared with control after 14 days. In previous studies, lambda-cyhalothrin was found to be less toxic to *B. bassiana* (Tkaczuk *et al*., 2015). The compatibility of *B. thuringiensis* with 27 chemical insecticides was studied by Morris (1977). He found that methomyl was the most pesticide compatible with *B. thuringiensis*. This result is agreed with my study.

Compatibility between *B. bassiana* and chlorfenapyre or abamectin and their effect on the response of *T. urticae* when treated with the combination of them was investigated in vitro in this study as shown in Table (3). The combination of the mixture of *B. bassiana* and half recommended the dose of chlorfenapyre or abamectin had a synergistic effect on *T. urticae* resulting 100 % mortality after five days. These results as the same results when used recommended dose from chlorfenapyre or abamectin. The mortality percentage of *T. urticae* reached to 51% and 74% after five and seven days when treated by *B. bassiana*. Also, the half dose from chlorfenapyre and abamectin caused 59% and 60% mortality percentages after seven days of treatment. These results indicated that the application of the mixture of chlorfenapyre or abamectin (half recommended dose) with *B. bassiana* on *T. urticae* showed a higher mortality than when applied individually, illustrating, in this case, an additive effect.

Table (3): Mortality percentage of *Tetranychus urticae* when treated with combinations of *Beauveria bassiana* and chlorfenapyre or abamectin.

Treatments	**Mortality percentage after application (Days)**			
	1 day	3 days	5 days	7 days
Chlorfenapyr (recommended dose)	81	100	100	100
Chlorofenapyr (half dose)	32	49	56	59
Chlorofenapyr (half dose) + *B. bassiana*	35	78	100	100
Abamectin (recommended dose)	87	100	100	100
Abamectin (half dose)	40	48	51	60
Abamectin (half dose) +*B. bassiana*	43	92	100	100
***B. bassiana* (recommended dose)**	0	34	51	74

Chlorfenapyre and abamectin are acaricides which were evaluated by many authors against *T. urticae* (Abd El-Mageed *et al.*, 2013 and Tawfek and El- Gohary, 2013). They found that chlorfenapyre and abamectin were more toxic against *T. urticae* compared with other compounds and control. Also, many studies investigated the effect of *B. bassiana* on *T. urticae* (Islam *et al*., 2017 and Baruah *et al*., 2008). They reported that mortality percentage increased after 3 days from treatment by *B. bassiana*. More previous studies were used *B. bassiana* as biopesticides against many pests.

Using biopesticides compatible with classic chemical pesticides is recommended in IPM as an effective and environmental sound strategy. The application of the mixture of chlorfenapyre or abamectin with *B. bassiana* on *T. urticae* gave a higher

mortality than when applied individually, illustrating, in this study, an additive effect. The compatibility in field trials or semi-field trials of *B. bassiana* with various chemical pesticides was tested by various authors (Shi and Feng, 2009 and Ansari and Sharma, 2005), thus making this fungus an interesting option to control mites in combination with other products. Laboratory studies were developed by Hernández *et al*. (2012) to evaluate the compatibility of flufenoxuron and azadirachtin with Beauveria bassiana against *T. urticae*. They found that the application of flufenoxuron with *B. bassiana* showed a clear synergy while the combination of azadirachtin and *B. bassiana* had an additive effect. Also, they mentioned that these combinations with *B. bassiana* could improve mite control by contributing to reducing the probability of resistance so often described in the literature. Mohan *et al.* (2007) studied the compatibility of azadirachtin A (AZA) and neem oil extract (0.15 % AZA) with thirty different isolates of *B. bassiana*. Of those studied twenty-three combinations were found to be compatible.

It is concluded that the mixture of biopesticides and chemical pesticides may have its implications on the use of a reduced quantity of chemical pesticides, which is a major cause of environmental pollution. In addition, due to the differential mode of action, this combination may also contribute to prolonging the generation of resistance in pest. Significantly, the cumulative strategy may improve the performance of integrated pest management programs.

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Effect of entomopathogenic fungi on *Pectinophora gossypiella* (Lepidoptera: Gelechiidae) and *Earias insulana* (Lepidoptera: Noctuidae) and their predators

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Pink and spiny bollworms, green lacewing, ladybird beetle, *Chrysoperla carnea*, *Coccinella septempunctata*, entomopathogenic fungi and toxicity.

Abstract:

Entomopathogenic fungi infect and kill insect pests in the green house and used as agents for biological control. The aim of this work is to study the toxicity of serial concentrations of fungal spore suspension of both *Metarhizium anisopliae* and *Paceilomyces lilicanus* against the newly hatched larvae of pink bollworm (PBW) *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) and spiny bollworm *Earias insulana* (Boisduval (Lepidoptera: Noctuidae) in addition to the effect of the two fungi on green lacewing, *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) eggs and larvae and on ladybird beetle *Coccinella septempunctata* L. (Coleoptera: Coccinellidae) eggs. Results showed that the toxicity of *P. lilicanus* was higher on *P. gossypiella* treatment; wheras the toxicity of *M. anisopliae* was higher in case of *E. insulana* treatment. On the other hand, the effect of the two fungi on *C. carnea* eggs was obvious effective, whereas, *C. septempunctata* was not affected after the same egg's treatment.

Introduction

Cotton bollworms included the pink bollworm (PBW) *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) and spiny bollworm (SBW) *Earias insulana* (Boisduval (Lepidoptera: Noctuidae) are considered the key insect pests infested each of squares, flowers as well as the green bolls causing destruction of the cotton plants resulting increasing qualities and quantities of the cotton yield. Using bioinsecticides proved to be harmless to predators and parasitoids in cotton field (Tillman and Mulrooney, 2000) and in laboratory conditions, it was harmless to *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) eggs and pupae stages irrespective of concentrations or method of treatments (Mandour, 2009).

Family Chrysopidae have high predatory capacity to different ecosystems (Costa *et al*. 2003). Importance of *C. carnea* as biological control agent for cotton pests; whereas insecticides influence different species of the natural enemy, it is important to evaluate the effects of the tested fungicides as biological control agents.

Coccinellidae is a widespread family of small beetles (Seago *et al*., 2011). The

ladybird beetle, *Coccinella septempunctata* L. (Coleoptera: Coccinellidae) mainly free-living predatory species. Therefore, it is considered to be useful insects, because many species prey on herbivorous homopterans (Liu and Stansly, 1996). Entomopathogenic fungi were successfully applied worldwide as biological control agents since 1880's (Krassilstschik, 1888). They were used for insect pests control programs (Herlinda *et al*., 2010 and for instance *Metarhizium anisopliae* and *Paceilomyces lilicanus* as well as the entomopathogenic bacteria, Bacillus *thuringiensis* were tested against the insect pests (the diamondback moth, the cabbage worm and beet armyworm) in the green house and field (Sabbour and Sahab, 2005). *M. anisopliae* is considered one of the most common entomopathogenic fungal species used as biological control agent against insect pests (Barra *et al*., 2013). In view of the importance of *C. carnea* and *C. septempunctata* as the biological control agents for cotton pests compared to insecticides effects on those species of natural enemy. This work aimed to evaluate the efficacy of two entomopathogenic fungi on the predators; *C. carnea* and *C. septempunctata* and their prey included *P. gossypiella* and *E. insulana*.

Materials and methods

1.Insect used:

First instar larvae of pink bollworm *P. gossypiella* was reared for several generations on modified artificial diet as described by Abd El-Hafez *et al*. (1982) under laboratory conditions at 27+1°C and 75+5% R.H. and spiny bollworm *E. insulana* was reared in Cotton Bollworm Research Department, Plant Protection Research Institute, Agricultural Research Center, Dokki. Giza, Egypt, on artificial diet described by (Amer, 2015).

Eggs of *C. carnea* and *C. septempunctata* were obtained from predators and parasitoids unit, Plant Protection Research Institute.

2.Fungus culture:

Isolates of *M. anisopliae* (Metschnikoff) Sorokin and *P. lilicanus* (Thom) Samson, were obtained from Assiut University, Mycological center Faculty of Science. The isolates were cultured on Sabouraud Dextrose Yeast Agar (SDYA) medium g/l (Sabouraud, 1892) containing 40 g glucose, 20 g peptone, 20 g agar, 2 gm Yeast extract and 1000ml of distilled water in flasks autoclaved at 21ºC for 15-20 min.

3.Inoclum preparations:

Fungal cultures were grown on (SDYA) medium g/l and incubated at 25±2ºC in darkness for 14 days. Conidial suspensions were prepared by scraping cultures with a sterile objective glass and transferred to 10 ml of sterile water containing 0.05% Tween 80 in a laminar flow chamber. The conidia were harvested by scraping the surface of the culture with inoculation needle. The mixture was stirred for 10 minute the hyphal was removed by filtering the mixture through fine mesh sieve. The conidial concentration of final suspension was determined by direct count using Haemocytometer. Serial dilutions were prepared in distilled water containing 0.1% tween- 80 and preserved at 5ºC until used. In vitro entomopathogenicity tests were applied to evaluate efficacy of the fungal isolates against the newly hatched larvae of *P. gossypiella* and *E. insulana*. A volume of 50 µl of the adjustable concentrations 108, 5X107, 2.5X106, 1.25X105 and 0.625X104 spores/ml viable conidia was directly applied to the larvae. Three replicates per treatment with per replicate were made.

4. Bioassay of treated *Pectinophora gossypiella* and *Earias insulana* larvae:

Response of the newly hatched larvae of *P. gossypiella* and *E. insulana* was studied. Serial concentrations of 108, 5x107, 2.5x106, 1.25x105 and 0.625x104 spores/ml were prepared. Thirty newly hatched larvae were transferred individually to the surface of the treated diet, each concentration replicated three times, after 24 hours

transferred the alive larvae on untreated diet and kept in glass tubes (2 x 7.5 cm) caped with cotton stopper. The same procedure was done with untreated diet exposed to newly hatched larvae and used as control. All tubes were incubated at 26±2ºc and 70-85±5% RH and inspected daily.

5. Bioassay of treated *Chrysoperla carnea* eggs and larvae:

The eggs were sprayed directly with 108 of *P. lilicanus* and *M. anisopliae* through laboratory bioassays then placed into glass tubes and observed daily for the number of hatched larvae in each treatment. The obtained larvae were maintained in the same tubes and fed with *P. gossypiella* eggs. Control replicates were treated by water only. thirty healthy starved larvae of the 2nd instar larvae of *C. carnea* were kept individually in glass tubes (2x7 cm) in each replicate and fed on treated *P. gossypiella* eggs by spraying the eggs cards with *P. lilicanus* and *M. anisopliae* solutions and dried them then complete nutrition on *P. gossypiella* eggs free from insecticidal treatment till formation of cocoons. Control replicates were treated by water only then incubated all tubes at 26 ± 1°C and 70 ±5% RH and evaluated daily until emergence of the insects. Mortality was recorded at intervals after 2, 3, 5,7,10 days after larval feeding.

6. Bioassay of treated *Coccinella septempunctata* eggs:

The eggs were sprayed directly with 108 of *P. lilicanus* and *M. anisopliae* through laboratory bioassays then placed into glass jars and observed daily for the number of hatched larvae in each treatment.

7.Data analysis:

Corrected cumulative mortalities were reported for both isolates from treatment and corrected according to Abbott´s (1925) as follows:

Corrected percent mortality = [(T – C)/(100-C)] x 100

The median lethal concentration (LC50) values were determined using Finney (1952).

Results and discussion

LC50 values and % expected mortality after treated the newly hatched larvae of *P. gossypiella* with different concentrations of *P. lilicanus* after 2, 3, 5, 7 and 10 days of treatments are shown in Table (1). The corresponding LC50 values were 5.60x107, 4.87x106, 4.85x106, 3.76x106 and 2.14x105spores/ml.

Expected mortality percentages of newly hatched larvae of *E. insulana* after treatment with different concentrations of *P. lilicanus* shown in Table (2). The LC50 values were 6.40 x107, 5.18x107, 5.02 x107, 4.05 x106 and 2.67 x106 spores/ml after 2, 3, 5, 7 and 10 days of treatment respectively. While after twelve days of treatment, all the treated larvae dead in contrary with the untreated larvae.

Response of newly hatched larvae of *P. gossypiella* after treatment with different concentrations of M. anisopliae is shown in Table (3). LC50 values were 3.92 x106, 2.91 x106 and 1.82 x105 after 2, 3, 5 days but after 7 and 10 days of treatment LC50 was 1.70x105 spores/ml.

Response of newly hatched larvae of *E. insulana* after treatment with different concentrations of *M. anisopliae* is shown in Table (4). LC50 values were 2.68 x107 after 2 days and 2.63 x107 after 3 and 5 days and 1.56 x105 after 7 days of treatment, respectively.

Table (1): Toxicity of *Paceilomyces lilicanus* against newly hatched larvae of *Pectinophora gossypiella* under laboratory conditions.

Conc.	%Expected Mortality values				
	After 2 days	After 3 days	After 5 days	After 7 days	After 10 days
108	60.41	64.20	84.07	88.90	96.82
5X107	50.82	52.94	78.27	83.48	93.67
2.5X106	41.11	41.65	71.43	76.64	88.54
1.25X105	32.20	32.20	63.75	68.51	81.00
Slope value	0.87±0.31	1.00±0.31	0.73±0.32	0.84±0.34	1.10±0.44
LC50	5.60 x107	4.87 x106	4.85 x106	3.76 x106	2.14 x105

Table (2): Toxicity of *Paceilomyces lilicanus* against newly hatched larvae of *Earias insulana* under laboratory conditions.

Conc.	% Expected Mortality values				
	After 2 days	After 3 days	After 5 days	After 7 days	After 10 days
108	62.20	66.10	68.96	94.62	98.03
5X107	46.80	51.71	55.81	89.82	95.28
2.5X106	32.16	36.60	42.24	82.50	90.11
1.25X105	20.41	23.94	29.94	72.56	81.72
0.625X104	12.62	14.95	20.14	60.57	69.99
Slope value	1.39±0.25	1.37±0.24	1.03±0.23	1.14±0.26	1.29±0.32
LC50	6.40 x107	5.18 x107	5.02 x107	4.05 x106	2.67 x106

Table (3): Toxicity of *Metarhizium anisopliae* against newly hatched larvae of *Pectinophora gossypiella* under laboratory conditions.

Conc.	%Expected Mortality values				
	After 2 days	After 3 days	After 5 days	After 7 days	After 10 days
108	65.36	65.95	89.09	93.21	93.21
5X107	54.09	60.00	76.74	81.79	81.79
2.5X106	42.47	47.53	59.07	62.69	62.69
1.25X105	31.48	33.42	39.29	39.74	39.74
Slope value	0.97±0.35	0.03±0.35	1.66±0.39	194±0.42	194±0.42
LC50	3.92 x106	2.91 x106	1.82 x105	1.70 x105	1.70 x105

Table (4): Toxicity of *Metarhizium anisopliae* against newly hatched larvae of *Earias insulana* under laboratory conditions.

Conc.	%Expected Mortality values			
	After 2 days	After 3 days	After 5 days	After 7 days
108	96.46	97.05	97.05	99.48
5X107	93.40	93.78	93.78	98.37
2.5X106	55.57	88.22	88.22	95.71
1.25X105	25.16	79.86	79.86	90.31
0.625X104	8.14	68.79	68.79	81.13
Slope value	2.80±0.32	1.18±0.30	1.18±0.30	1.41±0.42
LC50	2.68 x107	2.63 x107	2.63 x107	1.56 x105

In this field of study, El- Massry *et al*. (2016) found that *E. insulana* exhibited higher effective to *Trichoderma harzianum* treatment than *P. gossypiella.* There was a highly significant difference between the all tested concentrations comparing with the untreated one in case of the two larvae species. Also, Hegab and Zaki (2012) evaluate the effect of *B. bassiana* against *E. insulana*. The accumulated mortalities of both insects' larvae, after six days of treatment, were represented as the acute toxicity. Also, results cleared that the effect of Biover® fungi attained decreasing in all biological aspects.

Other authors observed the same finding in case of Tables (1, 2 and 3) that the treated larvae dead after 10 days of treatment as found by, Venugopal *et al.* (2017). They found that larval mortality observed after 3-7 -10 days of fungal treatment. With entomophthoralean fungi, unicellular yeast-like cells with chitinous walls (hyphal bodies) spread throughout the insect obtaining nutrients, leading to the death of the host by physiological starvation about 3-7 days after infection (Ritu *et al*., 2012) found the same different concentration of *B. basiansa* (62.98),(60.58),(59.67),(58.32).

Effect of the tested P. lilicanus and M. *anisopliae* using high concentrations (108 spores/ml) against *C. carnea* and *C. septempunctata* eggs presented in Table (5). After treating *C. carnea* eggs, the hatchibility percentage of eggs recorded 73.30% when treated with *P. lilicanus* with 21.43% reduction, while it was 86.7% in case of *M. anisopliae* treatment with 7.14% reduction, compared with 93.3% in control. While, after treating *C. septempunctata* eggs the hatchability percentage was 100% in case of *P. lilicanus* and *M. anisopliae* treatment.

The corrected mortality percentages of *C. carnea* 2nd instar larvae were recorded after 2, 3, 5 and 7 days of treatment with *P. lilicanus* and *M. anisopliae* are shown in Table (6). The results showed that the high concentration of the *P. lilicanus* and *M. anisopliae* affected on larvae predator significantly at 2, 3, 5 and 7 days respectively, the corresponding mortality percentages were 15, 15, 20 and 30%. *M. anisopliae* was more toxic to second instar larvae than *P. lilicanus*.

Table (5): Effect of *Metarhizium anisopliae* and *Paceilomyces lilicanus* on *Chrysoperla carnea* and *Coccinella septempunctata* eggs.

Tested fungi	*C. carnea*		*C. septempunctata*	
	%egg	%reduction	%egg	%reduction
P. lilicanus	73.30	21.43	100	0.00
M. anisopliae	86.70	7.14	100	0.00
Control	93.30	0.00	100	0.00

Table (6): Corrected mortality percentages of 2nd instar larvae of *Chrysoperla carnea* caused by *Metarhizium anisopliae* and *Paceilomyces lilicanus*.

Insecticides	% corrected Mortality				Larval Duration	%pupation	Pupal Duration	% adult emergence	
	2 days	3 days	5 days	7 days				♀	♂
P. lilicanus	15	15	20	30	20.83	66.67	9.29	0.00	50
M. anisopliae	25	55	80	85	17.83	92.86	8.71	30.7	61.5
Control	0.00	0.00	0.00	0.00	13.33	100	8.33	60	40

The immature stages (Larval and pupal duration) was recorded after treating the 2nd instar larvae of *C. carnea* with the two entomopathogenic fungi, results showed that *P. lilicanus* prolonged larval duration than control. Moreover, slight increase in pupal duration after treatment at 9.29 days compared with 8.33 days in control. So, the emerged adults from this treatment resulted malformed adults.

Figure (1) shows the malformed adults resulted from 2nd instar larvae of *C. carnea* treated with *P. lilicanus* compared with the normal one.

In this respect, Ayubi *et al*. (2013) studied the lethal effects of four compounds, imidacloprid, lufenuron, thiametoxam and thiodicarb, on the eggs and 1st instar larvae of C. carnea in laboratory conditions. Dipping bioassay tests were used for eggs and the residual contact method for larvae. Thiodicarb had no effect on eggs. On larvae, thiametoxam was the most toxic and lufenuron proved to be the least toxic. Also, Moustafa (2016) found that biocides were harmless on *c. carnea* eggs than conventional insecticides. Recently, Fernando (2018) the use of fungal entomopathogens as environmentally friendly alternatives for management of insect pests. Unfortunately, their effectiveness continues to be limited by their susceptibility to ultraviolet (UV) light and low moisture. In addition, this review presents several areas that should receive focused attention to increase the probability of success for making fungal entomopathogens an effective alternative to chemical control.

1 2 3 4

Figure (1): Normal and malformed adults after *Chrysoperla carnea* larvae treatment to insecticides

1: Normal adult 2**,3,4:** Malformed adults after treatment with ***Paceilomyces lilicanus*.**

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Pesticide efficacy of local save materials: Mineral oils and surfactant against broccoli pests

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Abstract:

Broccoli is a cruciferous vegetable that is a nutritional powerhouse and it infested by different insect pests. Pesticidal efficiency of some local materials: mineral oils (CAPL-1, CAPL-2) and surfactant (Sisi-6) were determined against both whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera :Aleyrodidae) (adult and nymphs) and cotton leafworm, *Spodoptera littoralis* (Boisduval) (Lepidoptera: Noctuidae) (larvae). Obtained results indicated that all tested materials showed succeded effect against to both two stages of whitefly at all tested concentrations 1.0,1.5 and 2.0% (V./V.) since they gave initial effect ≥ and equal 70% reduction and mean residual effect ≥ and equal 40% reduction of live individual / leaf, therefore 1% concentration is perferred for controling this pest for economic consideration. On the other hand, results of toxicity against second instar larvae of cotton leafworm as expressed by LC_{50}'s and toxicity indexes indicated that all tested materials showed toxicity effect, onar gave the highest toxic effect followed by surfactant Sisi-6 and mineral oils CAPL-1 and CAPL-2, also results indicated that tested materials showed latent toxic effect against larvae , pupae and moth emergency since they reduced percent moth emergency therefore they cause of broken of life-cycle of insect, onar showed the highest effect followed by surfactant Sisi-6 and mineral oils CAPL-1 and CAPL-2.

Introduction

Broccoli is considered among the most valuable vegetable crops, due to its composition of phytochemical compounds, with potential effects on preventing several cancer types and other illnesses (Brown *et al.*, 2002).

It is undesirable of using chemical pesticides for controlling pests infested broccoli crop since it is considered among food vegetable crops which remain for a short period in the field, therefore, some local, safe and cheep materials could be use as alternatives for conventional pesticides.

The white fly, *Bemisia tabaci* (Gennadius) (Hemiptera : Aleyrodidae) is considered the main insect pests infesting broccoli and cause great losses

not only in quantity but also in quality of the broccoli yield (Hashem *et al*., 2009). This pest has become resistant to the conventional insecticides on different crops (Palumbo *et al*., 2001). Cotton leaf worm. *Spodoptera littoralis* (Boisduval) (Lepidoptera: Noctuidae) is one of the most destructive agricultural pests in subtropical and tropical regions. The pest causes a variety of damage as a leaf feeder and a cutworm on seedlings. It can attack numerous economically important crops throughout the year (EPPO, 1997). In Egypt the Egyptian cotton leaf worm, *S. littoralis* is one of the most destructive phytophagous insect pests, not only to cotton, but also to other field crops and vegetables including broccoli (Kandil *et al*., 2003). Recently research has been made for new and nontraditional control agents effective against this pest since resistance has been recorded for most conventional insecticides (Rashwan *et al*., 1992). Published studies indicated that mineral oils, surfactants and plant oils proved pesticidal efficiency against different pests infested broccoli (El-Hariry and El-Sisi (1991); Rizk *et al*. (1999) and Mousa and El-Sisi (2001) and Badr *et al.* (1995).

The present study aims to determine the pesticidal efficiency of some mineral oils (CAPL-1), (CAPL-2) and surfactant (Sisi-6)against both whitefly, *B. tabaci* and cotton leafworm, *S. littoralis* infested broccoli crop.

Materials and Methods

1. Mineral oils:

CAPL-1: It is a sulphonated solar cut of petroleum oil, prepared as emulsifiable concentrate 96.6%. It is registered at no. 501 for controlling scale insects infested citrus horticulture, produced by Central Agricultural Pesticide Laboratory.

CAPL-2: It is a lubrication cut of petroleum oil, prepared as emulsifiable concentrate 96.6%. It is registered at no. 502 for controlling scale insects infested citrus crops. Produced by Central Agricultural Pesticide Laboratory.

2. Surfactant:

Sisi-6: It is anionic surfactant, prepared by Dr. El-Sisi, A. G. by neutralization of sulphonic acid with suitable alkaline. The product contained 10% potassium sulphonate.

3. Determination pesticidal efficiency against whitefly, *Bemisia tabaci*:

Experiment was conducted in broccoli field infested with whitefly at Giza. Spraying with previous materials at concentrations 1.0, 1.5 and 2% (V./V.) was done on Desember 22, 2015 using a hand sprayer provided with one nozzle. Pesticidal efficiency was determined according to Ministry of Agriculture Protocoles but at small scale. Infestation rate were determined before and after 1, 3, 5 and 7days of spraying by direct inspection for adult and by collecting 10 leaves from each treatment and inspecting them under binocular, then the mean number of nymphs' stage of whitefly / leaf was calculated. Percentage reductions were calculated according to equation of Henedrson and Tilton (1955).

Phytotoxicitys: It was determined by recording any flaming, curl and color change occurred in leaves of treated plants up to 7 days after treatment.

4. Toxicity of the tested materials against larval stage of cotton leafworm, *Spodoptera littoralis*:

Leaf-dip technique method was used to determine the toxicity of the studied materials against 2nd instar larvae by dipping leaves in different concentrations of each material then hanged to complete dry then introduced to 30 larvae 2nd instar larvae of each treatment, 3 replicates for each concentration. Dead and alive larvae was counted, then mortality percentage was recorded and corrected percent mortalities were calculated according to

Abbot formula (1925), LC-P lines were drawn up and LC_{50}'s, LC_{90}'s and slopes were calculated. Toxicity indexes were calculated according to Sun (1950) equation.

5. Pesticidal efficiency of the tested materials against cotton leafworm, *Spodoptera littoralis*:

To investigate the initial and latent effect of the tested materials, ten leaves of broccoli of each treatment were taken after spraying when plant become dry, then transferred to the laboratory and introduced to 2nd instar larvae of cotton leafwom under constant conditions of 25 ± 1°C and 70% ± 5% R.H., three replicates for each treatment each have 20 larvae. For studying the latent effect, other samples were taken each 2 days from treated plants continuously and introduced to the rest alive larvae until pupation stage. Mortality counts was recorded after 3, 5, 7 and 10 days of exposure, then mortality percentages were calculated, developmental effect against both pupae and moth emergency were studied by recording total numbers of formed pupae and moth emergency for each treatment then calculating their percentages by the method described by El-Sisi and Farrag (1989).

Pupation% = (No. of formed pupae / initial number of 2nd instar larvae) * 100

moth emergency% = (No. of formed moth / initial number of 2nd instar larvae) * 100

Results and Discussion

1.Pesticidal efficiency against whitefly, *Bemisia tabaci*:

According to the Ministry of Agriculture recommendations for using natural products and safe materials in controlling pests, succeeded materials should give initial effect not less than 40% reduction. According to these recommendations, results in Table (1) about the effect against numphs and Table (2) about the effect against adults of whitefly indicated that all tested materials at all tested concentrations gave high initial and residual effect agree with Ministry of Agriculture (1993) recommendations, also the effect increase as concentrations increased, but for economic considerations the lowest concentrations (1.0 %) is preferred. The obtained results are complied with El-Hariry and El-Sisi (1991), Rizk *et al*. (1999) and Mousa and El-Sisi (2001) findings of testing of those materials against sucking pierce pests. Results of field inspection of treated broccoli indicated that no any phytotoxic on broccoli was observed up to 7days of treatment.

Table (1): Pesticidal efficiency of the tested materials against nymphs of whitefly, *Bemisia tabaci* infested broccoli crop.

Treatments	Conc. (%)	Pre. Treatment count No. / leaf	Initial effect after 24hrs		Residual effect				
					No. / leaf after			Mean	%R
			*No. / leaf	%R	3days	5days	7days		
CAPL-1	1.0	178	28.3	78.93	23.4	30.4	33.6	29.13	77.2
	1.5	181.6	20.4	85.113	24.5	27.2	17.3	23	82.36
	2.0	197.2	20.1	86.492	20.5	12.7	37.3	23.5	83.4
CAPL-2	1.0	206.8	31.7	79.68	29.5	27.5	39.7	32.23	78.29
	1.5	170.1	19.3	84.96	16.3	19.5	21.1	18.96	84.47
	2.0	196.5	12.4	91.637	11	10	19.6	13.53	90.4
Sisi-6	1.0	186.9	17.8	87.379	35.2	63.2	24.1	40.83	69.58
	1.5	192.9	6.8	95.32	21	44.5	11.2	25.56	81.54
	2.0	202.3	3.1	97.96	35.4	15	13.6	21.33	85.319
Control		222.5	167.9	_	162.7	171.9	144.8	159.8	_

**No. / leaf = Mean No. of nymphs / broccoli leaf.*

Table (2): Pesticidal efficiency of the tested materials against adults of whitefly, *Bemisia tabaci* infested broccoli crop.

Treatments	Conc. (%)	Pre. Treatment count No. / leaf	Initial effect after 24hrs		Residual effect				
					No. / leaf after			Mean	%R
			*No. /leaf	%R	3days	5days	7days		
CAPL-1	1.0	10.9	19	72.19	1.3	1.5	2.7	1.8	73.18
	1.5	11.8	11	85.13	0.9	0.7	1.5	1.03	85.82
	2.0	12.1	9	88.14	0.7	0.8	0.9	0.8	89.26
CAPL-2	1.0	12	15	80.06	1	1.6	1.9	1.5	79.70
	1.5	11.9	12	83.91	0.9	1.1	1.6	1.2	83.62
	2.0	13.2	8	90.33	0.5	0.9	1.1	0.83	89.79
Sisi-6	1.0	12.6	15	81.01	1.1	1.5	3.6	2.06	73.45
	1.5	13.1	12	85.38	0.8	1.2	2.1	1.36	83.14
	2.0	12.2	8	89.54	0.6	0.8	1.2	0.86	88.55
Control		12.6	79	_	6.8	7.9	86	7.76	_

**No. / leaf = Mean No. of adults / broccoli leaf.*

2. Pesticidal efficiency against cotton leafworm, *Spodoptera littoralis*:

2.1.Toxicity of the tested materials against the second instar larvae of cotton leafworm, *Spodoptera littoralis*:

Results in Table (3) and Figure (1) indicated that all tested materials showed different toxicity effects against 2nd instar larvae. According to LC_{50}'s values also toxicity index surfactant Sisi-6 showed the highest toxic effect followed by mineral oils CAPL-1 and CAPL-2.

2.2. Insecticidal efficiency against larval stage of cotton leafworm, *Spodoptera littoralis*:

The results shown in Table (4) about the toxicity and latent effect against 2nd instar larvae of cotton leafworm indicated that:

2.2.1. The toxicity increased as both concentration and period of feeding with treated leave increased.

2.2.2. Sisi-6 showed the highest latent toxicity after 10 days against 2nd instar larvae followed by CAPL-1 and CAPL-2

2.2.3. The developmental effect against pupae and moth emergency indicated that treatment with Sisi-6 the highest decreased in pupae and moth emergency then cause broken the insect life cycle compared with untreated (control) followed by CAPL-1 and CAPL-2.

Results obtained were agree with Badr *et al.* (1995) findings about the latent effect of mineral oils against cotton leafworm. Generally, the mode of action could be explained as follows: the effect of mineral oils and plant oils against immature and mature stages is due to involve blocking of respiration as a result of presence of oil film (Smith and Pearce, 1948) then suffocation effect (De Ong *et al.*, 1927) also due to their antifeedant and developmental effect (Badr *et al.*, 1995). The pesticidal efficiency of any surfactant (Sisi-6) increased by its ability in decreasing the surface tension of water (El-Hariry and El-Sisi, 1991), since it might melt the epicuticle layer of pests as a result of its emulsifying effect, then cause mortality (Rizk *et al*., 1999).

It is concluded that the tested martials could be use as alternative of chemical pesticide for controlling whitefly infested broccoli crop as well as they showed toxic and latent effect against cotton leafworm. Also, they cause toxicity against larval stage and reducing moth emergency compared with untreated enough to cause broken of life cycle of this pest.

Table (3): Toxicity of the tested materials against the second instar larvae of *Spodoptera littoralis.*

Treatments	LC_{50} (%)	Toxicity Index	Slope	LC90
Sisi-6	**1.282**	**0.0039**	**1.792±1.09**	**6.656**
CAPL-1	**1.443**	**0.0035**	**1.787±1.09**	**7.520**
CAPL-2	**2.495**	**0.002**	**2.167±1.16**	**9.738**

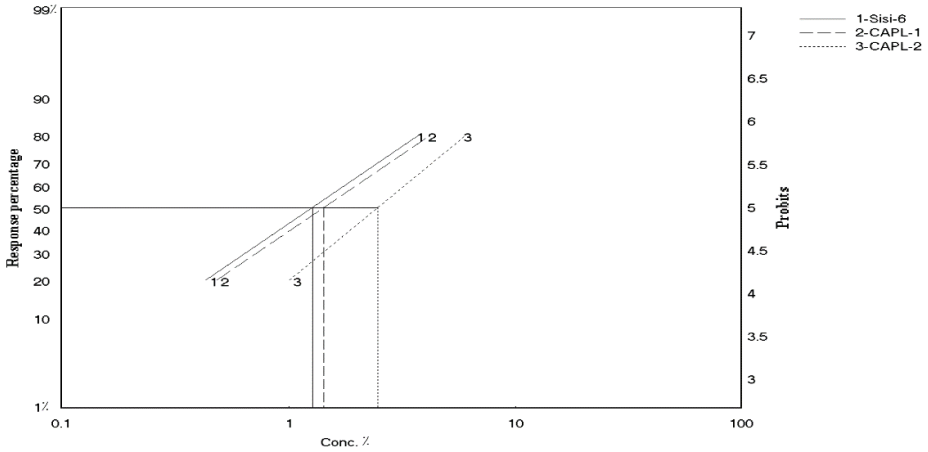

Figure (1): Toxicity of the tested materials against the second instar larvae of *Spodoptera littoralis.*

Table (4): Latent effect of tested materials against the second instar larvae of *Spodoptera littoralis.*

Treatments	Conc. (%)	% of Mortality After				% pupation	% Emergency
		3 days	5 days	7 days	10 days		
Sisi-6	**1.0**	**21.7**	**30.0**	**43.3**	**60.0**	**40**	**30**
	1.5	**26.7**	**35.0**	**53.3**	**71.6**	**28.4**	**20**
	2.0	**28.3**	**36.7**	**63.3**	**78.3**	**21.7**	**15**
CAPL-1	**1.0**	**25.0**	**33.3**	**38.3**	**53.3**	**46.7**	**33.4**
	1.5	**26.7**	**36.7**	**50.0**	**66.6**	**33.4**	**21.7**
	2.0	**33.3**	**46.7**	**60.0**	**75.0**	**25**	**16.7**
CAPL-2	**1.0**	**15.0**	**18.3**	**18.3**	**28.3**	**71.7**	**55**
	1.5	**20.0**	**25.0**	**35.0**	**51.6**	**48.4**	**35**
	2.0	**26.7**	**33.3**	**40.0**	**55.0**	**45**	**28.4**
Control		**0.0**	**1.7**	**3.3**	**5.0**	**95**	**90**

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Redescription and illustration of eight eriophyoid mites (Acari: Prostigmata: Eriophyoidea) with emphasis of their host plants from family Moraceae in Egypt

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Abstract:

Superfamily Eriophyoidea (Acari: Prostigmata) is tiny haplodiploid mites and strictly phytophagous, making galls, forming nests and living freely on plants. During the present study a survey of eriophyoid mites associated with plants of the family Moraceae from Egypt was studied. The results indicated that eight eriophyoid species were collected. These are, two species were belonging to family Diptilomiopidae and the remaining six to family Eriophyidae. They were *Diptilomiopus ficus* Attiah, 1967 and *Rhyncaphytoptus ficifoliae* Keifer, 1939 (family: Diptilomiopidae) and *Aceria fica* (Cotté, 1920); *Aceria benghalensis* (Soliman and Abou–Awad, 1977), *Aceria sycamori* (Soliman and Abou–Awad, 1977); *Neotegonotus sycamori* Abou–Awad, 1984, *Tegolophus niloticus* Abou–Awad, 1984 and *Aceria mori* (Keifer, 1939) (family: Eriophyidae). Redescription of these eight species (different stages) are presented and illustrated based on females, males and immature stages. A key to eriophyoid mite species associated with family Moraceae in Egypt is provided.

Introduction

Family Moraceae includes about 1,500 species in 53 genera. Most of the species are on trees or shrubs of the tropics or subtropics, but a few species are indigenous to temperate regions. The most important groups of this family are *Morus* spp. and *Ficus* spp. (Venkataraman, 1972). *Ficus carica* L. has been cultivated for a long time in various places worldwide for its edible fruit. It is assumed to originate from Western Asia and spread to the Mediterranean by humans; it is also a good source of food for fruit–eating animals in the tropics (Zohary and Hopf, 2000).

Up to date 121 eriophyoid species has been recorded from plants of the family Moraceae, 73 species of them was recorded on plants of genus *Ficus* (Amrine and de Lillo personal communication). Only eight eriophyoid species has been recorded from Moraceae in Egypt and described from females only (Soliman and Abou–Awad,

1977; Abou–Awad, 1984; Zaher, 1984 and Ueckermann, 1991). The knowledge on the host plant identification, mite habit and host plant relationships. Specific attention should be taken in finding and collecting males. Their morphology often helps to understand the female status as protogyne/deutogyne mites (Amrine and Manson, 1996).

More than 1,017 named species have been assigned to the genus *Aceria* Keifer, 1944. About 38 of them have been found in Egypt up to now (Elhalawany and Ueckermann 2015; 2018 and Amrine and de Lillo personal communication). With this study the total number of eriophyoid mites of Egypt increased to 103 species belonging to 34 genera (Elhlawany 2012, 2015, 2018 and Elhalawany *et al*. 2018).

The aim of this study is to redescribe and illustrate this eight eriophyoid mite species based on different stages.

Materials and methods

Mite specimens were collected from leaves and buds of plants of family Moraceae, at three different Governorates, Qualyubia, Gharbia and Giza of Egypt from 2016 to 2019. Eriophyoidea specimens were collected from plants by direct examination under stereo–microscope and mounted on microscope slides in Keifer's F–medium (Amrine and Manson 1996). The specimens were examined under a phase contrast microscope (Carl Zeiss, Germany). Illustrations were made with the use of a drawing tube attached to the phase contrast microscope and using Adobe Illustrator® CS6 (Adobe Systems Inc.). Identification to genus level was conducted using the key to world genera of the Eriophyoidea (Amrine *et al.*, 2003). Morphological terminology is based on Lindquist (1996) and data measurements follow (Amrine and Manson, 1996) and (de Lillo *et al*., 2010). All measurements were made using (Compound Eye) (Baker, 2005) and are given in micrometres (μm); the number of measured specimens (n) is given within parentheses in the description. For males and immature stages, only the ranges are given. Measurements are given in μm and are for lengths unless stated otherwise. Mite specimens are deposited in the mite reference collection of Fruit Trees Acarology Research Department, Plant Protection Research Institute, Agricultural Research Center, Egypt. Two paratypes of each species are deposited at the Plant Protection Research Institute collection, Egypt. Two paratypes of each species are deposited at the Collection of the Department of Zoology and Nematology, Faculty of Agriculture, Cairo University, Egypt.

Results and discussion

A key to the eriophyoid mite species associated with plants of the family Moraceae in Egypt

1- Gnathosoma usually small in comparison to the body; when large, with chelicerae triaght or slightly curved …… Eriophyidae 3

– Gnathosoma large in comparison to the body; chelicerae abruptly curved and bent down near base ……. Diptilomiopidae 2

2- Empodium divided, usually deeply; scapular setae absent; genu absent from both legs; coxal setae *1b* absent ……..…. *Diptilomiopus ficus* Attiah, 1967

– Empodium entire; scapular setae set just ahead of rear margin and projecting anteriorly. Legs with usual segments and setae ……..…..…. *Rhyncaphytoptus ficifoliae* Keifer, 1939

3- Body vermiform, annuli subequal dorsoventrally; prodorsal shield lack a frontal lobe, or with a slight projection over base, prodorsal shield tubercles on, rear shield margin, with transverse basal axes, scapular setae directed to rear ……..……..… *Aceria* 5

– Body usually more fusiform;annuli differed dorsoventrally, prodorsal shield normally with a broad–based frontal lobe over gnathosoma ……4

4 Dorsal opisthosoma having a middorsal ridge, first annuli large, projecting higher than other annuli; a deep cleft between prodorsal shield and opisthosoma; with prominent frontal lobe,

ridges on female coverflap in two uneven ranks…… *Neotegonotus sycamori* Abou–Awad, 1984

– Opisthosoma with three ridges; middorsal ridge stronger than lateral ridges but fades caudally, not ending a furrow; with strong frontal lobe; ridges on female coverflap in one rank …… *Tegolophus niloticus* Abou–Awad, 1984..

5- Tarsal empodium 5–rayed ……..…..6

– Tarsal empodium 6–rayed ……7

6 Prodorsal shield design with median line complete, female genital coverflap with 8–9 longitudinal ridges, dorsal annuli with oval microtubercles, on *Ficus carica* ….…… *Aceria fica* (Cotté, 1920)

– Prodorsal shield design with median line incomplete at 2/3, female genital coverflap with 12–13 longitudinal ridges, dorsal annuli with elongate microtubercles, on *F. benghalensis* and *F. sycomorus* ……..… *Aceria benghalensis* (Soliman and Abou–Awad, 1977)

7 Prodorsal shield design with median line complete broken, with 1st submedian line, dorsal annuli with elongate microtubercles, female genital coverflap with 10–12 longitudinal ridges on buds of M. alba ……..…….. *Aceria mori* (Keifer, 1939)

– Prodorsal shield design with median line complete, with two submedian lines, dorsal annuli with oval microtubercles, female genital coverflap with 12 longitudinal ridges, causing blister on *F. sycomorus* …… *Aceria sycamori* (Soliman and Abou–Awad, 1977)

1.Family Diptilomiopidae Keifer 1944

1.1. Subfamily Diptilomiopinae Keifer 1944

Genus *Diptilomiopus* Nalepa, 1916

Diagnosis: Body fusiform; gnathosoma large, abruptly curved and bent down near base; scapular setae sc absent; genu absent from both legs, paraxial tibial seta l' absent, empodium divided; setae 1b absent. This genus consists of 103 species (Amrine personal communication). Only one species has been recorded from Egypt.

***Diptilomiopus ficus* Attiah, 1967 (Figure, 1)**

Synonyms: *Diptilomiopus ficus* Attiah, 1967: 1-2; *Diptilomiopus ficus* Attiah, 1967: in Zaher, 1984:134.

Redescription: Female: (n=5). Body fusiform, 155 (150–175), 72 (70–75) width, 64 (63–70) thick; dark yellowish in life. **Gnathosoma** 52 (50–55), projecting downwards, pedipalp coxal setae ep 2 (2–3), dorsal pedipalp genual setae d 3 (3–4), subapical pedipalp tarsal setae v 3(2–3), cheliceral stylets 55 (53–56). **Prodorsal shield** broadly oval and short, convex shape and posterior slope; 30 (28–35) long, 60 (57–62) wide. Ornamentation on prodorsal shield consisting of network cells–like. Median line broken at centre; median, admedian and submedian lines connected by a transverse line at anterior 1/3 of prodorsal shield; the cells classes in four rows, the first 12 cells in anterior, five cells in second raw from anterior, and two cell in third and fourth row from anterior; lateral shield with granules; frontal lobe absent. Tubercles of scapular setae sc present 22(20–23) apart, small, rounded, ahead of rear shield margin; setae sc absent. **Coxal plates** with granules; anterolateral setae on coxisternum I 1b absent; proximal setae on coxisternum I 1a 31 (30–33), 7 (7–8) apart; proximal setae on coxisternum II 2a 50 (48–52), 25 (24–26) apart. Prosternal apodeme 5 (5–6); coxigenital area with 4 annuli, microtuberclated. Legs with genu absent from both legs, femur setae absent from both legs, tibia seta on leg I absent. **Leg I** 33 (30–35); femur 16 (15–17), basiventral femoral setae bv absent; genu absent; tibia 7 (6–7), paraxial tibial setae l' absent, tarsus 7 (7–8), paraxial, fastigial tarsal setae ft' 30 (30–32), antaxial, fastigial tarsal setae ft" 35 (32–40), setae u' 6 (4–6); tarsal empodium 9 (8–9), divided, each branch 7–8–rayed, tarsal solenidion ω 6(5–6) knobbed. **Leg II** 27 (26–29); femur 12 (12–1), setae bv absent; genu absent; tibia 6 (6–7), setae l' absent, tarsus 6 (5–6), tarsal setae ft' 11 (10–11), setae ft" 30 (30–35), setae u' 5 (5–6); empodium 9 (7–9), divided, each branch 7–8–rayed, ω 6 (5–6) knobbed. **Opisthosoma** with 55 (54–58) dorsal semiannuli; with pointed microtubercles on rear annular margins,

evenly rounded; with middorsal longitudinal ridge on either side flanked by shallow furrow and subdorsal ridge. With 68 (66–70) narrow ventral semiannuli (counted from the first semiannulus after the coxae II), with pointed microtubercles set on ventral semiannuli, last 12–14 ventral semiannuli with elongated, linear microtubercles. Setae c2 absent; setae d 44 (40–45), 45 (45–46) apart, on ventral semiannulus 25 (24–25); setae e 24 (24–26), 26 (26–27) apart, on ventral semiannulus 39 (39–40); setae f 27 (27–30), 29 (28–29) apart, on 9th ventral semiannulus from rear; setae h1 minute, setae h2 55 (55–60). External genital coverflap 28 (28–30) wide, 18 (17–18), smooth, with granules at base, proximal seta on coxisternum III 3a 8 (8–9), 19(19–20) apart. **Male:** (n=3). Similar to female, Body fusiform, 140–162, 68–72 width, 63–70 thick; dark yellowish in life. **Gnathosoma** 50–52, projecting downwards, setae ep 2–3, setae d 3–5, setae v 2–3, cheliceral stylets 53–54. **Prodorsal shield** shape and patterns similar to that of the female; 28–33 long, 57–60 wide. Tubercles of scapular setae sc present 20–21 apart, small, rounded, ahead of rear shield margin; setae sc absent. Coxal plates with granules; setae 1b absent; setae 1a 28–32, 7–8 apart; setae 2a 45–49, 24–25 apart. Prosternal apodeme 5–6; coxigenital area with 5 annuli, microtuberclated. Legs with genu absent from both legs, femur setae absent from both legs, tibia seta on leg I absent. **Leg I** 29–31; femur 15–17, basiventral femoral setae bv absent; genu absent; tibia 6–7, paraxial tibial setae l' absent, tarsus 6–7, paraxial, fastigial tarsal setae ft' 30–32, antaxial, fastigial tarsal setae ft" 32–37, setae u' 4–5; tarsal empodium 8–9, divided, each branch 7–8–rayed, tarsal solenidion ω 5–6 knobbed. **Leg II** 25–28; femur 11–13, setae bv absent; genu absent; tibia 6–7, setae l' absent, tarsus 5–6, tarsal setae ft' 9–10, setae ft" 30–33, setae u' 5–6; empodium 7–9, divided, each branch 7–8–rayed, ω 5–6 knobbed. **Opisthosoma** with 50–55 dorsal semiannuli; with pointed microtubercles on rear annular margins, evenly rounded; with middorsal longitudinal ridge on either side flanked by shallow furrow and subdorsal ridge. With 61–66 narrow ventral semiannuli, with pointed microtubercles set on ventral semiannuli, last 12–14 ventral semiannuli with elongated, linear microtubercles. Setae c2 absent; setae d 35–40, 41–43 apart, on ventral semiannulus 21–22; setae e 21–23, 22–24 apart, on ventral semiannulus 34–35; setae f 25–29, 27–29 apart, on 9th ventral semiannulus from rear; setae h1 minute, setae h2 50–57. Male genitalia 24–26 wide, 17–18 long, setae 3a 13–14, 20–21 apart. **Nymph:** (n=3). Similar to female, Body fusiform, 140–153, 65–70 width, 63–73 thick; yellowish in life. **Gnathosoma** 46–51, projecting downwards, setae ep 2–3, setae d 3–5, setae v 2–3, cheliceral stylets 53–57. **Prodorsal shield** shape and patterns similar to that of the female; 28–30 long, 55–60 wide. Tubercles of scapular setae sc present 20–21 apart, setae sc absent. Coxal plates with granules; setae I 1b absent; setae 1a 14–18, 7–9 apart; setae 2a 21–25, 14–15 apart, 3a 6–7, 15–16 apart. **Leg I** 29–30; femur 12–13, basiventral femoral setae bv absent; genu absent; tibia 5–6, paraxial tibial setae l' absent, tarsus 6–7, paraxial, fastigial tarsal setae ft' 28–30, antaxial, fastigial tarsal setae ft" 30–32, setae u' 3–4; tarsal empodium 6–7, divided, each branch 7–8–rayed, tarsal solenidion ω 4–5 knobbed. **Leg II** 25–28; femur 10–11, setae bv absent; genu absent; tibia 4–5, setae l' absent, tarsus 5–7, tarsal setae ft' 9–10, setae ft" 24–27, setae u' 3–5; tarsal empodium 6–7, divided, each branch 7–8–rayed, tarsal solenidion ω 4–5 knobbed. **Opisthosoma** with 47–50 dorsal semiannuli; with pointed microtubercles on rear annular margins, evenly rounded; dorsal annuli just behind posterior margin of prodorsal shield regular, with 43–46 narrow ventral semiannuli, with pointed microtubercles set on ventral semiannuli, last 15 ventral semiannuli with elongated, linear microtubercles. Setae c2 absent; setae d 22–25, 35 apart, on ventral semiannulus 20–21; setae e 20–22, 24–26 apart, on ventral semiannulus 25–26; setae f

22–24, 24 apart, on 8th ventral semiannulus from rear; setae h1 minute, setae h2 40–45.

Host plants: *Ficus carica* L. (Moraceae).**Other host plants:** *Ficus sycomorus* L. (Moraceae) during this study recorded as a new host plant. **Relation to the host plants:** Vagrant on lower surface of leaves, without visible damage.

Geographical distribution: Egypt.

Material examined: 5 females, two males and two nymphs on 2 slides from *Ficus sycomorus* (Moraceae), deposited at Plant Protection Research Institute collection, 5 April 2017, Qualyubia Governorate. 2 females and two males 2 slides from Kaha, Qalyubia Governorate, Egypt, 30°17'21.42" N, 31°12'45.82"E, 15 October 2016 coll. Ashraf Elhalawany deposited in Fruit Trees Acarology Research Department, Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt..

Remarks: The holotype of female was described by Attiah, 1967 on *Ficus carica* at Sabahia region near Alexandria, from Egypt; and short description of the male. Comparing the morphological characters of *D. ficus*, as well as the original description given by Attiah (1967), we did not find any regular differences between them.

1.2. Subfamily Rhyncaphytoptinae Roivainen 1953

Genus *Rhyncaphytoptus* Keifer, 1939

Diagnosis: Body fusiform; gnathosoma large, abruptly curved and bent down near base; scapular setae sc present; empodium entire; opisthosoma evenly rounded. This genus consists of 103 species (Amrine personal communication). Only one of these has been recorded from Egypt.

***Rhyncaphytoptus ficifoliae* Keifer, 1939a (Figure, 2)**

Synonyms: *Rhyncaphytoptus ficifoliae* Keifer, 1939a: 105; *R. ficifoliae* Keifer: in Zaher, 1984:133; *R. ficifoliae* Keifer: in Amrine *et al.* (2003): 164.

Redescription: Female:(n=10). Body fusiform, 200 (194–215), 68 (65–75) width, 72 (67–75) thick; amber in color. **Gnathosoma** 59 (56–60), projecting downwards, pedipalp coxal setae ep 4 (4–5), dorsal pedipalp genual setae d 7 (6–8), subapical pedipalp tarsal setae v 4(4–5), cheliceral stylets 58 (55–61). **Prodorsal shield** broadly subtriangular, with rounded frontal lobe over gnathosoma base; 40 (38–43) long, 60 (57–62) wide; prodorsal shield design with median and submedian lines absent, incomplete admedian lines forming a "U" shape between scapular tubercles, and short line lateral on each side. Scapular tubercles ahead of rear shield margin, 32 (30–33) apart, scapular setae sc 22 (20–23) projecting forward. **Coxal plates** smooth; anterolateral setae on coxisternum I 1b 10 (10–12), 11 (10–12) apart; proximal setae on coxisternum I 1a 38 (35–44), 11 (11–12) apart; proximal setae on coxisternum II 2a 55 (40–60), 28 (28–30) apart. Prosternal apodeme 8 (8–9); coxigenital area with 14–15 annuli between coxae and genitalia, microtuberclated. Legs with usual setae. **Leg I** 45 (43–46); femur 16 (15–17), basiventral femoral setae bv 11 (10–13); genu 7 (6–8), antaxial genual setae l″ 33 (29–34); tibia 10 (9–10), paraxial tibial setae l' 7 (6–8), tarsus 10 (10–11), paraxial, fastigial tarsal setae ft' 30 (30–33), antaxial, fastigial tarsal setae ft" 38 (37–41), setae u' 4 (3–4); tarsal empodium 8 (8–9), simple, 5–6–rayed, tarsal solenidion ω 10 (10–11) knobbed. **Leg II** 43 (43–44); femur 15 (14–15), setae bv 10 (9–12); genu 7 (6–8), genual setae l″ 33 (29–34); tibia 10 (9–10), paraxial tibial setae l' 7 (6–8), tarsus 10 (9–10), tarsal setae ft' 15 (15–17), setae ft" 38 (37–41), setae u' 4 (3–4); tarsal empodium 8 (8–9), simple, 5–rayed, tarsal solenidion ω 10 (10–11) knobbed. **Opisthosoma** with 20 (19–20) dorsal semiannuli; with linear microtubercles, evenly rounded, with 82 (80–85) narrow ventral semiannuli (counted from the first semiannulus after the coxae II), with pointed microtubercles set on ventral semiannuli, last 12–14 ventral semiannuli with elongated, linear microtubercles. Setae c2 22 (20–25), 59 (57–63) apart, on ventral semiannulus 12 (11–12); setae d 58 (55–60), 50 (48–51) apart, on ventral semiannulus 32 (31–33); setae e 22 (21–24), 36 (36–37)

apart, on ventral semiannulus 50 (50–51); setae f 33 (33–35), 30 (28–30) apart, on 6th ventral semiannulus from rear; setae h1 5 (4–5), setae h2 60 (55–60). External genital coverflap 28 (28–30) wide, 20 (18–21), smooth, proximal seta on coxisternum III 3a 22 (20–25), 19(19–20) apart. **Male:** (n=5). Similar to female, Body fusiform, 170–194, 65–67 width, 63–67 thick; amber in color. **Gnathosoma** 52–55, projecting downwards, setae ep 3–4, setae d 4–6, setae v 3–4, cheliceral stylets 52–54. **Prodorsal shield** shape and patterns similar to that of the female; 35–40 long, 57–60 wide. Tubercles of scapular setae sc 30–31 apart, on rear shield margin; setae sc 20–21, projecting forward. **Coxal plates** smooth; setae 1b 9–12, 10–12 apart; setae 1a 35–40, 10–12 apart; setae 2a 45–50, 24–27 apart. Prosternal apodeme 5–6; coxigenital area with 16–17 annuli, microtuberclated. **Leg I** 43–45; femur 15–16, setae bv 10–12; genu 6–7, antaxial genual setae l″ 28–30; tibia 9–10, paraxial tibial setae l' 6–7, tarsus 10–11, setae ft' 28–30, setae ft" 35–40, setae u' 3–4; tarsal empodium 8–9, simple, 5–6–rayed, tarsal solenidion ω 10–11, knobbed. **Leg II** 42–43; femur 14–15, setae bv 10–12; genu 6–7, antaxial genual setae l″ 8–10; tibia 9–10, tarsus 9–10, setae ft' 15–17, setae ft" 30–37, setae u' 3–4; tarsal empodium 8–9, simple, 5–rayed, tarsal solenidion ω 10–11, knobbed. **Opisthosoma** with 20 dorsal semiannuli; with linear microtubercles, evenly rounded; with 65–68 narrow ventral semiannuli, with pointed microtubercles set on ventral semiannuli, last 8–10 ventral semiannuli with elongated, linear microtubercles. Setae c2 20–22, 57–59 apart, on ventral semiannulus 12; setae d 55–57, 46–48 apart, on ventral semiannulus 29–30; setae e 13–15, 32–3 apart, on ventral semiannulus 45–47; setae f 27–30, 21–24 apart, on 6th ventral semiannulus from rear; setae h1 4–5, setae h2 55–60. Male genitalia 28–30 wide, 17–18 long, setae 3a 19–20, 20–22 apart. **Nymph:** (n=4). Body fusiform, 137–150, 58–60 width, 53–62 thick; yellowish in color. **Gnathosoma** 40–46, projecting downwards, setae ep 2–3, setae d 3–5, setae v 2–3, cheliceral stylets 40–45. Prodorsal shield broadly subtriangular, with rounded frontal lobe over gnathosoma base; 28–32 long, 48–51 wide. **Prodorsal shield** pattern with incomplete median line at 2/3, incomplete admedian lines forming a "U" shape between scapular tubercles, and two incomplete submedian lines forming V shape ahead of scapular tubercles, connected with two transverse line; Scapular tubercles ahead of rear shield margin, 24–25 apart, scapular setae sc 10–12 projecting forward. **Coxal plates** smooth; setae I 1b 6–7, 6–7 apart; setae 1a 25–28, 6–7 apart; setae 2a 32–35, 22–24 apart, 3a 6–7, 11–12 apart. **Leg I** 29–30; femur 8–9, setae bv 10–11; genu 4–5, antaxial genual setae l″ 16–18; tibia 4–5, paraxial tibial setae l' 3–4, tarsus 5–6, setae ft' 19–21, setae ft" 20–22, setae u' 2–3; tarsal empodium 3–4, simple, 4–rayed, tarsal solenidion ω 5–6, knobbed. **Leg II** 26–27; femur 7–8, setae bv 10–11; genu 4–5, antaxial genual setae l″ 6–8; tibia 4–5; tarsus 5–6, setae ft' 7–8, setae ft" 20–22, setae u' 2–3; empodium 3–4, simple, 4–rayed, tarsal solenidion ω 5–6, knobbed. **Opisthosoma** with 40–43 dorsal semiannuli; with pointed microtubercles on rear annular margins, with 57–60 narrow ventral semiannuli, with pointed microtubercles set on ventral semiannuli, last 10 ventral semiannuli with elongated, linear microtubercles. Setae c2 15–17, 47–48 apart, on ventral semiannulus 11–12; setae d 32–35, 34–35 apart, on ventral semiannulus 25–26; setae e 9–12, 22–23 apart, on ventral semiannulus 35–37; setae f 18–22, 21–22 apart, on 6th ventral semiannulus from rear; setae h1 2–3, setae h2 30–35.

Host plants: *Ficus carica* L. (Moraceae).

Relation to the host plants: Vagrant on lower surface of leaves, without visible damage.

Geographical distribution: Armenia; Chile; Egypt; Great Britain; Greece; India; Iran; Italy; Portugal; USA; Yugoslavia (Amrine and Stasny, 1994).

Material examined: 10 females, 5 males and two nymphs on 2 slides from *Ficus carica* (Moraceae), deposited at Plant Protection Research Institute collection, 5 April 2017, Qualyubia Governorate. Four females and two males 2 slides from Kaha, Qalyubia Governorate, Egypt, 30°17'21.42" N, 31°12'45.82"E, 15 October 2016 coll. Ashraf Elhalawany deposited in Fruit Trees Acarology Research Department, Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt.

Remarks: The holotype female was described by Keifer, 1939a on *Ficus* sp. from USA. The morphometry of the female appears to match the original description by Keifer, 1939. The principal differences between this species and the descriptions given by Keifer are the size of the specimens now examined is shorter 45 long; scapular seta c2 short 13 long; seta d short 40 long; seta e short 16 long seta f short 27long and seta 3a short 14 long; the Egyptian specimens are slightly longer than those in Keifer's description. This is the first description of male and immature stages of *R. ficifoliae*.

2.Family Eriophyidae Nalepa, 1898

2.1. Subfamily Phyllocoptinae Nalepa, 1892

Genus *Neotegonotus* Newkirk and Keifer, 1971

Diagnosis: Body fusiform; scapular setae sc and tubercles ahead of rear shield margin, directed posteriorly; deep cleft between prodorsal shield and opitshosma; first annuli large, projecting higher than other annuli; empodium entire; legs with usual segmentation and setae; opisthosoma with middorsal ridge, dorsal annuli broader and narrower ventral annuli. The genus consists of 6 species (Amarine *et al*., 2003 and Wei *et al.*, 2003).

***Neotegonotus sycamori* Abou–Awad, 1984 (Figure, 3)**

Synonyms: *Neotegonotus sycamori* Abou–Awad, 1984: 21-13.; *N. sycamori* Abou–Awad, 1984: in Meyer, 1981:373-375; *N. sycamori* Abou–Awad, 1984: in Amrine and Stasny, 1994: 233.

This species was collected at the first time by Abou-Awad on sycamore associated with *Tegolophus niloticus* in Aswan, with short description of male.

Redescription: Female: (n = 6) body fusiform, 162 (151–177) long without gnathosoma, 56 (53–58) wide, 60 (51–65) thick; dark yellow. **Gnathosoma 30** (25–31) long, projecting obliquely downwards, basal setae ep 3 (2–3), antapical setae d 6 (5–6), chelicerae 17 (16–19) long. **Prodorsal shield** 45 (43–46) long including broad prominent frontal lobe 7 (6–8), 52 (50–55) wide; sub semicircular; prodorsal shield ornamentation with median and submedian lines absent; admedian lines in complete forming U shape between scapular tubercles, reached at 1/2; surface of prodorsal shield punctuated. Scapular tubercles on ahead of rear shield margin, 25 (25–27) apart, setae sc 17 (14–18), projecting posteriorly. **Coxigenital area** coxae I with faint granules, with 5-6 annuli between coxae and genitalia, prosternal apodeme present 8 (7–8); anterolateral setae on coxisternum I 1b 7 (6–7), 13 (13–14) apart; proximal setae on coxisternum I 1a 20 (19–22), 8 (7–8) apart; proximal setae on coxisternum II 2a 40 (38–42), 22 (20–22) apart. **Leg I** 32 (30–33), femur 10 (9–10), setae bv 10 (8–10); genua 5 (4–5), setae l" 25 (24–27); tibiae 9 (8–9), setae l' 3 (3–4), setae located 1/4 from dorsal base; tarsi 6 (6–7); empodium em simple 5 (5–6), 4–rayed, tarsi solenidia ω knobbed, 8 (8–9), setae ft' 18 (17–19), setae ft" 23 (22–24), setae u' 2–3. **Leg II** 28 (27–30), femur 9 (8–9), setae bv 11 (9–11); genua 5 (4–5), setae l" 9 (9–10); tibiae 7 (7–8); tarsi 5 (5–6); em simple 5 (5–6), 4–rayed, ω knobbed, 9 (8–9), setae ft' 8 (7–10), setae ft" 20 (18–22), setae u' 2–3. **Opisthosoma** 23 dorsal annuli broad, with middorsal longitudinal ridges, fading caudally; a deep cleft between prodorsal shield and opitshosma; first annuli large, projecting higher than other annuli; with linear elongate microtubercles. Ventral annuli with 54 (53–55) annuli (counted from first annulus after coxae II), microtubercles elliptical, placed on posterior ventral annuli,

the last 20-27th ventral microtubercles linear. Lateral setae c2 10 (7–11), 44 (43–45) apart, on annulus 7 from coxae II; setae d 50 (46–52), 25 (24–25) apart, on annulus 17 (17–18); setae e 9 (8–9), 11 (10–11) apart, on annulus 30 (29–30); setae f 25 (24–25), 11 (11–12) apart, on annulus 6th annulus from rear. Setae h2 47 (44–57); setae h1 minte. **External genitalia** 12 (12–13), 20 (19–20) wide, coverflap with scoring in two series, an anterior with about 14-16 longitudinal ridges and a posterior with about 11 ones, proximal setae 3a 16 (15–17), 15 (15–16) apart. **Male:** (n=1). Similar to female. Body fusiform, 160 excluding gnathosoma, 50 wide. **Gnathosoma** 29, chelicerae 17, setae ep 3, setae d 6. **Prodorsal shield** 43 long including prominent frontal lobe frontal lobe 7, 50 wide; shape and patterns similar to those of the female. Scapular tubercles on ahead of rear shield margin, 25 apart, setae sc 16, projecting posteriorly. **Coxigenital area** with coxae I with granules, with 6 annuli between coxae and genitalia, prosternal apodeme present 6; setae 1b 7, 12 apart; setae 1a 20, 8 apart; 2a 36, 20 apart. **Leg I** 29, femur 8, setae bv 10; genua 5, setae l" 24; tibiae 8, setae l' 3; tarsi 6; em simple 5, 4–rayed, ω knobbed, 8, setae ft' 18, setae ft" 23, setae u' 3. **Leg II** 27, femur 8, setae bv 10; genua 4, setae l" 8; tibiae 7; tarsi 5; em simple 5, 4–rayed, ω knobbed, 8, setae ft' 7, setae ft" 21, setae u' 2. Opisthosoma 21 dorsal annuli and 45 ventral annuli, microtubercles similar that of female. Lateral setae c2 8, 42 apart, on annulus 7 from coxae II; setae d 48, 24 apart, on annulus 15; setae e 8, 11 apart, on annulus 24; setae f 25, 11 apart, on annulus 6th annulus from rear. Setae h2 48; setae h1 minte. **External genitalia** 11 long, 16 wide, with granules, setae 3a 20, 13 apart.

Host plants: *Ficus sycomorus* L., (Moraceae). **Relation to the host plants:** this mite found was found on lower leaves of sycamore; associated with *Diptilomiopus ficus* without no observed damage.

Geographical distribution: Aswan and Qualyubia Governorates in Egypt.

Material examined: Ten females and male on 5 slides, are , deposited in the mite reference collection of Fruit Trees Acarology Research Department, Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt, 23 Feb. 2019, Qualyubia Governorate 30°17'21.42" N, 31°12'45.82"E; coll. Ashraf Elhalawany.

Remarks: The holotype female was described by Abou-Awad, 1984 on *F. sycomorus* in Aswan from Egypt. The morphometry of the female appears to match the original description by Abou-Awad. In this study described the female and male collected from the same host in Qualyubia Governorate.

2.2. Subfamily Phyllocoptinae Nalepa, 1892

Genus *Tegolophus* Keifer, 1961

Diagnosis: Body fusiform; scapular setae sc and tubercles near rear shield margin, directed posteriorly; empodium entire; legs with usual segmentation and setae; opisthosoma with 3 ridges. This genus consists of 96 species (Amrine personal communication). Only three of these have been recorded from Egypt.

Tegolophus niloticus Abou–Awad, 1984 (Figure, 4)

Synonyms: *Tegolophus niloticus* Abou–Awad, 1984: 23-25; *T. niloticus* Abou–Awad, 1984: in Meyer, 1981:385; *T. niloticus* Abou–Awad, 1984: in Amrine and Stasny, 1994: 292.

Redescription: Female: (n=10) body fusiform, 180 (154–185) long without gnathosoma, 56 (51–58) wide, 50 (47–52) thick; light yellow. **Gnathosoma 25** (25–27) long, projecting obliquely downwards, basal setae ep 3 (3–4), antapical setae d 4 (4–5), chelicerae 18 (17–19) long. **Prodorsal shield** 41 (40–43) long including broad rounded frontal lobe 6(6–7), 43 (40–45) wide; subtriangular; prodorsal shield ornamentation with median and submedian lines absent; admedian lines complete forming jug shape; surface of prodorsal shield punctuated; lateral area with granules. Scapular tubercles on rear shield margin, 24 (21–24) apart, setae sc 21 (20–21), projecting

posteriorly. **Coxigenital area** with short dashes, with 5 annuli between coxae and genitalia, prosternal apodeme present 6 (5–7); anterolateral setae on coxisternum I 1b 7 (6–7), 11 (11–12) apart; proximal setae on coxisternum I 1a 22 (21–23), 8 (8–9) apart; proximal setae on coxisternum II 2a 37 (35–40), 22 (20–22) apart. **Leg I** 25 (23–25), femur 8 (7–8), setae bv 7 (7–8); genua 4 (4–5), setae l" 20 (19–21); tibiae 4 (4–5), setae l' 4 (4–5), setae located 1/4 from dorsal base; tarsi 5(4–5); empodium em simple 5 (5–6), 5–rayed, tarsi solenidia ω slightly knobbed, 7 (6–7), setae ft' 18 (18–20), setae ft" 23 (22–24), setae u' 2–3. **Leg II** 23 (20–23), femur 7 (7–8), setae bv 5 (5–6); genua 3 (3–4), setae l" 6 (6–8); tibiae 4 (4–5); tarsi 5(4–5); em simple 5 (5–6), 5–rayed, ω slightly knobbed, 8 (7–8), setae ft' 8 (7–10), setae ft" 20 (18–22), setae u' 2–3. **Opisthosoma** 29 (28–29) dorsal annuli broad, with three longitudinal ridges, middorsal ridge stronger than lateral ridges, fading caudally. Ventral annuli with 54 (53–55) annuli (counted from first annulus after coxae II), microtubercles oval, placed on posterior ventral annuli, the last 10th ventral microtubercles linear. Lateral setae c2 17 (15–18), 53 (52–53) apart, on annulus 7 from coxae II; setae d 40 (36–45), 35 (33–35) apart, on annulus 17 (17–18); setae e 10(10–11), 18 (17–18) apart, on annulus 30 (30–32); setae f 15 (14–15), 19 (19–20) apart, on annulus 6th annulus from rear. Setae h2 47 (42–47), 7 (7–8) apart; setae h1 minte. **External genitalia** 15 (14–15), 23 (22–24) wide, coverflap with 12 longitudinal ridges in two rows, proximal setae 3a 23 (20–25), 14 (14–15) apart. **Male:** (n=5). Similar to female. Body fusiform, 140–165 including gnathosoma, 47–50 wide, 44–48 thick; light yellow. **Gnathosoma** 22–24, chelicerae 17–18, setae ep 3–4, setae d 3–5. **Prodorsal shield** 36–38 long including broad rounded frontal lobe 5–6, 40–43 wide; shape and patterns similar to those of the female. Scapular tubercles on rear shield margin, 18–20 apart, setae sc 18–19, are projecting posteriorly. **Coxigenital area** with short dashes, with 6-7 annuli between coxae and genitalia, prosternal apodeme present 5–7; setae 1b 7–8, 9–10 apart; setae 1a 22–25, 8–9 apart; 2a 30–36, 20–21 apart. **Leg I** 23–25, femur 6–7, setae bv 7–8; genua 4–5, setae l" 19–21; tibiae 4–5, setae l' 4–5; tarsi 4–5; em simple 5–6, 5–rayed, ω slightly knobbed, 6–7, setae ft' 18–20, setae ft" 21–23, setae u' 2–3. **Leg II** 20–23, femur 6–7, setae bv 5–6; genua 3–4, setae l" 6–8; tibiae 4–5; tarsi 4–5; em simple 5–6, 5–rayed, ω slightly knobbed, 7–8, setae ft' 7–9, setae ft" 18–21, setae u' 2–3. **Opisthosoma** 28–29 dorsal annuli broad, with three longitudinal ridges, middorsal ridge stronger than lateral ridges, fading caudally. Ventral annuli with 50–53 annuli, microtubercles oval, placed on posterior ventral annuli, the last 10th ventral microtubercles linear. Lateral setae c2 15–17, 47–50 apart, on annulus 7 from coxae II; setae d 36–42, 27–29 apart, on annulus 17; setae e 8–9, 16–17 apart, on annulus 30; setae f 18–22, 19–20 apart, on annulus 6th annulus from rear. Setae h2 35–42; setae h1 minte. **External genitalia** 10–11 long, 17–18 wide, with granules, setae 3a 16–19, 14–15 apart. **Nymph:** (n= 4). Similar to female. Body fusiform, 140–150 excluding gnathosoma, 47–50 wide, 44–48 thick; light yellow. **Gnathosoma** 20–22, chelicerae 17–19, setae ep 2–3, setae d 4–5. **Prodorsal shield** 37–38 long including broad rounded frontal lobe, 43–45 wide; shape and patterns similar to those of the female; admedian line forming U shape. Scapular tubercles on rear shield margin, 19–21 apart, setae sc 16–17, are projecting posteriorly. **Coxigenital area** with short dashes and few granules, prosternal apodeme present 5–6; setae 1b 7–8, 8–9 apart; setae 1a 22–25, 7–8 apart; 2a 30–32, 20–21 apart; setae 3a 8-9, 8-9 apart. **Leg I** 22–23, femur 6–7, setae bv 5–6; genua 3–4, setae l" 15–17; tibiae 4–5, setae l' 3–4; tarsi 4–5; em simple 3–4, 4–rayed, ω slightly knobbed, 5–6, setae ft' 10–12, setae ft" 16–17, setae u' 1–2. **Leg II** 20–22, femur 6–7, setae bv 5–6; genua 3–4, setae l" 6–8; tibiae 3–4; tarsi 3–4; em simple 3–4, 4–rayed, ω slightly knobbed, 6–7, setae ft' 6–8, setae ft" 16–17, setae u' 1–2. **Opisthosoma** 36–38

dorsal annuli, with elongate linear microtubercles. Ventral annuli with 45–47 annuli, microtubercles oval, placed on posterior ventral annuli, the last 10th ventral microtubercles linear. Lateral setae c2 15–16, 43–44 apart, on annulus 7 from coxae II; setae d 23–25, 27–29 apart, on annulus 17; setae e 8–9, 16–17 apart, on annulus 25-26; setae f 17–18, 14–15 apart, on annulus 6th annulus from rear. Setae h2 35–40; setae h1 minte.

Host plants: *Ficus sycomorus* L., (Moraceae). **Relation to the host plants:** This mite found was found buds of sycamore; associated with *Aceria benghalensis* Soliman and Abou-Awad, without no observed damage.

Geographical distribution: Egypt.

Material examined: Six females, three males and two nymphs on 2 slides on *F. sycomorus* (Moraceae) are deposited at the Plant Protection Research Institute collection, Giza, Egypt, 8 October 2018, Qualyubia Governorate 30°15'25.17" N, 31°15'20.33"E; coll. Ashraf Elhalawany. Four females and four males on 2 slides, deposited in the mite reference collection of Fruit Trees Acarology Research Department, Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt. Five females on two slides, deposited at the collection of the Department of Zoology and Nematology, Faculty of Agricultural, Cairo University, Egypt.

Remarks: The holotype female was described by Abou-Awad, 1984 on *F. sycomorus* in Aswan from Egypt. The morphometry of the female appears to match the original description by Abou-Awad. In this study described the female, male and nymph collected from the same host in Qualyubia Governorate.

2.3.Subfamily Eriophyinae Nalepa, 1898

Genus *Aceria* Keifer, 1944

Diagnosis: Body vermiform; scapular tubercles and setae on rear shield margin, scapular setae scdirected posteriorly; legs with usual segmentation and setae, empodium entire; opisthosoma with dorso–ventral annuli subequal, with granules. This genus consists of 1017 species (Amrine personal communication). This genus consists of 38 species have been recorded from Egypt.

***Aceria fica* (Cotté, 1920) (Figure, 5)**

Synonyms: *Eriophyes ficus* Cotté, 1920: 28–30; *Eriophyes fici* Ewing, 1922 in Essig, 1922: 466; *Eriophyes fici* Essig and Smith, 1922: 47; *Eriophyes ficus* Baker, 1939: 266–275; *Eriophyes ficus* Nemoto *et al.* 1980: 49–53; *Aceria ficus* Meyer, 1981: 117–126; *Aceria ficus* Mohanasundaram, 1990: 82; *Aceria ficus* Amrine and Stasny, 1994: 47; *Aceria ficus* Abou–Awad *et al*.,1998: 367–371; *Aceria ficus* de Lillo and Monfreda, 2004: 295; *Aceria fica* Xue *et al.*, 2009: 461–484; *Aceria ficus* Elhalawany, 2012; *Aceria fica* Wang *et al.*, 2014.

Redescription: Female: (n=15) Body vermiform, 185 (170–220) long without gnathosoma, 50 (48–52) wide, 53(50–54) thick; yellow in color. **Gnathosoma** 28 (27–30) long, projecting obliquely downwards, basal setae ep 3 (3–4), antapical setae d 6 (5–7), chelicerae 23 (22–25) long. **Prodorsal shield** 34 (31–35) long including short frontal lobe tapering, 40 (38–45) wide; subtriangular; median line complete with dart shape marks at base, admedian lines complete, submedian lines complete forked at end, ahead of scapular tubercles; two cells lateral of prodorsal shield with heavy granules. Scapular tubercles on rear shield margin, 26 (25–28) apart, setae sc 28 (24–29), projecting posteriorly. **Coxigenital area** with granules, with 6 annuli between coxae and genitalia; setae 1b 8 (7–9), 12 (12–13) apart; setae 1a 25 (25–27), 7 (7–8) apart; setae 2a 35 (29–38), 21 (20–22) apart. **Leg I** 34 (32–35), femur 11 (11–12), setae bv 7 (7–8); genua 5 (5–6), setae l" 24 (22–25); tibiae 6 (6–7), setae l' 5 (4–6), setae located 1/4 from dorsal base; tarsi 7(7–8); empodium em simple 5 (5–6), 5–rayed, tarsi solenidia ω slightly tapered, 7 (7–8), setae ft' 22 (20–22), setae ft" 25 (25–27), setae u' 2–3. **Leg II** 32 (30–32), femur 8 (8–10), setae bv 7 (7–8); genua 5 (4–5), setae l" 10 (9–12); tibiae 6 (5–

6); tarsi 6 (5–6); em simple 5 (5–6), 5–rayed, ω slightly tapered, 7 (7–8), setae ft' 9 (7–10), setae ft" 25 (25–27), setae u' 2–3. **Opisthosoma** with 73 (66–75) dorso–ventrally semiannuli; dorsally with elongate oval microtubercles on posterior annular margins, ventrally with oval microtubercles on rear annular margins, the last 10th ventral microtubercles linear. Lateral setae c2 22 (21–25), 44 (43–45) apart, on annulus 11 (10–11) from coxae II; setae d 40 (35–41), 29 (27–29) apart, on annulus 24 (24–25); setae e 15 (13–16), 16 (15–17) apart, on annulus 43 (43–44); setae f 24 (23–25), 22 (22–23) apart, on 6th annulus from rear. Setae h2 65 (60–70); setae h1 3 (3–4). **External genitalia** 14 (13–14), 20 (20–21) wide, coverflap with 8–9 longitudinal ridges, setae 3a 20 (20–22), 15 (14–15) apart. **Male:** (n=6). Similar to female. Body vermiform m, 154–167 excluding gnathosoma, 35–38 wide, 38–48 thick; yellow in color. **Gnathosoma** 23–25, chelicerae 22–23, setae ep 3–4, setae d 5–6. **Prodorsal shield** shape and patterns similar to those of the female, 32–34 long, 30–33 wide; Scapular tubercles near the rear shield margin, 23–25 apart, setae sc 19–23, projecting diagonal posteriorly. **Coxigenital area** with granules; setae 1b 6–8, 11–12 apart; setae 1a 18–20, 7–8 apart; setae 2a 23–25, 19–20 apart. **Leg I** 30–31, femur 9–11, setae bv 7–8; genua 4–5, setae l" 22–24; tibiae 6–7, setae l' 4–5, setae located 1/4 from dorsal base; tarsi 7–8; empodium em simple 5–6, 5–rayed, tarsi solenidia ω slightly tapered, 7–8, setae ft' 18–20, setae ft" 23–25, setae u' 2–3. **Leg II** 28 –29, femur 8–9, setae bv 7–8; genua 4–5, setae l" 9–11; tibiae 5–6, setae l' 4–5; tarsi 5–6; em simple 5–6, 5–rayed, ω slightly tapered, 7–8, setae ft' 8–9, setae ft" 22–25, setae u' 2–3. **Opisthosoma** with 64–67 dorso–ventrally semiannuli; microtubercles shape same that of the female. Lateral setae c2 16–20, 33–34 apart, on annulus 9–10 from coxae II; setae d 34–38, 27–28 apart, on annulus 19–20; setae e 10–13, 17–18 apart, on annulus 36–37; setae f 20–23, 19–20 apart, on 7th annulus from rear. Setae h2 55–60; setae h1 2–3. **External genitalia** 11–12 long, 18–20 wide, with granules, setae 3a 10–12, 14–15 apart. **Nymph:** (n=4). Body vermiform, 140–157; width 37–40. **Gnathosoma** 23–25, curved downward, setae ep 2–3, setae d 4–5, chelicerae 19–20. **Prodorsal shield** shape and patterns similar to those of the female, 29–30 long, 26–28 wide. Tubercles sc on rear shield margin, 23–25 apart, setae sc 19–23, directed backward. **Coxisternal plates** with faint granules, setae 1b 4–5, 8–9 apart; setae 1a 16–18, 8–9 apart; setae 2a 22–25, 19–21 apart; setae 3a 5–6, 7–8 apart. **Leg I** 24–28, femur 7–8, setae bv 6–7; genua 3–4, setae l" 14–15; tibiae 5–6, setae l' 2–3, setae located 1/3 from dorsal base; tarsi 4–5; empodium em simple 4–5, 4–rayed, ω slightly tapered, 5–6, setae ft' 14–16, setae ft" 18–20, setae u' 1–2. **Leg II** 25–27, femur 6–7, setae bv 5–6; genua 3, setae l" 6–8; tibiae 5–6; tarsi 5–6; em 4–5 simple, 4–rayed, ω slightly tapered 6–8, setae ft' 7–8, setae ft" 16–18, setae u' 1–2. **Opisthosoma** with 60–65 dorso–ventrally semiannuli, microtubercles shape similar to that of the female. Setae c2 15–17, 34–36 apart, on 10 ventral semiannulus; setae d 37–41, 30–32 apart, on 20–21 ventral semiannulus; setae e 13–15, 25–27 apart, on 34 ventral semiannulus; setae f 20–22, 19–21 apart, on 6th semiannulus from rear. Setae h1 1–3; h2 35–45. **Larva:** (n=4). Body vermiform, 124–133; width 35–37. **Gnathosoma 18**–20 curved downward, setae ep 1–2, setae d 3–4, chelicerae 16–17. **Prodorsal shield** subtriangular, 27–28 long, 31–32 wide; median and admedian lines complete; submedian lines present on anterior 2/3, subparallel; lateral area with granules. Tubercles sc on rear shield margin, 20–21 apart; setae sc 14–15 directed forward. **Coxisternal plates** with granules setae 1b 3–4, 11–12 apart; 1a 13–14, 7–8 apart; 2a 22–24, 21–22 apart. Setae 3a 4–5, 6–7 apart. **Leg I** 20–21; femur 6–7, bv 5–6; genu 3–4, l" 13–15; tibia 3–4, seta l' 3–4; tarsus 4–5, ft' 13–15, ft" 14–17; ω 5–6; em 3–4, simple, 4–rayed. **Leg II** 18–19; femur 5–6, bv 5–6; genu 3, l" 5–7; tibia 3–4; tarsus 5–6, ft' 6–7, ft" 15–18; ω 5–6; em 3–4, 4–rayed.

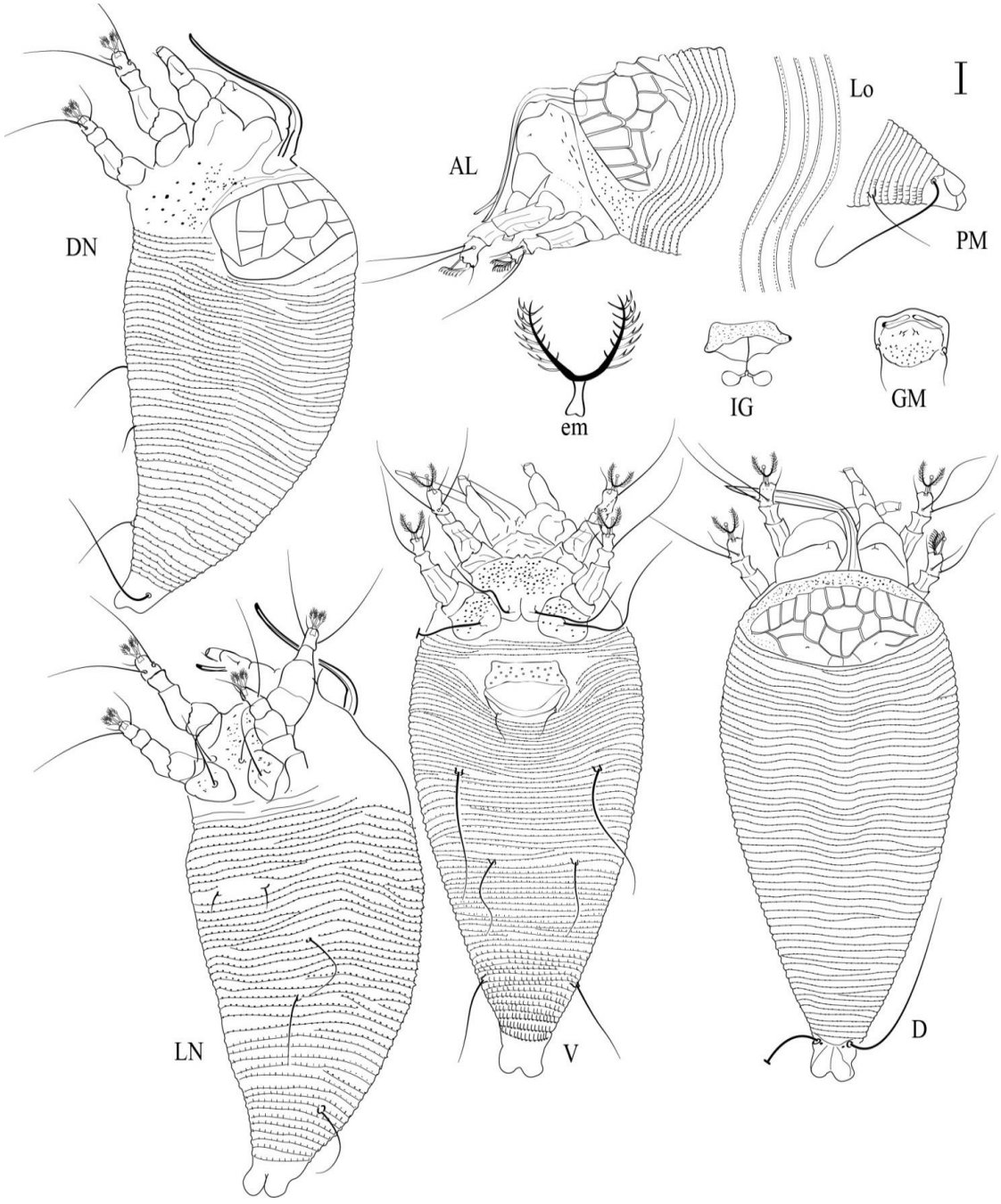

Figure (1): Line drawings of *Diptilomiopus ficus* Attiah: AL, anterio–lateral mite; PM, postero–lateral mite; D, dorsal mite; em, empodium; GM, male genitalia; IG, internal female genitalia; DN, dorsal nymph; LN, lateral nymph. Scale bars: 10µm for AL, PM, D, V, GM, IG, DN, LN; 2.5µm for em.

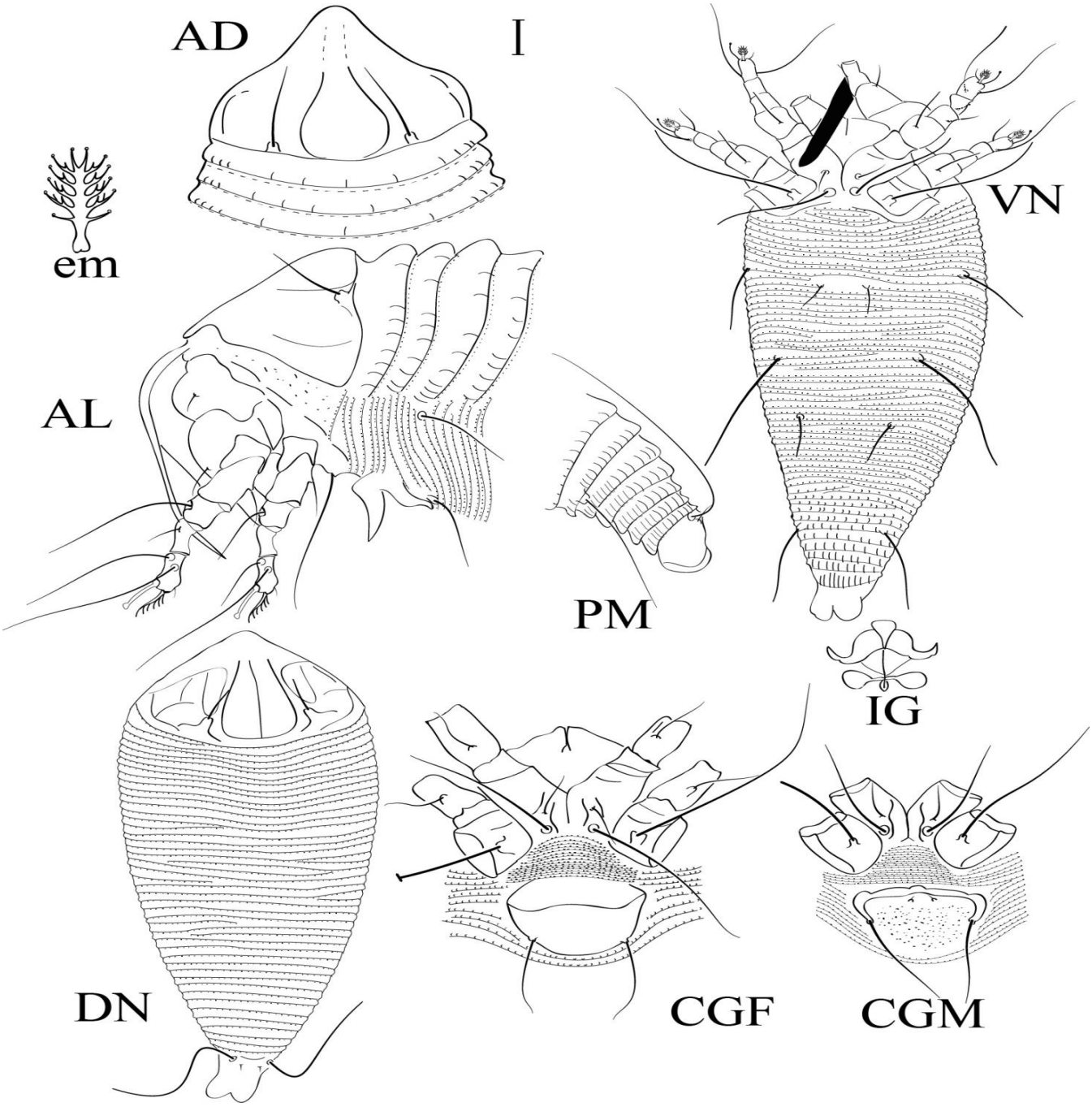

Figure (2): Line drawings of *Rhyncaphytoptus ficifoliae* Keifer: AD, anterio–dorsal mite; AL, anterio–lateral mite; PM, postero–lateral mite; CGF, coxi–genital region of female; CGM, coxi–genital region of male; em, empodium; IG, internal female genitalia; DN, dorsal nymph; VN, ventral nymph. Scale bars: 10µm for AD, AL, PM, CGF, CGM, IG; DN, VN; 2.5µm for em.

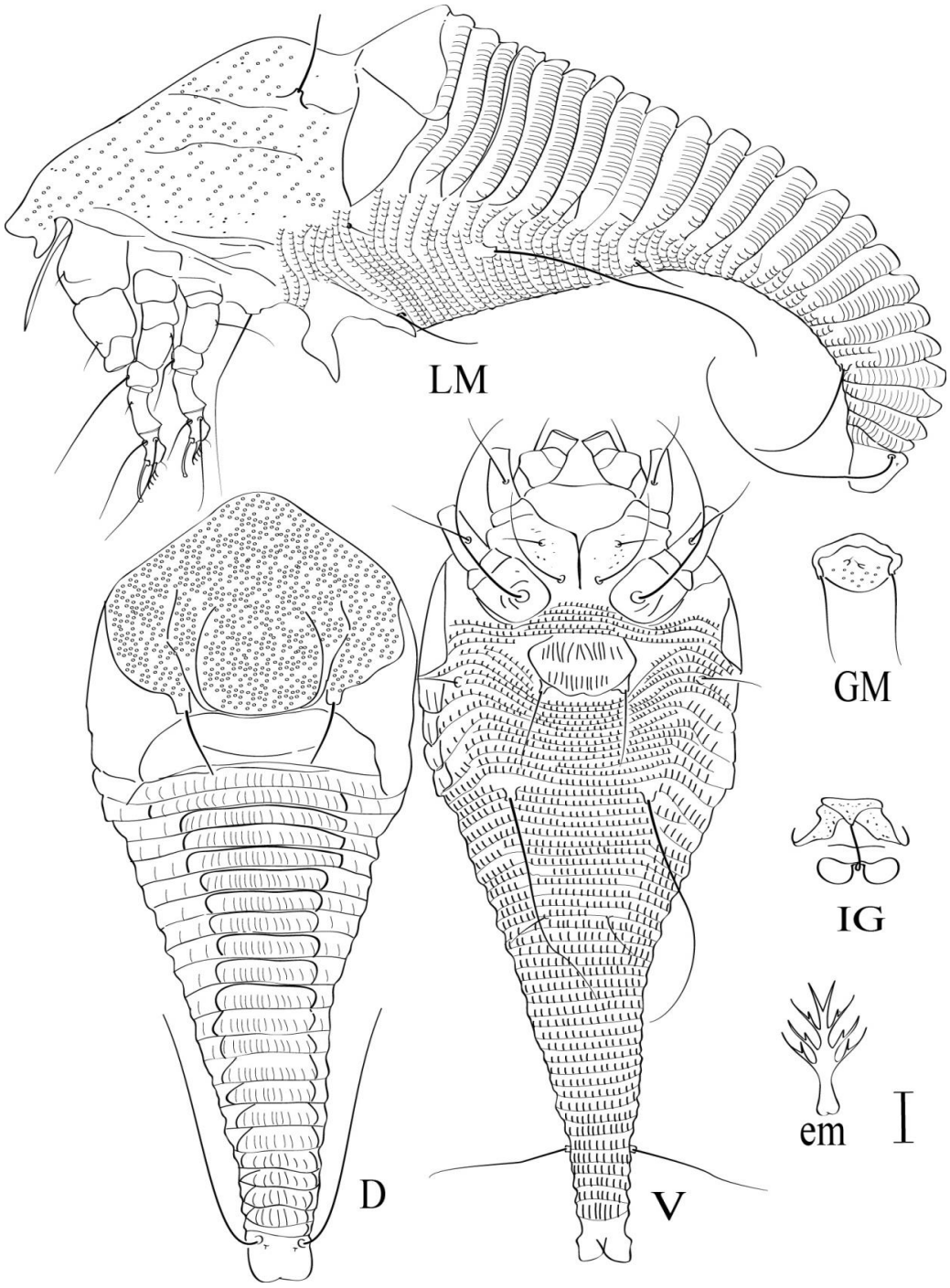

Figure (3): Line drawings of *Neotegonotus sycamori* Abou–Awad, 1984: : LM, lateral view of mite; D, dorsal mite; V, ventral view of female; GM, male genitalia; IG, internal female genitalia em, empodium. Scale bars: 10µm for LM, D, V, GM, IG; 2.5µm for em.

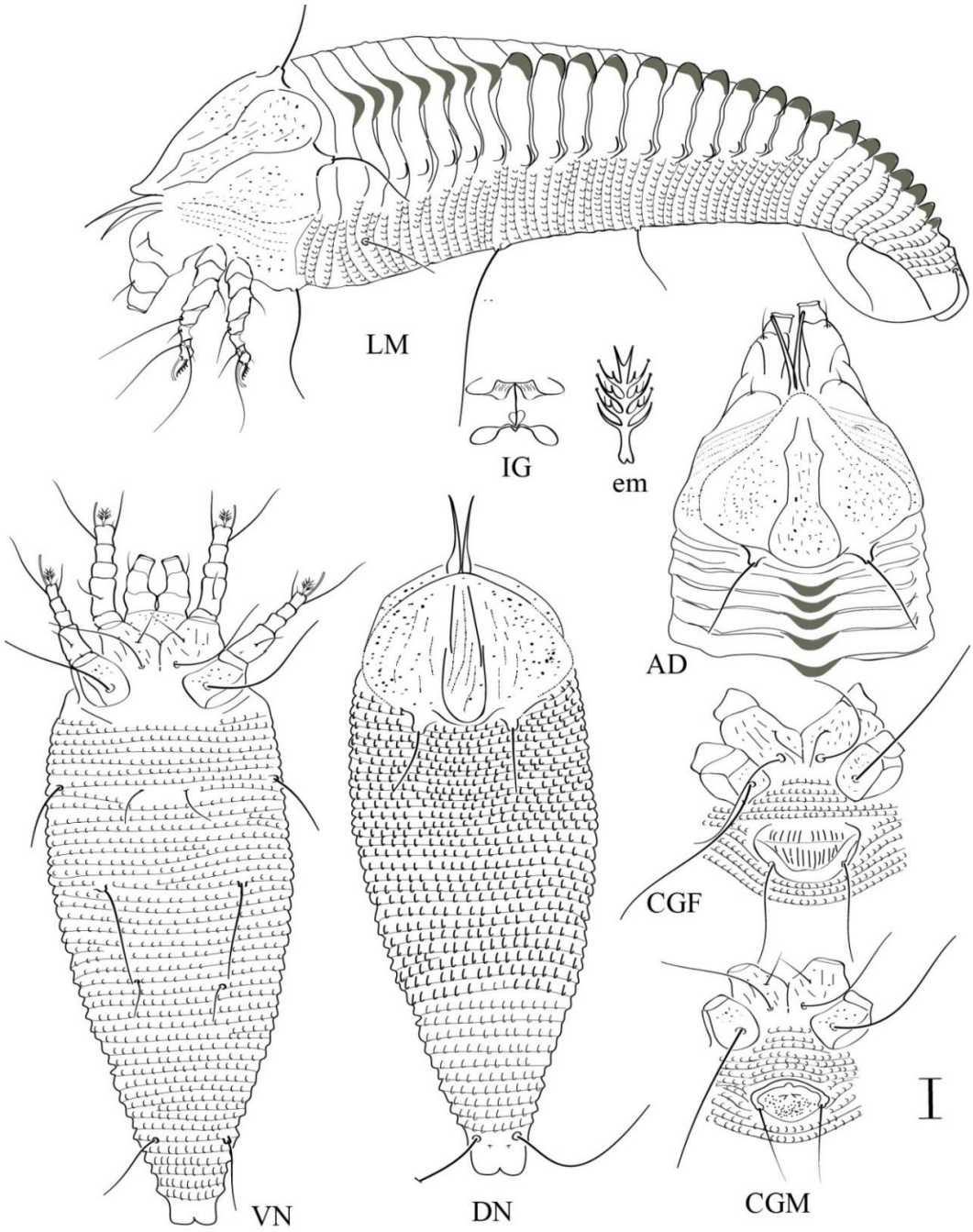

Figure (4): Line drawings of *Tegolophus niloticus* Abou–Awad: LM, lateral view of mite; AD, anterio–dorsal mite; CGF, coxi–genital region of female; CGM, coxi–genital region of male; em, mpodium; IG, internal female genitalia; DN, dorsal nymph; VN, ventral nymph. Scale bars: 10µm for LM, AD, CGF, CGM, IG, DN, VN; 2.5µm for em.

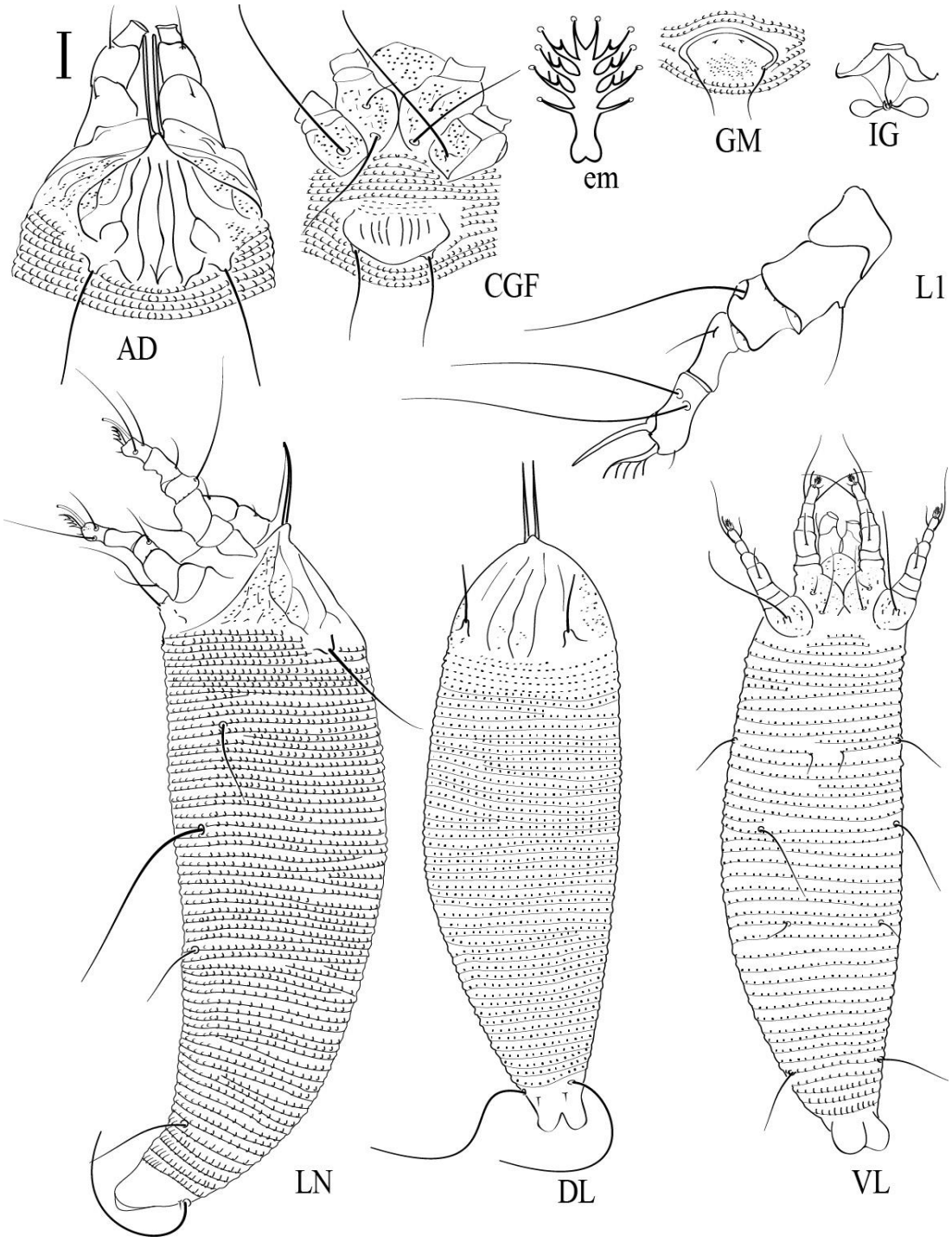

Figure (5): Line drawings of *Aceria fica* (Cotté): AD, anterio–dorsal mite; CGF, coxi–genital region of female; em, empodium; GM, male genitalia; IG, internal female genitalia; L1, Leg I; LN, lateral nymph; DL, dorsal larva; VL, ventral larva. Scale bars: 10µm for AD, CGF, GM, IG, LN, DL, VL; 5 µm for L1; 2.5µm for em.

Opisthosoma with 50–52 dorsal semiannulus, and 41–43 ventral semiannulus, with minute round microtubercles situated on rear margin of each semiannulus. Seta c2 10–12, 33–34 apart, on 9 ventral semiannulus; setae d 18–20, 26–27 apart, on 16–17 ventral semiannulus; setae e 6–7, 17–18 apart, on 25 ventral semiannulus; setae f 14–15, 18 apart, on 5th semiannulus from rear; h1 1–2; h2 35–38.

Host plants: *Ficus carica* L. (Moraceae).

Relation to the host plants: Injuring fig buds, found on both the surface of leaf and within the figs; causing rusting of the leaves, injury to the buds, leaf bronzing and distortion, leaf chlorosis and leaf drop also transmitting virus.

Geographical distribution: Australia; Brazil; Egypt; France; Great Britain; Greece; India; Iran; Italy; Japan; Mexico; Portugal; South Africa; Saudi Arabia; USA.

Material examined: 10 females, 5 males and two nymphs on 2 slides from *F. carica* (Moraceae), deposited at the Fruit Trees Acarology Research Department, Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt, 5 April 2017, Qualyubia Governorate, 30°15'56.24"E, 31°13'49.85"N coll. Ashraf Elhalawany. Four females, two males and three nymphs on 2 slides from Kafr Ibri, Gharbia Governorate, 30°41'56.00"E, 31°10'49.07"N, 10 September 2018 coll. Ahmad Amer deposited Fruit Trees Acarology Research Department, Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt. Five females and three males and five larvae on 2 slides from deposited at the Collection of the Department of Zoology and Nematology, Faculty of Agricultural, Cairo University, Egypt.

Remarks: The holotype female was described by Cotté, 1920 on *F. carica* in France. The morphometry of the female appears to match the original description by Cotté. In this study described the female, male, nymph and larva collected from the same host in Giza and Gharbia Governorates.

***Aceria benghalensis* (Soliman & Abou–Awad, 1977) (Figure, 6)**

Synonyms: *Eriophyes benghalensis* Soliman & Abou–Awad, 1977: 670-672*; Aceria benghalensis* (Soliman & Abou–Awad, 1977) in Ueckermann, 1991: 5. *A. benghalensis* in Amrine and Stasny, 1994: 26& 246; *A. benghalensis* in Zaher, 1984: 91.

Redescription: Female: (n=7) Body vermiform, 190 (170–205) long without gnathosoma, 38 (37–40) wide, 39 (37–40) thick; whitish in color. **Gnathosoma** 18 (17–19) long, projecting obliquely downwards, basal setae ep 3 (2–4), antapical setae d 6 (5–7), chelicerae 16 (15–17) long. **Prodorsal shield** 28 (28–29) long including short frontal lobe tapering, 38 (37–42) wide; semicircular; median line incomplete with dart shape marks at base, admedian lines complete, submedian lines in complete forked at 1/2, curved inwards laterally ahead of scapular tubercles, with granules between submedian lines; lateral of prodorsal shield with heavy granules. Scapular tubercles on rear shield margin, 15 (15–16) apart, setae sc 16 (15–18), projecting posteriorly. **Coxigenital are**a with granules and short dashes, with 8 annuli between coxae and genitalia, prosternal apodeme present; setae 1b 7 (7–8), 8 (8–9) apart; setae 1a 21 (20–22), 7 (7–8) apart; setae 2a 30 (29–32), 17 (16–17) apart. **Leg I** 25 (22–25), femur 8 (7–8), setae bv 7 (7–8); genua 3 (3–4), setae l" 16 (16–17); tibiae 4 (4–5), setae l' 5 (4–5), setae located 1/3 from dorsal base; tarsi 5(4–5); empodia em simple 5 (4–5), 5–rayed, tarsi solenidia ω slightly tapered, 7 (6–8), setae ft' 15 (14–16), setae ft" 20 (19–22), setae u' 2–3. **Leg II** 22 (20–23), femur 7 (7–8), setae bv 7 (7–8); genua 3 (3–4), setae l" 7 (6–7); tibiae 3 (3–4); tarsi 5(4–5); empodia em simple 5 (4–5), 5–rayed, tarsi solenidia ω slightly tapered, 7 (6–8), setae ft' 7 (7–9), setae ft" 20 (19–22), setae u' 2–3. **Opisthosoma** with 66 (65–68) dorso–ventrally semiannuli; dorsally with elongate oval microtubercles on posterior

annular margins, ventrally with oval microtubercles on rear annular margins, the last 6th ventral microtubercles linear. Lateral setae c2 19 (18–20), 34 (33–35) apart, on annulus 9 (8–9) from coxae II; setae d 45 (45–51), 27 (27–29) apart, on annulus 20 (19–20); setae e 8 (7–9), 16 (15–17) apart, on annulus 36 (35–37); setae f 21 (20–22), 19 (19–20) apart, on 6th annulus from rear. Setae h2 45 (40–47); setae h1 3 (3–4). **External genitalia** 14 (13–14), 18 (18–19) wide, coverflap with 12–13 longitudinal ridges, setae 3a, 15 (12–17), 12 (12–14) apart. **Male:** (n=5). Similar to female. Body vermiform, 150–160 excluding gnathosoma, 35–38 wide, 35–38 thick; whitish in color. **Gnathosoma** 16–17, chelicerae 16–18, setae ep 3–4, setae d 5–6. **Prodorsal shield** shape and patterns similar to those of the female, 26–27 long, 29–30 wide; Scapular tubercles near the rear shield margin, 16–17 apart, setae sc 13–17, projecting diagonal posteriorly. **Coxigenital area** with granules and short lines, prosternal apodeme present; setae 1b 8–9, 8–9 apart; setae 1a 19–20, 9–10 apart; setae 2a 25–27, 17–18 apart. **Leg I** 21–24, femur 7–8, setae bv 7–8; genua 3–4, setae l" 14–16; tibiae 4–5, setae l' 4–5, setae located 1/3 from dorsal base; tarsi 4–5; empodium em simple 4–5, 5–rayed, ω slightly tapered, 6–8, setae ft' 14–16, setae ft" 19–21, setae u' 2–3. **Leg II** 19–21, femur 6–7, setae bv 6–7; genua 3–4, setae l" 6–7; tibiae 3–4; tarsi 4–5; em simple 4–5, 5–rayed, ω slightly tapered 6–8, setae ft' 6–8, setae ft" 17–20, setae u' 2–3. **Opisthosoma** with 60–64 dorso–ventrally semiannuli; microtubercles shape same that of the female. Lateral setae c2 14–16, 33–34 apart, on annulus 8–9 from coxae II; setae d 34–38, 24–25 apart, on annulus 18–19; setae e 5–8, 15–16 apart, on annulus 31–32; setae f 18–20, 18–20 apart, on 6th annulus from rear. Setae h2 35–42; setae h1 2–3. **External genitalia** 11–12 long, 17–18 wide, with granules, setae 3a 11–13, 13–14 apart.

Nymph: (n=2). Body vermiform, 135–147; width 27–29. **Gnathosoma** 15–18, curved downward, setae ep 2–3, setae d 4–5, chelicerae 14–16. **Prodorsal shield** shape and patterns similar to those of the female, 24–26 long, 29–30 wide. Tubercles sc on rear shield margin, 14–16 apart; sc 13–15 directed forward. **Coxisternal plates** with faint granules, setae 1b 5–7, 7–8 apart; setae 1a 14–16, 8–9 apart; setae 2a 17–20, 15–16 apart. Leg I 18–20, femur 6–7, setae bv 6–7; genua 3, setae l" 14–15; tibiae 3–4, setae l' 3–4, setae located 1/3 from dorsal base; tarsi 3–4; empodium em simple 4–5, 5–rayed, ω slightly tapered, 5–6, setae ft' 10–11, setae ft" 16–17, setae u' 1–2. Leg II 16–17, femur 5–6, setae bv 6–7; genua 3, setae l" 6–7; tibiae 3–4; tarsi 4–5; em 4–5 simple, 5–rayed, ω slightly tapered 6–8, setae ft' 5–6, setae ft" 14–16, setae u' 1–2. **Opisthosoma** with 57–62 dorso–ventrally semiannuli, dorsally with elongate oval microtubercles situated on rear margin of each semiannulus, ventrally annuli with oval microtubercles, situated on rear margin of each semiannulus; elongated on the posterior annuli. Setae c2 13–14, 26–28 apart, on 8 ventral semiannulus; setae d 29–31, 25–26 apart, on 19–20 ventral semiannulus; setae e 6–7, 18–20 apart, on 35 ventral semiannulus; setae f 19–20, 18–20 apart, on 6th semiannulus from rear. Setae h1 1–3; h2 25–35.

Host plants: *Ficus benghalensis* L. and new host *Ficus sycomorus* L., (Moraceae).

Relation to the host plants: Found under scale of open buds, causing discoloration and blasting of buds of F. benghalensis. In this study the first author recorded this mite on buds of *F. sycomorus* causing rusting and blasting of buds.

Geographical distribution: Aswan and Qualyubia Governorates in Egypt.

Material examined: 5 females, 2 males and two nymphs on 2 slides on *F. sycomorus* (Moraceae), are deposited at Fruit Trees Acarology Research Department, Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt, 8 October 2018, Qualyubia Governorate 30°15'25.17" N, 31°15'20.33"E; coll. Ashraf Elhalawany. Four females and two males 2 slides, deposited in the mite reference

collection of Fruit Trees Acarology Research Department, Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt. Four females and two males 2 slides, deposited at the Collection of the Department of Zoology and Nematology, Faculty of Agricultural, Cairo University, Egypt.

Remarks: The holotype of female was described by Soliman and Abou–Awad, 1977 on *F. sycomorus*. The morphometry of the female appears to match the original description by Soliman and Abou–Awad, 1977. The first record of male and immature stages during this study; also, a new host plant.

***Aceria mori* (Keifer, 1939) (Figure, 7)**

Synonyms: *Eriophyes mori* Keifer, 1939 in Keifer, 1939b: 485. *A. mori* (Keifer) in Keifer 1952:31; *A. mori* (Keifer) in Amrine and Stasny 1994: 66; *A. mori* (Keifer) in Zaher *et al.* , 1984: 92-93.

Redescription: Female: (n=10) Body vermiform, 184 (165–193) long without gnathosoma, 45 (41–52) wide, 47(45–50) thick; whitish in color. **Gnathosoma** 23 (23–25) long, projecting obliquely downwards, basal setae ep 3 (3–4), antapical setae d 6 (5–7), chelicerae 22 (20–22) long**. Prodorsal shield** 31 (31–33) long including short frontal lobe tapering, 38 (38–41) wide; subtriangular; median line incomplete broken at 1/3 and 2/3, admedian and submedian lines complete; lateral of prodorsal shield with granules. Scapular tubercles on rear shield margin, 23 (22–24) apart, setae sc 11 (10–13), projecting posteriorly. Coxigenital area with granules, with 7–8 annuli between coxae and genitalia; setae 1b 8 (7–9), 12 (12–13) apart; setae 1a 20 (18–21), 7 (7–8) apart; setae 2a 32 (29–32), 21 (20–22) apart. **Leg I** 25 (23–26), femur 8 (7–8), setae bv 6 (5–6); genua 5 (4–5), setae l" 21 (20–23); tibiae 5 (4–5), setae l' 4 (4–5), setae located 1/4 from dorsal base; tarsi 6(6–7); empodium em simple 6 (6–7), 5–rayed, tarsi solenidia ω slightly knobbed, 8 (8–9), setae ft' 19 (18–20), setae ft" 25 (25–27), setae u' 2–3. **Leg II** 23 (21–23), femur 7 (7–8), setae bv 6 (5–6); genua 4 (4–5), setae l" 21 (20–23); tibiae 4 (4–5); tarsi 6(6–7); empodium em simple 6 (6–7), 5–rayed, tarsi solenidia ω slightly knobbed, 8 (8–9), setae ft' 11 (8–12), setae ft" 25 (25–27), setae u' 2–3. **Opisthosoma** with 62 (60–65) dorso–ventrally semiannuli; dorsally with elongate oval microtubercles on posterior annular margins, ventrally with oval microtubercles on rear annular margins, the last 6–8th ventral microtubercles linear. Lateral setae c2 22 (20–22), 45 (40–45) apart, on annulus 8 (8–9) from coxae II; setae d 34 (30–36), 31 (30–31) apart, on annulus 16 (16–17); setae e 11 (8–12), 19 (18–20) apart, on annulus 31 (30–32); setae f 18 (17–20), 18 (17–18) apart, on 6th annulus from rear. Setae h2 38 (33–40); setae h1 3 (3–4). **External genitalia** 12 (12–13), 23 (20–24) wide, coverflap with 12 longitudinal ridges, setae 3a 9 (8–9), 14 (14–15) apart. **Male:**(n=6). Similar to female. Body vermiform, 165–198 excluding gnathosoma, 44–50 wide, 40–48 thick; whitish in color. **Gnathosoma** 22–2, chelicerae 20–21, setae ep 3–4, setae d 5–6. **Prodorsal shield** shape and patterns similar to those of the female, 31–33 long, 38–41 wide; Scapular tubercles near the rear shield margin, 23–24 apart, setae sc 10–12, projecting backward. **Coxigenital area** with granules; setae 1b 6–8, 11–12 apart; setae 1a 18–20, 7–8 apart; setae 2a 30–32, 19–21 apart. **Leg I** 24 (23–24), femur 7–8, setae bv 5–6; genua 4–5, setae l" 20–22; tibiae 4–5, setae l' 4–5; tarsi 6–7; em simple 6–7, 5–rayed, tarsi solenidia ω slightly knobbed 8–9, setae ft' 18–20, setae ft" 24–26, setae u' 2–3. **Leg II** 21–23, femur 7–8, setae bv 5–6; genua 4–5, setae l" 20–23; tibiae 4–5; tarsi 6–7; empodium em simple 6–7, 5–rayed, tarsi solenidia ω slightly knobbed, 8–9, setae ft' 8–11, setae ft" 23–25, setae u' 2–3. **Opisthosoma** with 60–63 dorso–ventrally semiannuli; microtubercles shape same that of the female. Lateral setae c2 19–20, 45–48 apart, on annulus 8 from coxae II; setae d 30–32, 31–33 apart, on annulus 16–17; setae e 11–13, 20–21 apart, on annulus 31–32; setae f 21–22, 19–20 apart, on 6th annulus from rear. Setae h2 35–

40; setae h1 2–3. **External genitalia** 13–14 long, 21–22 wide, with granules, setae 3a 8–9, 15–16 apart. **Nymph:** (n=4). Body vermiform, 143–157; width 40–43. **Gnathosoma** 22–23, curved downward, setae ep 2–3, setae d 4–5, chelicerae 19–21. **Prodorsal shield** shape and patterns similar to those of the female, 29–30 long, 36–38 wide. Tubercles sc on rear shield margin, 21–22 apart, setae sc 7–8, directed backward. **Coxisternal plates** with faint granules, setae 1b 7–8, 11–12 apart; setae 1a 16–17, 7–8 apart; setae 2a 22–25, 19–21 apart; setae 3a 3–4, 5–6 apart. **Leg I** 17–18, femur 6–7, setae bv 3–4; genua 3–4, setae l" 14–15; tibiae 3–4, setae l' 3–4; tarsi 3–4; empodium em simple 3–4, 4–rayed, ω slightly knobbed, 5–6, setae ft' 11–12, setae ft" 14–15, setae u' 1–2. **Leg II** 15–17, femur 5–6, setae bv 3–4; genua 3, setae l" 5–6; tibiae 3–4; tarsi 3–4; em 3–4 simple, 4–rayed, ω slightly knobbed 5–6, setae ft' 7–8, setae ft" 16–18, setae u' 1–2. **Opisthosoma** with 44–49 dorso–ventrally semiannuli, microtubercles shape similar to that of the female. Setae c2 10–11, 33–34 apart, on 8 ventral semiannulus; setae d 24–26, 30–31 apart, on 15–16 ventral semiannulus; setae e 10–12, 25–27 apart, on 28 ventral semiannulus; setae f 10–12, 19–21 apart, on 6th semiannulus from rear. Setae h1 1–3; h2 30–35.

Host plants: *Morus alba* L. (Moraceae).

Relation to the host plants: Injuring mulberry buds and causing rusting of the buds.

Geographical distribution: Armenia; Egypt; India; Italy; South Africa; USA.

Material examined: 10 females, 3 males and two nymphs on 5 slides from *M. alba* (Moraceae), deposited at Fruit Trees Acarology Research Department, Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt,, 5 May 2017, Sharkia Governorate, 30°23'51.96"N, 31°32'57.06"E, 25 April 2016, coll. Amira Mesbah. Four females and four males on 2 slides from Tanan, Qalyubia Governorate, 30°14'48.37"N, 31°12'59.72"E, 25 May 2018, coll. Ashraf Elhalawany, deposited in Fruit Trees Acarology Research Department, Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt. Five females and three males on 2 slides from deposited at the Collection of the Department of Zoology and Nematology, Faculty of Agricultural, Cairo University, Egypt.

Remarks: The holotype of female was described by Keifer, 1939 on *M. alba* in USA. The morphometry of the female appears to match the original description by Keifer, 1939 and 1952. The first record of male and immature stages during this study.

***Aceria sycamori* (Soliman and Abou–Awad, 1977) (Figure, 8)**

Synonyms: *Eriophyes sycamori* Soliman & Abou–Awad, 1977:672-673; *Aceria sycamori* (Soliman & Abou–Awad, 1977) in Ueckermann, 1991:5; *A. sycamori* (Soliman and Abou–Awad, 1977) in Amrine and Stasny, 1994: 90; *A.* sycamori (Soliman and Abou–Awad, 1977) in Zaher, 1984: 91-92.

Redescription: Female: (n=9) Body vermiform, 185 (178–190) long without gnathosoma, 40 (38–42) wide, 37(36–38) thick; whitish in color. **Gnathosoma** 20 (17–22) long, projecting obliquely downwards, basal setae ep 3 (3–4), antapical setae d 5 (5–6), chelicerae 16 (15–16) long. **Prodorsal shield** 31 (29–32) long including short frontal lobe tapering, 36 (32–38) wide; subtriangular; median line complete with dart shape marks at base, broken at 1/2 in two parts; admedian and submedian lines in complete, parallel; area between submedian lines with heavy granules and short lines. Scapular tubercles on rear shield margin, 16 (16–17) apart, setae sc 16 (15–17), projecting posteriorly. **Coxigenital area** with granules, with 8 annuli between coxae and genitalia; setae 1b 8 (8–9), 10 (9–10) apart; setae 1a 21 (21–23), 8 (8–9) apart; setae 2a 25 (25–32), 20 (18–20) apart. **Leg I** 27 (27–29), femur 9 (8–9), setae bv 7 (7–8); genua 4 (4–5), setae l" 23 (22–25); tibiae 4 (4–5), setae l' 4 (4–5), setae located 1/4 from dorsal base; tarsi 6(6–7); empodium em simple 5 (5–6), 6–rayed, tarsi solenidia ω slightly knobbed, 7 (6–7),

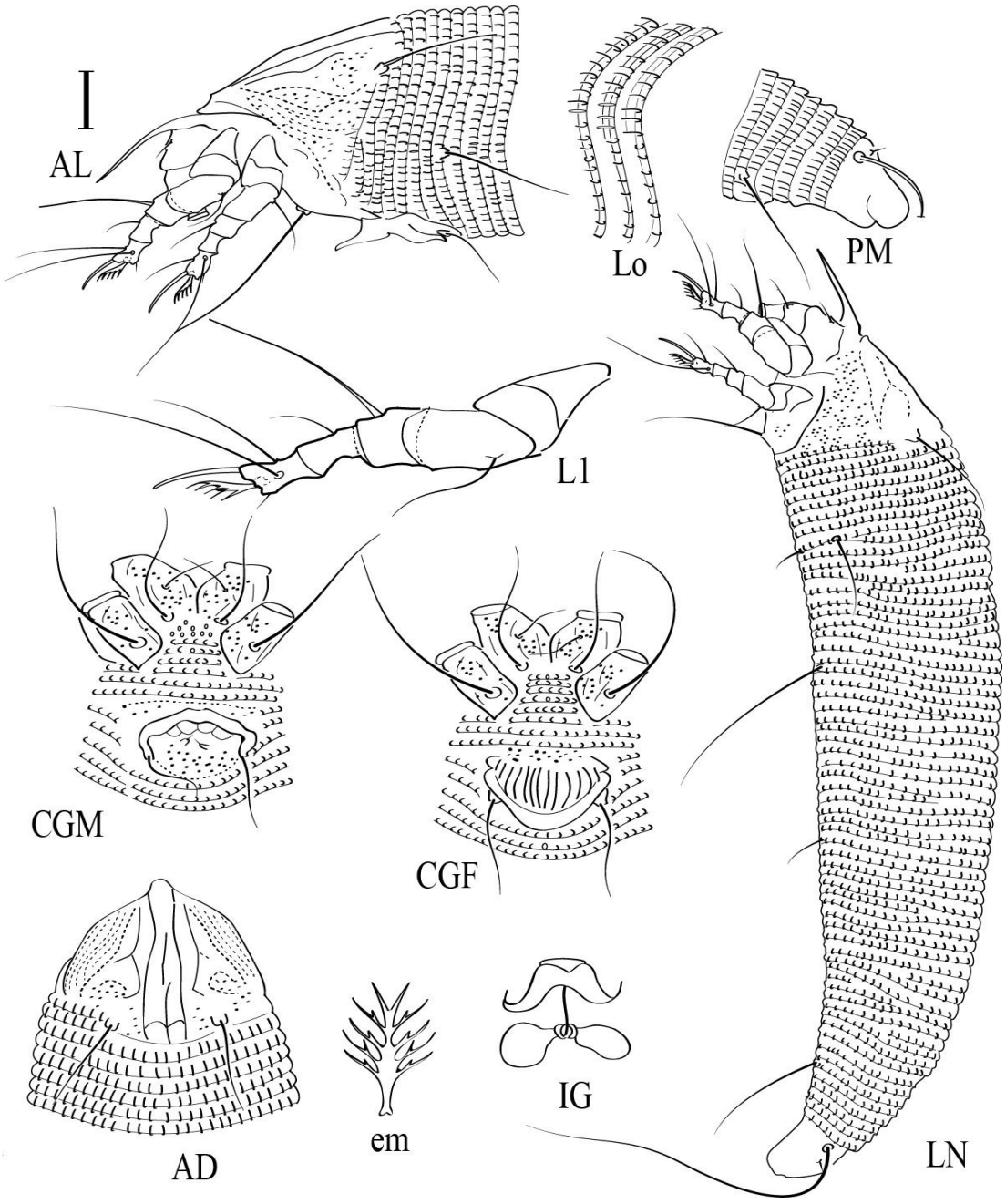

Figure (6): Line drawings of *Aceria benghalensis* (Soliman and Abou–Awad): AD, anterio–dorsal mite; AL, anterio–lateral mite; PM, postero–lateral mite; CGF, coxi–genital region of female; CGM, coxi–genital region of male; em, empodium; IG, internal female genitalia; LN, lateral nymph. Scale bars: 10µm for AD, AL, PM, CGF, CGM, IG, LN; 2.5µm for em.

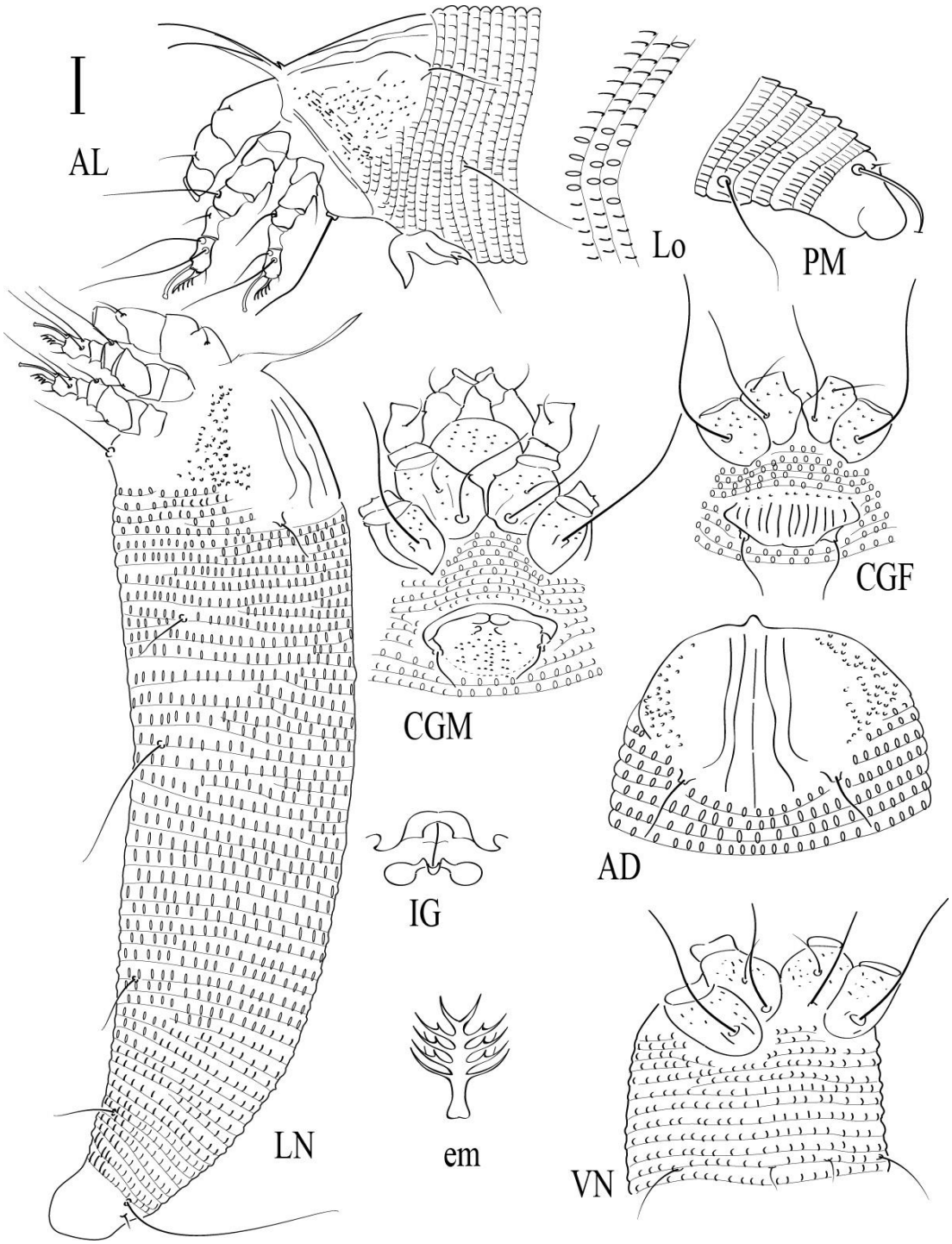

Figure (7): Line drawings of *Aceria mori* (Keifer): AL, anterio–lateral mite; PM, postero–lateral mite; AD, anterio–dorsal mite; CGF, coxi–genital region of female; CGM, coxi–genital region of male; em, empodium; IG, internal female genitalia; LN, lateral nymph; VN, ventral nymph. Scale bars: 10µm for AL, PM, AD, CGF, CGM, IG, LN, VN; 2.5µm for em.

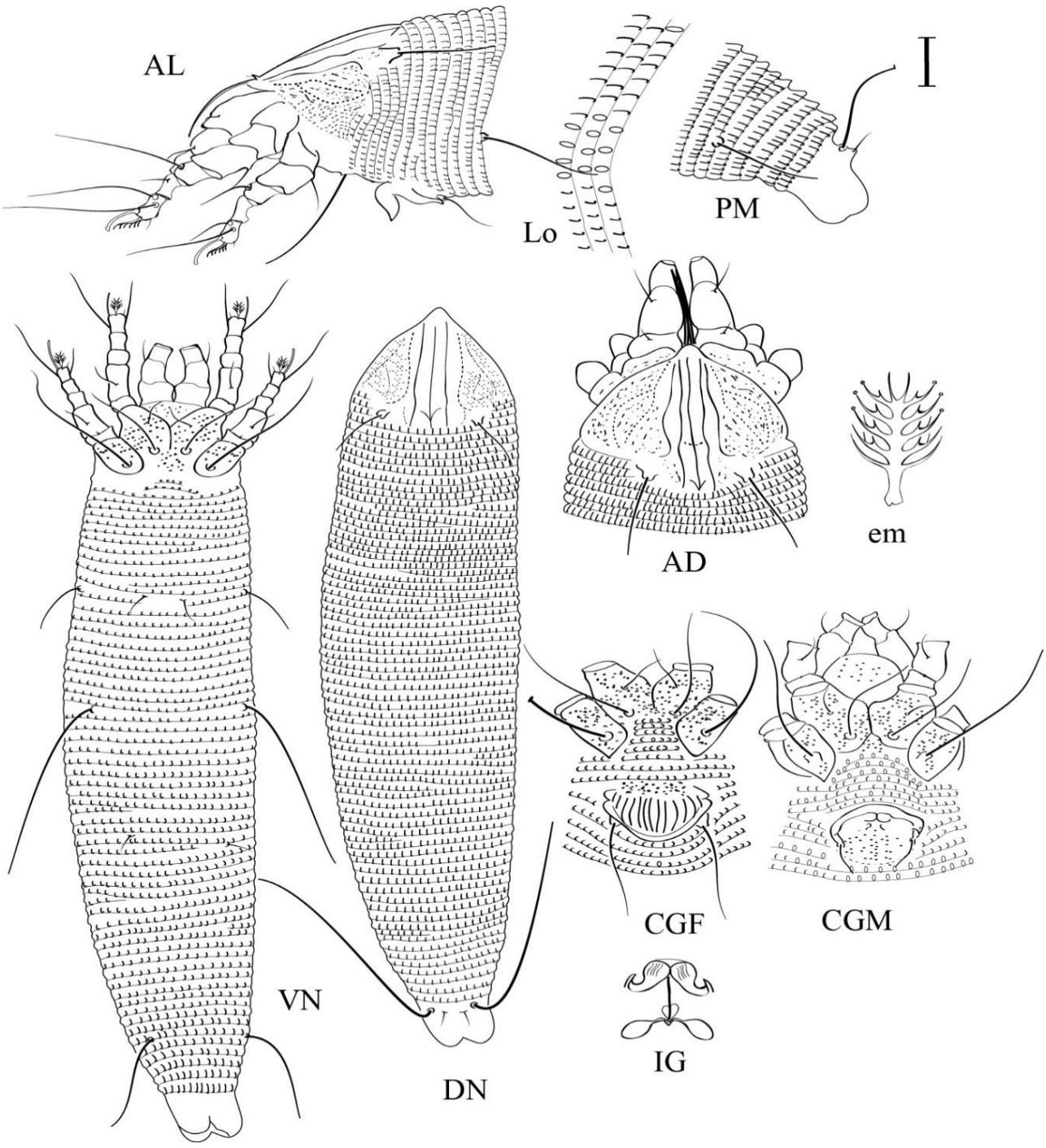

Figure (8): Line drawings of *Aceria sycamori* (Soliman and Abou–Awad): AL, anterio–lateral mite; PM, postero–lateral mite; AD, anterio–dorsal mite; CGF, coxi–genital region of female; CGM, coxi–genital region of male; em, empodium; IG, internal female genitalia; DN, dorsal nymph; VN, dorsal nymph. Scale bars: 10µm for AL, PM, AD, CGF, CGM, IG, DN, VN; 2.5µm for em.

setae ft' 21 (20–22), setae ft" 26 (25–27), setae u' 2–3. **Leg II** 23 (22–26), femur 7 (7–8), setae bv 5 (5–6); genua 4 (4–5), setae l" 9 (9–11); tibiae 4 (4–5); tarsi 5(5–6); em simple 5 (5–6), 6–rayed, ω slightly knobbed, 8 (7–8), setae ft' 8 (7–10), setae ft" 18 (18–20), setae u' 2–3. **Opisthosoma** with 75(75–77) dorsal semiannuli; with elongate oval microtubercles on posterior annular margins, with 71(71–73) narrow ventral semiannuli, with oval microtubercles on rear annular margins, the last 8th ventral microtubercles linear. Lateral setae c2 21 (18–21), 31 (30–32) apart, on annulus 11 (10–11) from coxae II; setae d 40 (35–41), 28 (27–29) apart, on annulus 24 (24–25); setae e 18 (18–19), 16 (16–18) apart, on annulus 42 (42–44); setae f 19 (19–20), 22 (22–23) apart, on 6th annulus from rear. Setae h2 47 (45–50); setae h1 3 (3–4). **External genitalia** 13 (13–15), 19 (19–21) wide, coverflap with 11–13 longitudinal ridges, with granules at base; setae 3a 20 (17–20), 16 (16–17) apart. **Male:** (n=7). Similar to female. Body vermiform, 144–150 excluding gnathosoma, 31–33 wide, 32–34 thick; whitish in color. **Gnathosoma** 17–18, chelicerae 15–16, setae ep 3–4, setae d 5–6. **Prodorsal shield** shape and patterns similar to those of the female, 25–27 long, 25–28 wide; Scapular tubercles near the rear shield margin, 16–17 apart, setae sc 13–14, projecting diagonal posteriorly. **Coxigenital area** with granules, with 7 annulus between coxae and genitalia; setae 1b 5–6, 13–14 apart; setae 1a 21–22, 7–8 apart; setae 2a 25–30, 20–21 apart. **Leg I** 20–22, femur 6–7, setae bv 5–6; genua 4–5, setae l" 22–24; tibiae 4–5, setae l' 4–5, setae located 1/4 from dorsal base; tarsi 4–5; empodium em simple 5–6, 6–rayed, tarsi solenidia ω slightly knobbed, 6–7, setae ft' 18–20, setae ft" 22–24, setae u' 2–3. **Leg II** 18 –19, femur 5–6, setae bv 5–6; genua 3–4, setae l" 8–10; tibiae 4–5; tarsi 4–5; em simple 5–6, 6–rayed, ω slightly knobbed, 7–8, setae ft' 8–9, setae ft" 19–23, setae u' 2–3. **Opisthosoma** with 64–66 dorsal semiannuli, and 60–61 ventral semiannuli, microtubercles shape same that of the female. Lateral setae c2 16–18, 30–32 apart, on annulus 10–11 from coxae II; setae d 34–38, 27–28 apart, on annulus 19–20; setae e 5–6, 14–15 apart, on annulus 31–32; setae f 18–20, 18–20 apart, on 6th annulus from rear. Setae h2 25–38; setae h1 2–3. **External genitalia** 11–12 long, 14–17 wide, with granules, setae 3a 6–9, 11–12 apart. **Nymph:** (n=4). Body vermiform, 158–164; width 30–31. **Gnathosoma** 17–18, curved downward, setae ep 2–3, setae d 4–5, chelicerae 15–16. Prodorsal shield shape and patterns similar to those of the female, 25–26 long, 25–27 wide. Tubercles sc on rear shield margin, 16–17 apart, setae sc 11–12, directed backward. **Coxisternal plates** with faint granules setae 1b 5–6, 12–13 apart; setae 1a 21–22, 7–8 apart; setae 2a 22–28, 20–21 apart; setae 3a 4–5. **Leg I** 20–21, femur 7–8, setae bv 4–5; genua 3–4, setae l" 10–12; tibiae 4, setae l' 2–3, setae located 1/3 from dorsal base; tarsi 4–5; empodium em simple 4–5, 4–rayed, ω slightly tapered, 5–6, setae ft' 10–12, setae ft" 13–15, setae u' 1–2. **Leg II** 17–18, femur 6–7, setae bv 4–5; genua 3, setae l" 6–8; tibiae 3; tarsi 3–4; em 4–5 simple, 4–rayed, ω slightly tapered 6–8, setae ft' 5–6, setae ft" 12–14, setae u' 1–2. **Opisthosoma** with 65–70 dorsal semiannuli, and 58–60 ventral semiannuli, microtubercles shape same that of the female. Setae c2 10–11, 29–30 apart, on 12 ventral semiannulus; setae d 35–37, 25–26 apart, on 21–22 ventral semiannulus; setae e 4–5, 17–18 apart, on 34 ventral semiannulus; setae f 20–21, 16–17 apart, on 6th semiannulus from rear. Setae h1 2–3; h2 41–45.

Host plants: *Ficus sycomorus* L. (Moraceae). **Relation to the host plants:** This mite found was found in blister on the lower leaf surface of sycamore

Geographical distribution: Egypt.

Material examined: Ten females, 5 males and 2 nymphs on 2 slides from *F. sycomorus* (Moraceae), deposited at the Plant Protection Research Institute collection, Giza, Egypt, 10 June 2018, Qualyubia governorate, 31°15'19.73"N, 30°15'25.21"E coll. Ashraf

Elhalawany, deposited in Fruit Trees Acarology Research Department, Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt, 30° 2'42.51"N, 31°12'30.77"E, 5 August 2018 coll. Ashraf Elhalawany, deposited in Fruit Trees Acarology Research Department, Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt. Four females on 2 slides from deposited at the collection of the Department of Zoology and Nematology, Faculty of Agricultural, Cairo University, Egypt.

Remarks: The holotype of female was described by Soliman and Abou–Awad, 1977 on *F. sycomorus*. The morphometry of the female appears to match the original description by Soliman and Abou–Awad, 1977. The first record of male and immature stages during this study.

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Taxonomic studies of common genera and species of family Pseudococcidae (Hemiptera: Coccoidea) with a taxonomic key for the species in Egypt

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Abstract:
Mealybugs (Hemiptera: Coccoidea: Pseudococcidae) are phloem –sucking insects, most of them are important and serious agricultural pests in Egypt. This study revealed the presence of seven mealybug species (Dysmicoccus *brevipes* (Cockerell), *Ferrisia virgata* Cockerell, *Planococcus citri* (Risso), *Planococcus ficus* (Signoret) , *Phenacoccus parvus* Morrison, *Phenacoccus solenopsis* Tinsley and *Saccharicoccus sacchari* Ferris) infested different host plants at different Governorates in Egypt. The present work included the identification based on (light and scanning) microscope as well as synonyms, host plants and geographical distributions of these species. Also, a taxonomic key for these species was provided.

Introduction

Mealybugs (Hemiptera: Coccoidea: Pseudococcidae) are speciose group of plant sap-sucking insects. It is considered the second largest family of scale insects, with approximately 2,012 described species in more than 273 genera worldwide (Ben-Dov *et al*., 2015). This family is more common in the tropical, subtropical and temperate regions (Ben-Dov, 1994). It is represented in Egypt by 50 species belonging to 29 genera (Abd-Rabou *et al.*, 2010).

Pseudococcids have negative economic impacts on a wide range of economic crops as vegetables, orchids trees, ornamental plants and green house crops. They feed by sucking – sap from the small phloem on different parts of plants including trunk, roots, leaves, rachis, buds and fruits. Pseudococcids cause direct and indirect damages, depending on the species and the site used for feeding (Mani and Shivaraju, 2016). Recently, Pseudococcidae are considered and identified as vectors of virus diseases (Herrbach *et al*. (2016).

Two primary clades of Pseudococcidae were recovered and classified into two subfamilies, Phenacoccinae and Pseudococcinae. (Hardy *et al*. 2008). The taxonomic characters of this family are summarized: 1. have eight-segmented antennae. 2. Denticles are present on the tarsal claws. sclerotised spiracles without pores inside the atria. 3. Sclerotised spiracles without pores inside the atria. 4. Ostioles are characteristic of mealybugs, and occur as an anterior and a posterior pair, and consist of groups of large setae. 5. Anal ring is located

between the two anal lobes (Cox, 1987). The aim of this work is to identifiy and redescribe the most common Egyptian species of family Pseudococcidae based on the taxonomic morphological characters.

Materials and methods

Specimens of mealybug were collected from different Governorates of Egypt during 2015 to 2017 from the aerial parts of the economic crops and different ornamental plant species. The specimens and parts of the infested plants were collected and placed in labeled plastic bags. In laboratory the specimens were picked off from the host plants individually with a very fine paint brush wetted with 70% alcohol and preserved in 70% alcohol for slide and scanning electron microscopy preparation. Each specimen was labeled by the recorded information of the host plant and collecting date. The methods of preparation the specimens for light microscopic was carried out according to Ezz, (1982). The study of scanning electron microscopic was carried out according to (Sirisena *et al*., 2015).

Results and discussion

Key to the investigated species of Family Pseudococcidae

1- Tarsal digitules setose; claw with denticle; quinquelocular pores present; antennae nine segmented; anal ring with dome-shaped; dorsal setae as spine **……Phenacoccinae**…**2**

-Tarsal digitules knobbed; claw without denticle; quinquelocular pores absent; antennae less than nine segmented; anal ring with setose-like spinules; dorsal setae like-hair…… …. **Pseudoccoccinae**….**3**

2.Quniquelocular pores present; legs with translucent pores on hind tibia only; discoidal pores absent; circulus small……..…....***Phenacoccus parvus*** **Morrsion, 1924**

-Quniquelocular pores absent; legs with translucent pores on meta femur and meta tibia; discoidal pores present; circulus large ……. ……..***Phenacoccus solenopsis*** **Tinsly, 1898**

3.Antannae 7- segments; circulus large as hourglass – shaped; last four abdominal segments with one long seta on lateral margins……..***Saccharicoccus sacchari*** **(Cockerell, 1895)**

-Antannae 8 segments,circulus small, last four abdominal segments without setae on lateral margins.……..……..……..4

4.Cerarii body absent; dorsal tubular ducts large with orifices around sclerotized area, with one or more setae arise……..**……*Ferrisia virgate*** **(Cockerell, 1893)**

-Cerarii body present, dorsal tubular ducts normally without orifices ……..…**5**

5.Cerarii body with 17 pairs; cerarius with stout conical setae; anal lobes with irregular sclerotized area……...…….……***Dysmicoccus brevipes*** **(Ferris, 1950)**

-Cerarii body with 18 pairs, cerarius with conical setae, anal lobes with regular sclerotized area…**…….…...6**

6.Dorsal setae stout; circulus quadrate shaped; translucent pores on hind coxa and tibia; ventral oral collar tubular ducts between antennae more five……*Planococcus citri* **(Risso, 1813)**

-Dorsal setae slender; circulus broad shaped; translucent pores on hind coxa, femur and tibia; ventral oral collar tubular ducts between antennae less five**...*Planococcus ficus*** **(Signoret, 1875)**

Subfamily Pseudococcinae Cockerell; Silvestri, 1911: 132

Genus: *Ferrisia* Fullaway, 1923

Description

Body oval elongate; legs normally; claw without dentical; circulus present in all species; with one pair of cerarii on anal lobs only; oral collar tubular duct with orifices each surrounded by sclerotized area from which one or more setae arise. This genus represented in Egypt by one species, *Ferrisia virgata*.

Ferrisia virgata **(Cockerell, 1893) (Figures, 1-2)**

Synonyms:

Dactylopius segregatus Cockerell, 1893: 254.

Dactylopius virgatus Cockerell, 1893: 178.
Dactylopius virgatus farinosus Cockerell, 1893: 178.
Dactylopius virgatus humilis Cockerell, 1893: 179.
Dactylopius ceriferus Newstead, 1894: 24.
Dactylopius talini Green, 1896: 7.
Dactylopius setosus Hempel, 1900: 386.
Pseudococcus virgatus; Kirkaldy, 1902: 103.
Dactylopius magnolicida King, 1902a: 616.
Pseudococcus magnolicida; Cockerell, 1902: 252.
Pseudococcus virgatus farinosus; Cockerell, 1902: 252.
Pseudococcus segregatus; Fernald, 1903: 109.
Pseudococcus virgatus humilis; Fernald, 1903: 111.
Dactylopius virgatus madagascariensis Newstead, 1908: 7.
Pseudococcus marchali Vayssiere, 1912: 366.
Pseudococcus virgatus madagascariensis; Lindinger, 1913: 68.
Pseudococcus bicaudatus Keuchenius, 1915: 49.
Ferrisia virgata; Fullaway, 1923: 308.
Ferrisiana virgata; Takahashi, 1929: 429.
Heliococcus malvastrus McDaniel, 1962: 323.
Ferrisiana setosus; Ali, 1970a: 108.
Ferrisia neovirgata Khalid & Shafee, 1988: 71.
Dactylopius cerciferus; Tao, 1999: 14.

Description

Adult female body shaped oval elongate, greyish-yellow, length 4.5 mm and width 2.51 mm, with one pair of anal lobes cerarii only; (Figure1d). Antennae 8-segmented, measurements; in microns as follows: I (62.5); II (70.8); III (92.5); IV (55); V (64.2); VI (63.3); VII (60.8) and VIII (126.7). (Figure 1a – 2a). Legs normally developed, measurements of hind leg, in microns, as follows: coxae (153.2); trochanter (96); femur (285.3); tibia (295); tarsus (108.5) and claw (24.8) without denticle (Figure1b-2C), circulus moderately large, oral collar duct that continues into sclerotized area which surrounds the opening of the duct, this orifice is variable in size but is usually approximately circular, flat and associated with 1-5 short slender setae.(Figure 1,c), two pairs of ostioles clearly developed.(Figure 2D)

Host plants: It was found on henna plant, *Lawsonia inermis*, Fam. Lythraceae, tickberry, *Lantana camara*, Fam. Verbenaceae and rushfoil, *Croton* sp., Fam. Euphorbiaceae**.**

Distribution

Egypt: Cairo, Giza, Assiout, Qena, Ismailiya, Port-said, and Suez.

World: this species is distributed in the following zoogeographic regions: Palaearctic, Afrotropical, Australasian, Oriental and Nearctic

Genus: *Dysmicoccus* Ferris, 1950

Description

Body oval to circular, legs developed, claw without dintical, tarsal claws elongate sometimes, hind legs with translucent pores; Circulus present or absent; Cerarii 4-17 pairs, each cerarius with two or more conical setae, provided with few auxiliary setae and trilocular pores; Multilocular pores present or absent dorso-venterally.

***Dysmicoccus brevipes* (Cockerell, 1893)(Figure, 3)**

Synonyms:

Dactylopius bromeliae; Signoret, 1875: 310.
Pseudococcus brevipes; Fernald, 1903: 98.
Pseudococcus bromeliae; Fernald, 1903: 98.
Dactylopius (***Pseudococcus***) ***ananassae*** Kuwana, 1909: 162.
Pseudococcus missionum Cockerell, 1910: 113.
Pseudococcus bromeliae; Hempel, 1912: 24.
Pseudococcus palauensis Kanda, 1933: 135.
Pseudococcus longirostralis James, 1936: 207.
Pseudococcus defluiteri Betrem, 1937: 43.
Pseudococcus pseudobrevipes Mamet, 1941b: 58
Dysmicoccus brevipes; Moghaddam, 2009: 34.

Description

Adult female Body oval circular, dark orange, length 5.4 mm and width 3.9 mm, dorsum covered with thin layer of white wax, body margins with 17 pairs of cerarii, each cerarius with two large conical setae and cluster of trilocular pores(Figure 3d), antennae 8- segmented, measurements in microns, as follows: I (55.8); II (50); III (40);

IV (30); V (32.5); VI (34.2); VII (37.5) and VIII (76.7).(Figure3b). Legs normally small, measurements of hind leg, in microns, as follows: coxea (97.5); trochanter (75); femur (197.5); tibia (161.7); tarsus (80.8) and claw (27.5) without "denticle" (Figure3 c), Hind coxae and tibia with translucent pores. Abdominal segmented 4 and 5 with large oval circulus and divided by intersegmental line (Figure 3e). Anal ring normally small and circular.

Host plant: it was found on date palm tree, *Phoenix dactylifera*, Fam. Arecaceae.

Distribution

Egypt: Cairo, Giza, Alexandria, Fayoum, and North Sina

World: this species is distributed in the following zoogeographic regions: Palaearctic, Afrotropical, Australasian, Oriental, Nearctic and Neotropical.

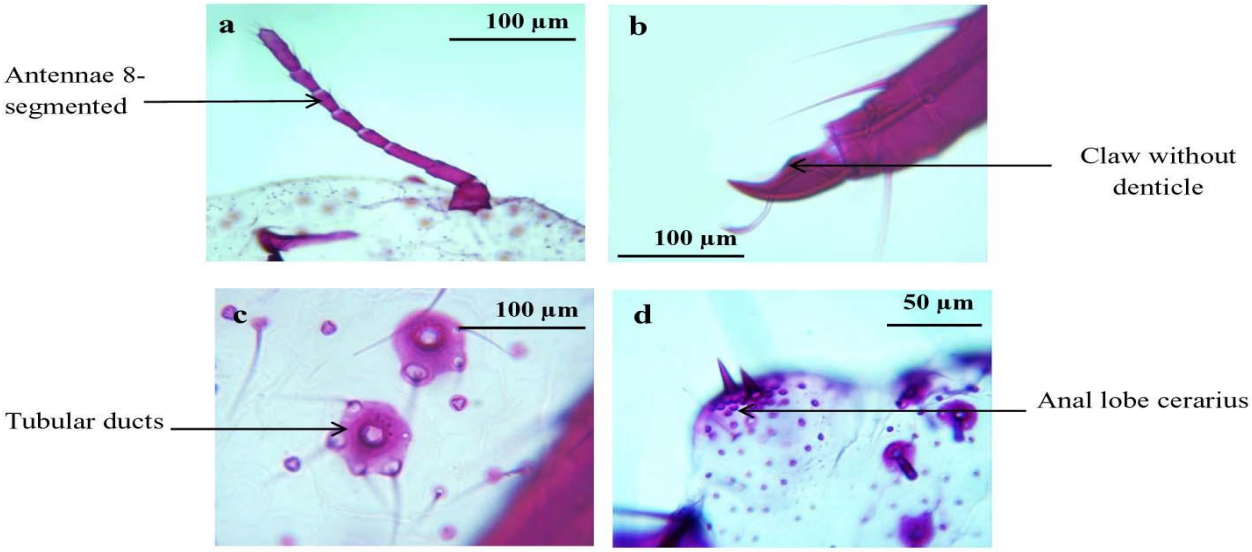

Figure (1): Morphological characters of *Ferrisia virgate*, a: Antennae segmented, b: Claw, c: tubular ducts, d: Cerarius.

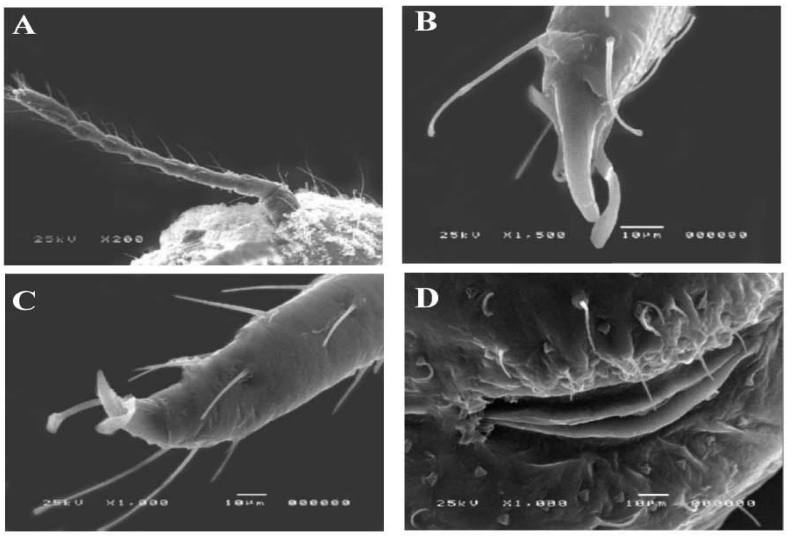

Figure (2) Scanning electron micrographs of *Ferrisia virgate*, showing A: Antennae, B: Tarsal digitules, C: Claw, D: Ositoles.

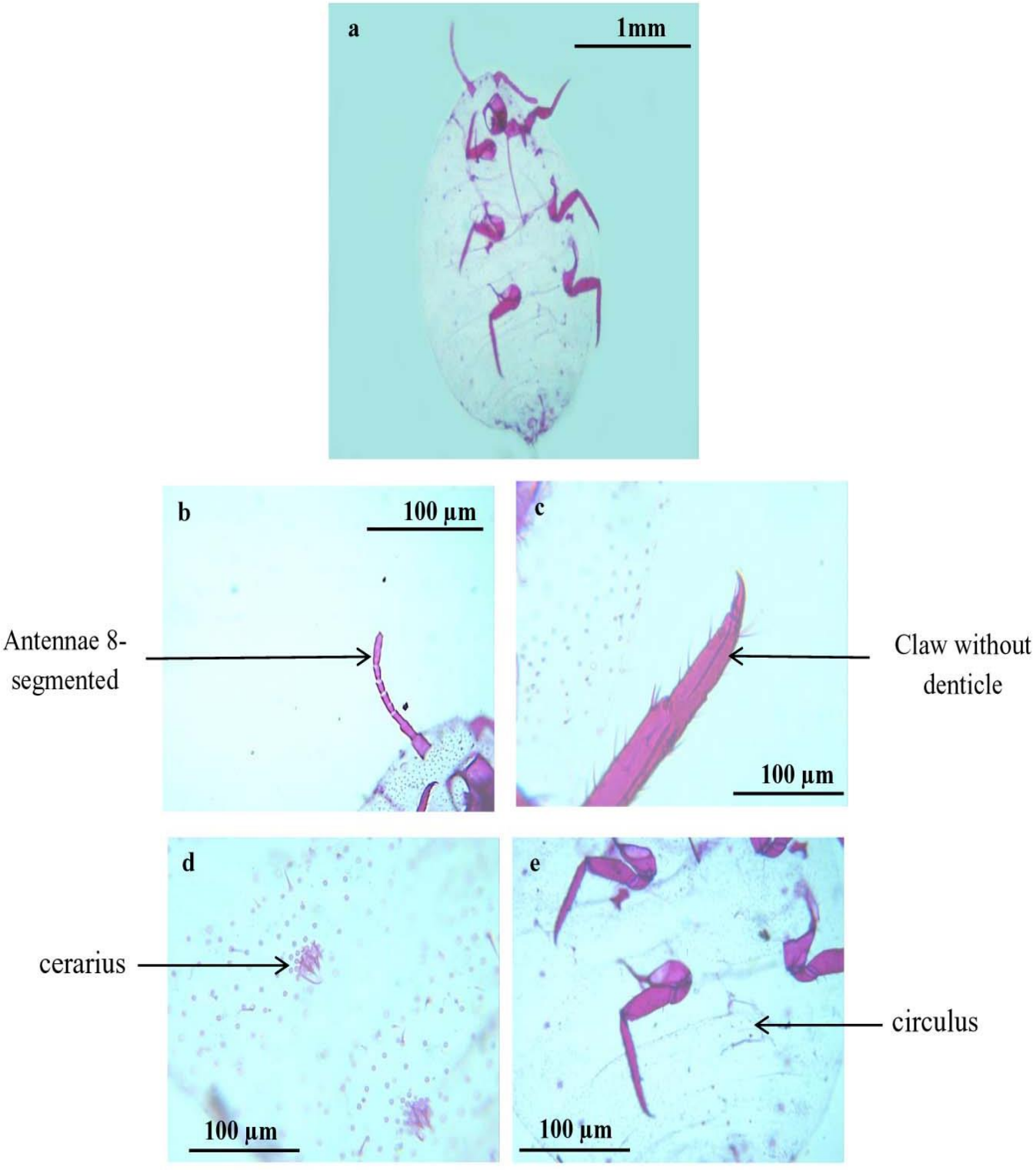

Figure (3): Morphological characters of *Dysmicoccus brevipes*, a: Adult female, b: Antennae segmented, c: Claw,d: Cerarius, e: Circulus.

Genus: *Planococcus* Ferris, 1950

Description

Body oval shaped, marginal provided with 18 pairs of cerarii, anal lobes cerarii with auxiliary setae, antennae 8 segmented, claws without denticles, hind legs with translucent pores on coxa and tibiae sometimes on hind femora, circulus quadrate shaped, multilocular disc pores and trilocular disc pores present dorso-venterally, quinquelocular disc pores and oral rim tubular ducts absent, ventrally oral collar tubular ducts present. This genus is represented in Egypt by two species

***Planococcus citri* (Risso, 1813) (Figure, 4).**

Synonyms:

Dorthesia citri Risso, 1813: 416.
Coccus tuliparum Bouche, 1844: 301.
Coccus citri; Boisduval, 1867: 348.
Coccus citry; Alfonso, 1875: 428.
Dactylopius alaterni Signoret, 1875: 309.
Dactylopius ceratoniae Signoret, 1875: 311.
Dactylopius citri; Signoret, 1875: 312.
Dactylopius citri; Signoret, 1875: 312.
Dactylopius cyperi Signoret, 1875: 314.
Dactylopius robiniae Signoret, 1875: 322.
Dactylopius tuliparum; Signoret, 1875: 323.
Lecanium phyllococcus Ashmead, 1879: 160.
Coccus citry; Targioni Tozzetti, 1881: 134.
Dactylopius brevispinus Targioni Tozzetti,1881: 137.
Dactylopius destructor Comstock, 1881: 342.
Dactylopius farinosus; Cockerell, 1898: 109.
Dactylopius secretus Hempel, 1900: 387.
Phenacoccus spiriferus Hempel, 1900: 389.
Phenacoccus spiniferus; Hempel, 1901: 110.
Pseudococcus citri; Cockerell, 1902: 252.
Pseudococcus cyperi; Fernald, 1903: 101..
Pseudococcus robiniae; Fernald, 1903: 108.
Pseudococcus tuliparum; Fernald, 1903: 111.
Pseudococcus alaterni; Fernald, 1903: 97.
Pseudococcus ceratoniae; Fernald, 1903: 99.
Pseudococcus citri coleorum Marchal, 1908: 236.
Dactylopius* (*Trechocorys*) *citri; Newstead, 1908: 9.
Pseudococcus citri phenacocciformisBrain,1915: 116.
Planococcus citri; Ferris, 1950: 165.
Planococcoides cubanensis Ezzat&McConnell,1956: 53.
Planococcus citricus Ezzat & McConnell, 1956: 69.
Planococcus cucurbitae Ezzat & McConnell, 1956: 71.

Description

Adult female body oval shaped, body pink or orange brown in color, length 2.63mm and width 1.6 mm, dorsum covered with powdery white wax except central longitudinal stripe, body margins with 18 pairs of distinct cerarii, , anal lobe cerarii with auxiliary setae(Figure **4C**), antennae 8-segmented, measurements in microns, as follows: I (50.83); II (54.2); III (50.8); IV (35); V (36.6); VI (34.2); VII (39.2) and VIII (86.7).(Figure **4A**). Legs normally developed, measurements of hind leg, in microns, as follows: coxea (87.5); trochanter (84.2); femur (178.3); tibia (183.3); tarsus (85.8) and claw (26.6) without denticle, hind coxae and tibia with translucent pores. (Figure**4B**). circulus large and quadrate shaped. (Figure **4E**). ostioles distinct (Figure **4D**)**.** Oral collar-tubular duct in two sizes ventrally, the smaller ducts distributed in rows over median area of abdominal segments (from 3 to 8), larger ducts distributed in groups on marginal body, and sparsely between antennae and middle coxa of lateral margins.

Host plant: It was found on sand croton plant, *Croton glandulosus*, Fam. Euphorbiaceae, bitter orange tree, *Citrus aurantium*, Fam. Rutaceae, king orange tree, *Citrus nobilis*, Fam. Rutaceae, and grape vine plant, *Vitis vinifera*, Fam. Vitaceae.

Distribution

Egypt: Alexandria, Cairo, Beheira, Benisuef, Dakahhliya, El wadi el guided, Fayoum, Gharbiya, Gize, Ismailiya, Qena, Minya, Port-said, Qalyubiya and Sharqiya.

World: this species is distributed in the following zoogeographic regions: Palaearctic, Afrotropical, Australasian, Oriental and Nearcti

***Planococcus ficus* (Signoret, 1875)(Figure, 5)**

Synonyms:

Coccus vitis; Nedzilskii, 1869: 19.
Dactylopius vitis; Lichtenstein, 1870: L.
Dactylopius ficus Signoret, 1875: 315.

Dactylopius vitis Signoret, 1875: 324.
Dactylopius subterraneus Hempel, 1900: 388.
Pseudococcus ficus; Fernald, 1903: 101.
Pseudococcus vitis Fernald, 1903: 112.
Coccus vitis; Lindinger, 1912: 365.
Pseudococcus vitis Leonardi, 1920: 408.
Pseudococcus citrioides Ferris, 1922: 208.
Pseudococcus vitis Bodenheimer, 1924: 84.
Pseudococcus citri; Balachowsky & Mesnil, 1935: 729.
Coccus vitis Borchsenius, 1949: 132.
Dactylopius ficus; Borchsenius, 1949: 132.
Planococcus citrioides; Ferris, 1950: 164.
Planococcus vitis Ezzat & McConnell, 1956: 103.
Planococcus ficus; Ezzat & McConnell, 1956: 79.
Pseudococcus praetermissus Ezzat, 1962: 165.
Planococcus vitis Matile-Ferrero, 1984: 227.
Planococcus ficus; Moghaddam, 2009: 34.

Common name: Grapevine mealybug.

Description

Adult female body oval shaped and concave in lateral view, Body pink or orange brown in color, length 2.74 mm and width 1.5mm, body dorsum covered with powdery white wax except central longitudinal stripe down not as on *Planococcus citri*, body marginal provided with 18 pairs of distinct cerarii, usually each cerarius with two short conical setae and few number of trilocular pores, except cerarius on head and thorax which provided with long and slender setae, anal lobe cerarii with auxiliary setae.(Figure **5d**). Antennae 8- segmented; measurements, in microns, as follows: I (36.7); II (41.7); III (43.3); IV (29.2); V (30); VI (32.5); VII (47.5) and VIII (90.3). (Figure**5a**). Legs normally developed, measurements of hind leg, in microns, as follows: coxea (55.8); trochanter (43.4); femur (125); tibia (111.7); tarsus (75); and claw (25.8) without "denticle"(Figur 5c), hind coxae, femur and tibiae with translucent pores usually. (Figure **5e**). Abdominal segmented 4^{th} & 5^{th} with large circulus and broad in shaped. Anal ring normally small circular and with 3 pairs of long setae. (Figure**5f**).

Host plant it was found on grape vine plant, *Vitis vinifera*, Fam. Vitaceae.

Distribution

Egypt: Cairo, Fayoum, and Gize

World: this species is distributed in the following zoogeographic regions: Palaearctic, Afrotropical, Australasian, Oriental and Nearcti

Genus: Saccharicoccus Ferris, 1950

Description

Body elongate and oval shaped, marginal without cerarii, anal lobes cerarii present, antennae 7 segmented, legs normall and short, claws without denticles, dorsally with two pairs of ostioles, circulus: hour- glass shaped and large, anal ring normally, multilocular disc pores present dorso-ventrally, tubular ducts present ventrally. This genus is represented in Egypt by one species *Saccharicoccus sacchari*.

***Saccharicoccus sacchari* (Cockerell, 1895)(Figures, 6-7)**

Synonyms:

Dactylopius sacchari Cockerell, 1895a: 195.
Pseudococcus sacchari; Cockerell, 1902: 252.
Dactylopius sacchari brasiliensis van Gorkum, 1913: 29.
Trionymus calceolariae; Fullaway, 1923: 308.
Trionymus sacchari; Fullaway, 1923: 308.
Erium sacchari; Lindinger, 1935: 122.
Trionymus praegrandis James, 1936: 200.
Trionymus sacchari; Zimmerman, 1948: 266.
Saccharicoccus sacchari; Ferris, 1950: 217.
Soccharicoccus sacchari; Tang, 2001: 3.

Common name: Pink sugar cane mealybug

Description

Adult female Body pink elongate and broadly oval; length 6.3 mm, width 3.75 mm; body cerarii absent, anal lobe cerarius associated with two small conical setae, two pairs of clearly developed ostioles, antennae normally, 7- segmented,(Figure **6a-7A**) measurements in microns, as follows: I (56.7); II (52.7); III (45.8); IV (55.8); V (32.5); VI (42.5); and VII (79.2).Legs relatively small, measurements of hind leg, in

microns, as follows: coxea (117.3); trochanter (70.8); femur (204.1); tibia (146.7); tarsus (85); and claw(27.5), combined tibia and tarsus are shorter than combined trochanter and femur, claw without "denticle ", hind leg with translucent pores. (Figure **6 b-7B**) Abdominal segmented 4th & 5th with circular as hour- glass shaped, (Figure **6d-7D**) last four abdominal segmented provided with long setae laterally, and equal in size at segments 7th & 8th, but smaller on segment 6th, (Figure **6c-7C**).

Host plant: it was found on sugar cane plant, *Saccharum officinarum*, Fam. Poaceae.

Distribution

Egypt: Beni Suef, Qena, and Minya**.**

World: this species is distributed in the following zoogeographic regions: Palaearctic, Afrotropical, Australasian, Oriental and Nearcti

***Subfamily* Phenacoccinae šulc, 1944: 152**

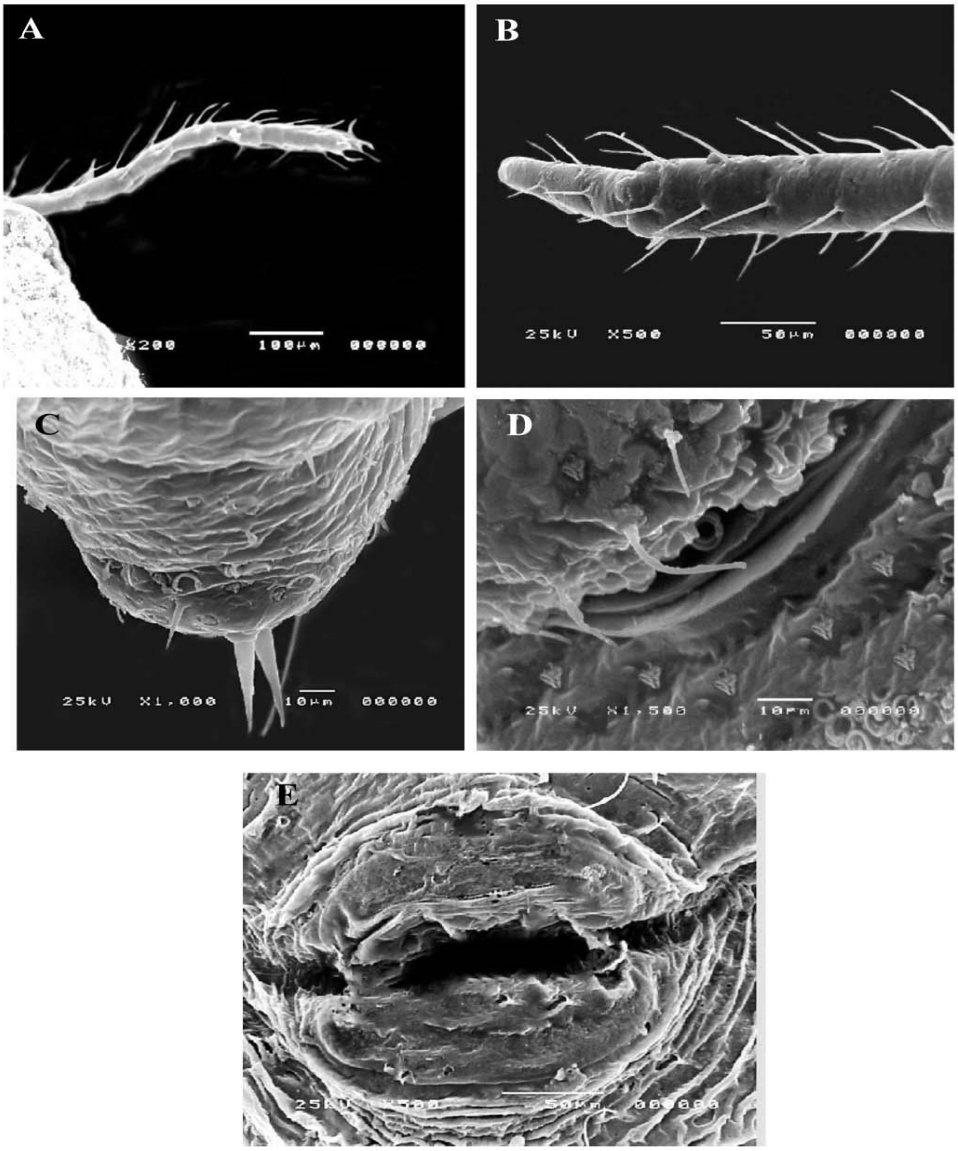

Figure (4): Scanning electron micrographs of *Planococcus citri*, showing A: Antennae, B: Claw, C: Cerarius, D: Ositoles, E: Circulus.

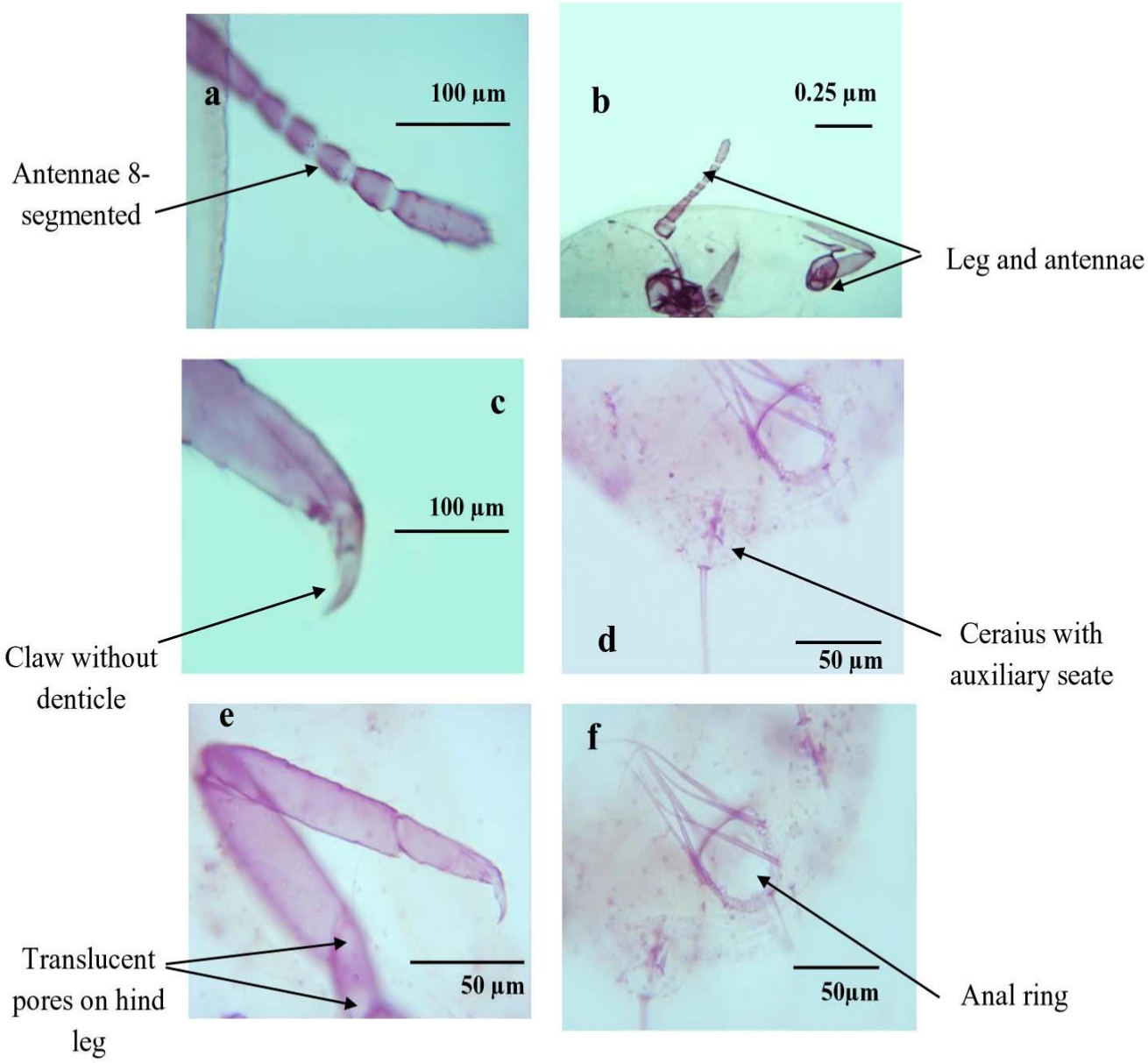

Figure (5): Morphological characters of *Planococcus ficus*, a: Antennae segmented, b: Leg and antennae, c: Claw without denticle, d: Ceraius with auxiliary seate, e: Translucent pores on hind leg, f: Anal ring.

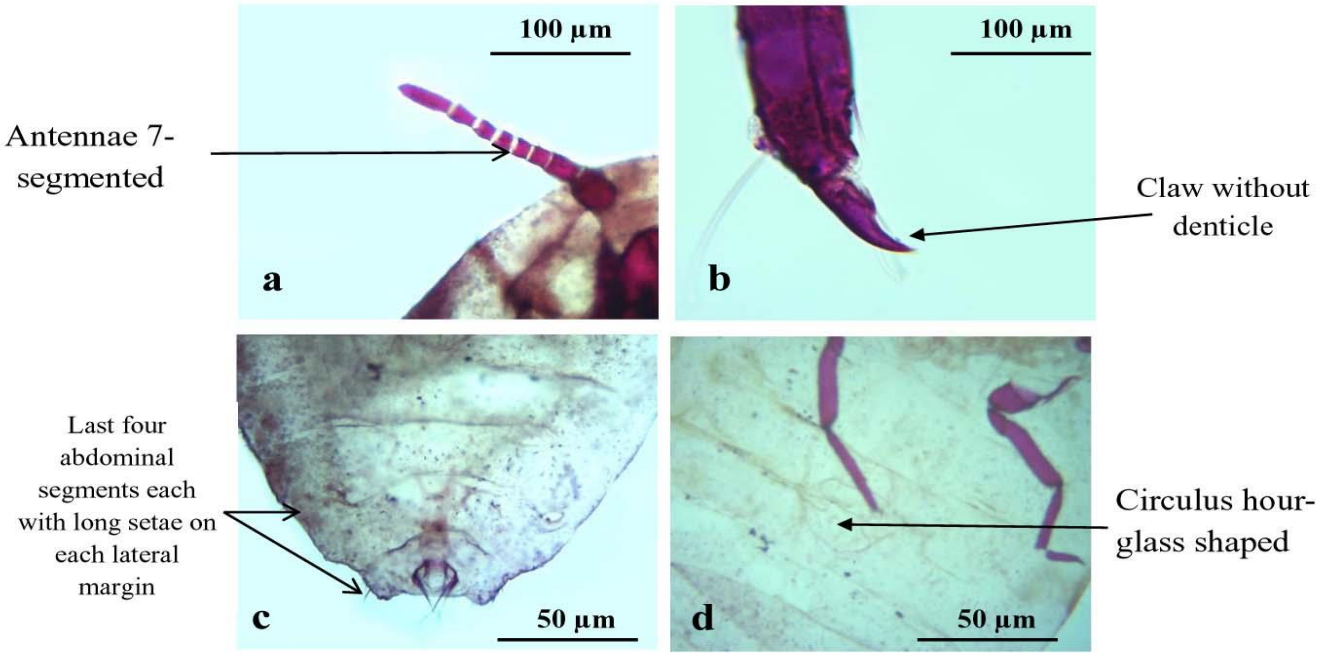

Figure (6): Morphological characters of *Saccharicoccus sacchari*, a: Antennae segmented, b: Claw, c: Last four abdominal segments each with long setae on each lateral margin, d: Circulus as hour-glass shaped.

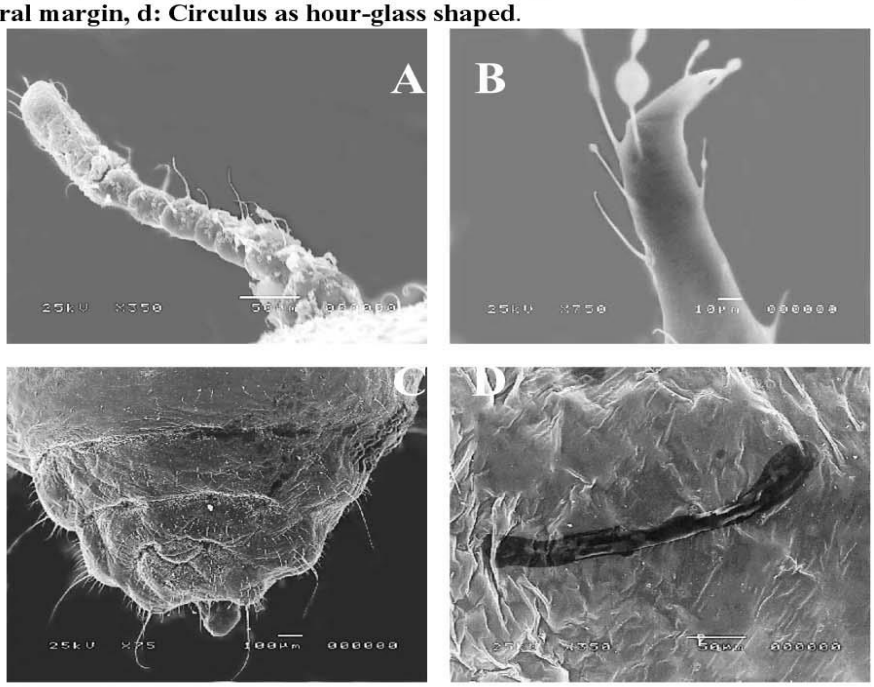

Figure (7): Scanning electron micrographs of *Saccharicoccus sacchari,* showing A: Antennae, B: Claw, C: Last four abdominal segments each with long setae on each lateral margin, D: Circuls.

Genus: *Phenacoccus* Cockerell, 1893

Description

Body oval and globular shape, marginal provided with 8-18 pairs of cerarii, each cerarius with two conical setae, anal lobes cerarii with auxiliary setae, antennae 9 segmented, legs normally, claw with dentical, hind legs with translucent pores, dorsally two pairs of ostioles, circulus absent or present with different shapes and size, anal lobe bars absent, anal ring normal, multilocular disc pores present venterally, present or absent on dorsally, quinquelocular pores and trilocular disc pores present venterally, ,discoidal pores sometimes apparent, oral rim tubular ducts absent, oral collar tubular duct present dorso-venterally, body setae different type (flagellate on venter and small and lanceolate on dorsal). This genus is represented in this studied by two species *Phenacoccus solenopsis, Phenacoccus parvus,* and for first time these taxa described in Egypt.

***Phenacoccus solenopsis* Tinsly, 1898**

(Figures, 8-9)

Phenacoccus solenopsis Tinsley, 1898: 47.

Phenacoccus cevalliae Cockerell, 1902a: 315.

Phenacoccus gossypiphilous Abbas, Arif & Saeed, 2005: 83.

Phenacoccus gossypiphilous Arif, Abbas & Saeed, 2007: 3.

Phenacoccus gossypiphilous Abbas, Arif, Saeed & Karar, 2008: 103.

Description

Adult female large species, body generally oval shaped and membranous, (Figure **9A**) .length 3.025 mm, width 2.03 mm, dark green, almost black, body dorsum covered with thin powdery secretion, and dark spots on segments of thorax and abdomen, body marginal with 18 pairs of cerarii, each cerarius with two small conical setae (Figure **9F**), and associated by few trilocular pores, dorsal body setae small and lanceolate, quinquelocular pores absent. antennae 9 segmented;the measurements in microns; as follows: I (56.8); II (90.8); III (63.3); IV (58.3); V (63.3); VI (55); VII (50.8); VIII (40.8); and IX (75).(Figure **8a-9B**)Legs normally developed, measurements of hind leg, in microns, as follows: coxea (237.5); trochanter (129.2); femur (285); tibia (290); tarsus (115); and claw (30.8) with "denticle",(Figure **8b-9C,D**) apex of meta femur and meta tibia with translucent pores. Segments 4^{th} &5^{th} with more oval and larger circulus. (Figure **8d-9G**), Anal ring normally circular with 3 pairs of long setae,(Figure **8,c**)**.** multilocular pores present only ventrally in groups around vulva, (Figure **8e-9H**), ostioles developed and represent dorsally.(Figure **9E**).

Host plants: it was found on okra plant, *Abelmoschus esculentus*, Fam. Malvaceae, extra-long staple cotton plant, *Gossypium barbadense*, Fam. Malvaceae, corn plant, *Zea mays*, Fam. Poaceae, *eggplant*, *Solanum melongena*, Fam. Solanaceae.

Distribution

Egypt: Alexandria, Beheira, Cairo, Giza, and Qalyubiya.

World: this species is distributed in the following zoogeographic regions: Palaearctic, Afrotropical, Australasian, Oriental and Nearcti

***Phenacoccus parvus* Morrison, 1924**

(Figure, 10)

Synonyms:

Phenacoccus parvus Morrison 1924: 147.

Phenacoccus surinamensis Green 1933: 51.

Common name: Lantana mealybug

Description

Adult female Large species generally; body oval shaped, often flattened dorso-ventrally and membranous, light yellow in color, body dorsum covered with thin powdery secretion, Body length 3.36 mm, and width 2.2 mm, Body with 18 pairs of cerarii, around margins, each cerarius with two small conical setae, and associated with few trilocular pores, body setae short and stout. Antennae 9-segmented; measurements in microns; as follows: I (62.1); II (92.3); III (62.4); IV (59.3); V (64.9); VI (55.06); VII (51.5); VIII (41.4); IX and (76.8).(Figure **10a**). Legs normally developed; measurements of hind leg, in microns, as

follows: coxea (231.5); trochanter (122.6); femur (273.4); tibia (288.7); tarsus (116.1) and claw (25.2) with minute tooth on plantar surface of the claw "denticle", (Figure **10 b**), hind tibia with translucent pores; quinquelocular pores present ventrally. (Figure **10e**). Abdominal segments 4th & 5th with oval and small circular (Figure **10 c**).

Host plants: it was found on tick berry plant, *Lantana camara*, Fam. Verbenaceae

Distribution

Egypt: Cairo, Giza.

World: this species is distributed in the following zoogeographic regions: Palaearctic, Afrotropical, Australasian, Oriental and Nearcti

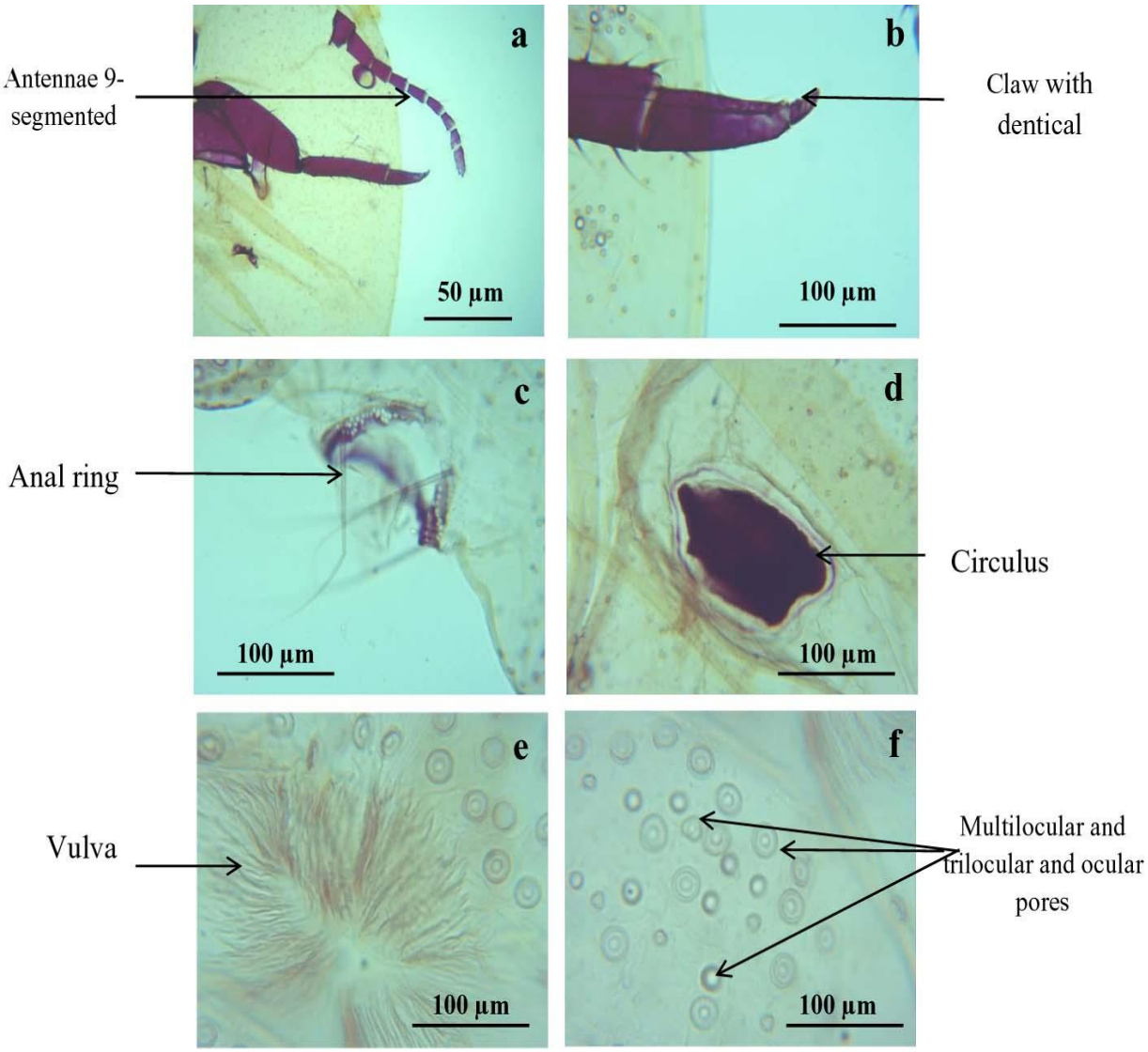

Figure (8): Morphological characters of *Phenacoccus solenopsis*, a: Antennae segmented, b: Claw, c: Anal ring, d: Circulus, e: Vulva, f: Multilocular and trilocular and ocular pores.

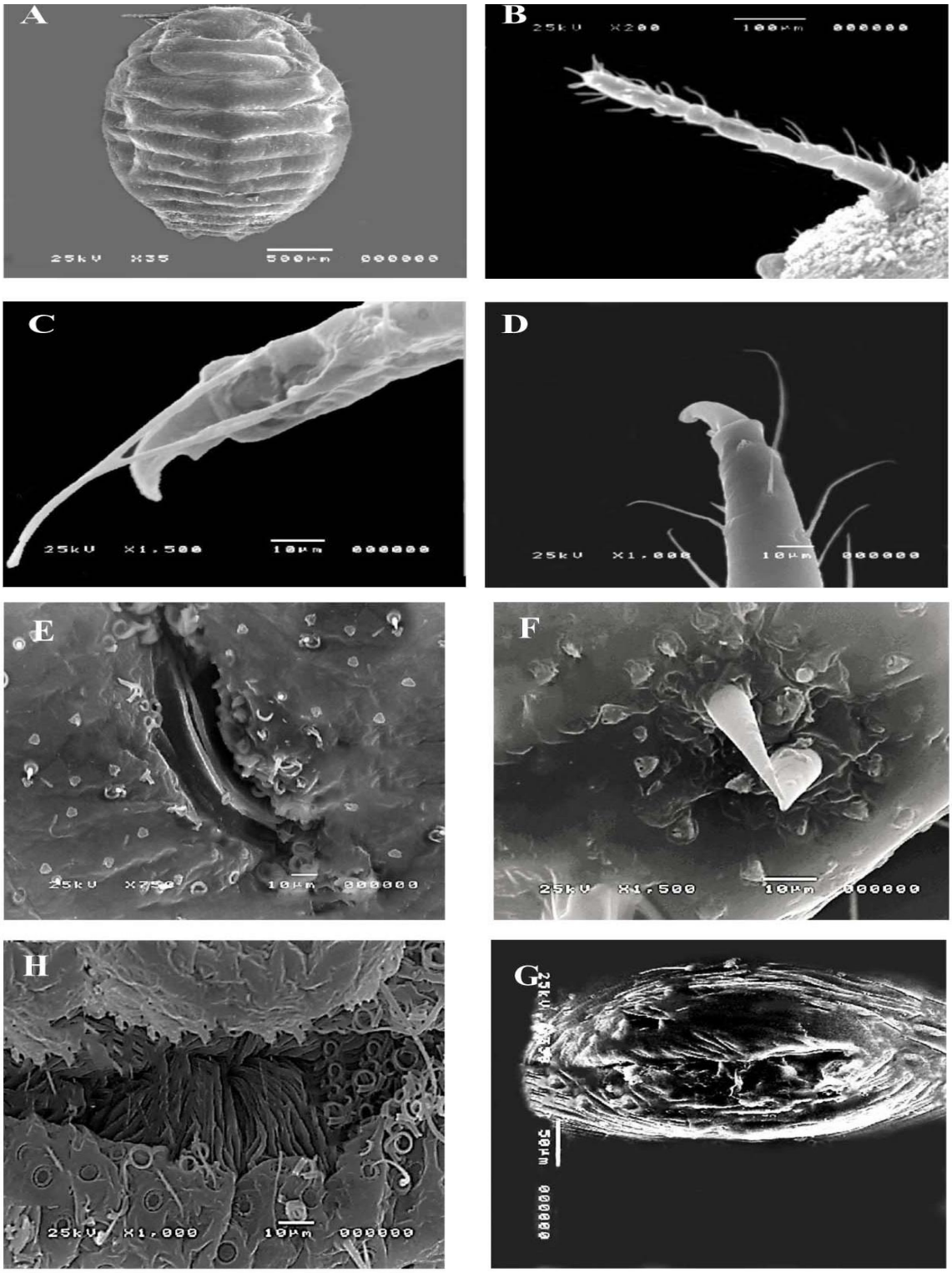

Figure (9): Scanning electron micrographs of *Phenacoccus solenopsis,* showing, A: Adult female, B: Antennae, C: Claw, D: Tarsal digitules, E: Ostioles. F: Cerarius with two conical setae and trilocular pores, G: Circulus, H: Vulva.

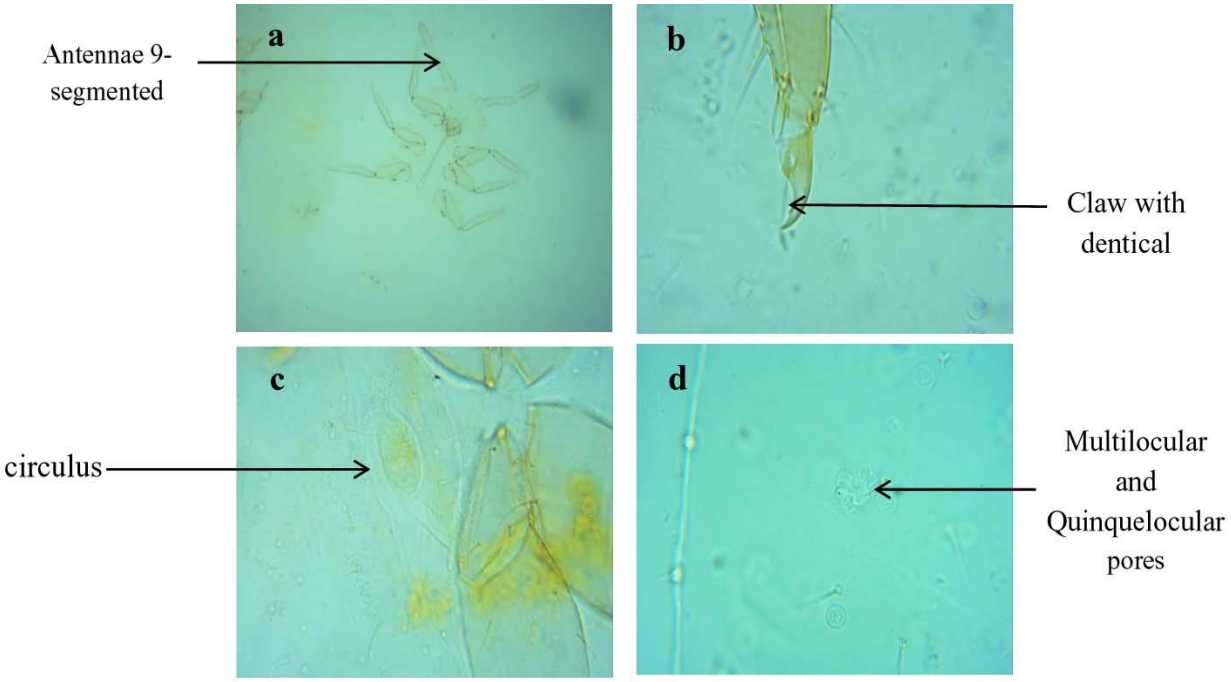

Figure (10): Morphological characters of *Phenacoccus parvus*, a: Antennae segmented, b: Claw, c: Circulus, e: Multilocular & quinquelocular pores.

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New records of Aphelinidae from Iran, and updated checklist of Iranian Aphelinidae, Azotidae and Eriaporidae (Hymenoptera: Chalcidoidea)

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Abstract:

This paper deals with the faunistic data for 13 species of Aphelinidae (Hymenoptera) within nine genera, *Aphelinus* Dalman, 1820, *Aphytis* Howard, 1900, *Cales* Howard, 1907, *Centrodora* Förster, 1878, *Coccophagus* Westwood, 1833, *Encarsia* Förster, 1878, *Marietta* Motschulsky, 1863, *Proaphelinoides* Girault, 1917 and *Pteroptrix* Westwood, 1833.

Introduction

Aphelinid wasps (Hymenoptera: Chalcidoidea: Aphelinidae) are tiny parasitic wasps, with about 1,168 described species in about 33 genera (Noyes, 2018). These wasps are very unusual in that the males and females may have different ontogenies. The females of such species always develop as primary endoparasitoids of hemipterans hosts (usually Coccoidea), whilst the males have host relationships that differ from those of conspecific females - they may be primary ectoparasitoids of Hemiptera, hyperparasitoids of other chalcidoid larvae or pupae within their hemipterans hosts, or primary endoparasitoids of lepidopteran eggs (Viggiani, 1984 and Woolley, 1997). Aphelinid wasps are one of the most important biocontrol agents and decrease significantly the population densities of several agricultural and forest pests. Even some species have been successfully used in classical biocontrol programs (Myartseva *et al.*, 2013).

The fauna of Iranian Aphelinidae was studied rather well, which totally 138 species within 13 genera [*Ablerus* (11), *Aphelinus* (14), *Aphytis* (11), *Centrodora* (0), *Coccobius* (16), *Coccophagoides* (1), *Coccophagus* (11)), *Encarsia* (48), *Eretmocerus* (18), *Euryischia* (*Euryischia* sp.), *Marietta* (3), *Myiocnema* (1), *Pteroptrix* (4)] have been listed by Abd-Rabou *et al.* (2013). Of course, now the genus *Ablerus* is classified under the family Azotidae Nikols'kaya and Yasnosh, 1966

and the genera *Euryischia* and *Myiocnema* in Eriaporidae (Noyes, 2018), now with a total of 126 known species within 10 genera. Fifty-eight species of Aphelinidae are recorded to Iran in Noyes (2018), including seven species not registered in Abd-Rabou *et al.* (2013). The purpose of this paper is to introducing of 13 aphelinids as new records for the fauna of Iran.

Material and methods

The material of the present faunistic survey were obtained through the rearing of their hosts, Aleyrodidae, Aphididae, Coccidae, Diaspididae (Hemiptera) and Tettigoniidae (Orthoptera) in optimum conditions (25±1 ºC, 60±5% RH, 14:10 L: D) in an incubator for emergence of parasitoids. The collected specimens were put in 75% ethanol after emergence and were examined by a stereoscopic binocular microscope. In this paper, classification, nomenclature and distributional data were taken from Noyes (2018).

Results and discussion

In this investigation, totally 13 species of Aphelinidae (Hymenoptera) within nine genera are represented as new records for the fauna of Iran: *Aphelinus* (one species), *Aphytis* (three spp.), *Cales* (one sp.), *Centrodora* (one sp.), *Coccophagus* (one sp.), *Encarsia* (two spp.), *Marietta* (one sp.), *Proaphelinoides* (one sp.) and *Pteroptrix* (two spp.). Additionally, two genera, *Cales* and *Proaphelinoides* are new country records too.

Family Aphelinidae Thomson, 1876

Genus *Aphelinus* Dalman, 1820

***Aphelinus annulipes* (Walker, 1851)**

Material examined: Ardabil province, Germi (Damirchi), 3♀♀, September 2010, ex *Saltusaphis scirpus* (Theobald, 1915) (Hemiptera: Aphididae).

General distribution: Czech Republic, France, Germany, Hungary, Netherlands, Russia, Slovakia, Sweden, Ukraine and United Kingdom.

Genus *Aphytis* Howard, 1900

***Aphytis abnormis* (Howard, 1881)**

Material examined: West Azarbaijan province: Khoy (Bilehvar), 4♀♀, 1♂, May 2012, ex *Lepidosaphes ulmi* (Linnaeus, 1758) (Hemiptera: Diaspididae).

General distribution: France, Greece, Hungary, Spain, Turkey and United States of America.

***Aphytis holoxanthus* DeBach, 1960**

Material examined: Zanjan province, Tarom (Gilvan), 2♀♀, 1♂, August 2014, ex *Lepidosaphes beckii* (Newman, 1869) (Hemiptera: Diaspididae).

General distribution: Argentina, Australia, Brazil, Caribbean, China, Cuba, Cyprus, Dominican, El Salvador, Hong Kong, India, Israel, Lebanon, Mexico, Peru, South Africa, Taiwan, Trinidad and Tobago and United States of America.

***Aphytis neuter* Yasnosh and Myartseva, 1971**

Material examined: North Khorasan province: Bojnord (Emamdarreh), 2♀♀, May 2011, ex *Quadraspidiotus perniciosus* (Comstock, 1881) (Hemiptera: Diaspididae).

General distribution: Tadzhikistan, Turkey, Turkmenistan, former USSR[1] and Uzbekistan.

Genus *Cales* Howard, 1907

***Cales noacki* Howard, 1907**

Material examined: Mazandaran province, Savadkooh (Shirgah), 2♀♀, 16.vii.2013, ex *Parabemisia myricae* (Kuwana) (Hemiptera: Aleyrodidae).

General distribution: Argentina, Azores, Brazil, Canary Islands, Chile, El Salvador, France, Greece, Haiti, Israel, Italy, Madeira, Malta, Mexico, Morocco, Peru, Reunion, Spain, Tunisia, Turkey, United States of America and Uruguay.

Genus *Centrodora* Förster, 1878

***Centrodora amoena* Förster, 1878**

1- Union of Soviet Socialist Republics: Extending across the entirety of Northern Asia and much of Eastern Europe. The Soviet Union had spanned eleven time zones and incorporated a wide range of environments and landforms. Counter-clockwise from northwest to southeast, the Soviet Union shared land borders with Norway, Finland, Poland, Czechoslovakia, Hungary, Romania, Turkey, Iran, Afghanistan, China, Mongolia, and North Korea.

Material examined: Kordestan province, Saqez (Kakeh Siab), 1♀, 1♂, June 2011, ex *Conocephalus* sp. nr. *fuscus* (Fabricius, 1793) (Orthoptera: Tettigoniidae).
General distribution: Azerbaijan, Czech Republic, Georgia, Germany, Hungary, Russia, Slovakia, Spain, Sweden, Ukraine and United Kingdom.

Genus *Coccophagus* Westwood, 1833

***Coccophagus pulchellus* Westwood, 1833**
Material examined: East Azarbaijan province, Horand (Avalan), 2♀♀, September 2013, ex *Eulecanium tiliae* (Linnaeus, 1758) (Hemiptera: Coccidae).
General distribution: Czech Republic, France, Germany, Greece, Hungary, Italy, Montenegro, Poland, Serbia, Spain and United Kingdom.

Genus *Encarsia* Förster, 1878

***Encarsia diaspidicola* (Silvestri, 1909)**
Material examined: Golestan province, Gorgan (Naharkhoran Park), 3♀♀, 1♂, August 2012, ex *Quadraspidiotus perniciosus* (Comstock) (Hemiptera: Diaspididae) on *Populus* sp. (Salicaceae).
General distribution: Bermuda, Brazil, Haiti, India, Italy, Japan, Puerto Rico, Reunion, South Africa, United States of America, former USSR and Western Samoa.

***Encarsia intermedia* (Ferriere, 1961)**
Material examined: Ardabil province, Pars-Abad (Aslanduz), 3♀♀, July 2015, ex *Leucaspis pusilla* Löw (Hemiptera: Diaspididae).
General distribution: Caucasus[1], France, Germany, Sweden, Switzerland and Transcaucasus.

Genus *Marietta* Motschulsky, 1863

***Marietta carnesi* (Howard, 1910)**
Material examined: Qazvin province, Alamut (Juladeh), 2♀♀, 1♂, June 2012, ex *Parlatoria pergandii* Comstock, 1881 (Hemiptera: Diaspididae).
General distribution: Australia, China, Egypt, Hawaii, India, Italy, Japan, Mauritius, Micronesia, New Caledonia, Russia, South Korea, Spain, United States of America and former USSR.

Genus *Proaphelinoides* Girault, 1917

***Proaphelinoides elongatiformis* Girault, 1917**
Material examined: Mazandaran province, Ramsar (Sarlimak), 2♀♀, 2♂♂, September 2013, ex *Odonaspis secreta* (Cockerell, 1896) (Hemiptera: Diaspididae).
General distribution: Caucasus, China, Georgia, Guam, Japan, Sri Lanka, Transcaucasus and former USSR.

Genus *Pteroptrix* Westwood, 1833

***Pteroptrix maritima* Nikols'kaya, 1952**
Material examined: Kurdistan province: Kamyaran (Qaleh-Kumaeein), 3♀♀, July 2007, ex *Lepidosaphes ulmi* (Linnaeus, 1758) (Hemiptera: Diaspididae).
General distribution: Armenia, Caucasus, Hungary, Italy, Russia, Ukraine and former USSR.

***Pteroptrix smithi* (Compere, 1953)**
Material examined: North Khorasan province: Bojnord (Aladagh), 4♀♀, 2♂♂, April 2009, ex *Aonidiella aurantii* (Maskell, 1879) (Hemiptera: Diaspididae).
General distribution: China, Egypt, Israel, Italy, Mexico, Philippines, Taiwan and United States of America.

Now, with the 13 new couuntry records, 141 species of Aphelinidae within 12 genera, 11 species of Azotidae and two species of Eriaporidae are known from Iran. Among the different genera, *Encarsia* with 50 recorded species **is** the most diverse. The list of Iranian Aphelinidae, Azotidae and Eriaporidae is given on the basis of Abd-Rabou *et al.* (2013), with the new records represented with **(*)** and the species listed in Noyes (2018) by **(○)** and the records not included in Abd-Rabou *et al.* (2013) by **(●)**.

List of Iranian Aphelinidae, Azotidae and Eriaporidae

I. Genus *Aphelinus* Dalman, 1820

1)*Aphelinus abdominalis* (Dalman, 1820)
2)*Aphelinus albipodus* Hayat & Fatima, 1992
3)*Aphelinus annulipes* (Walker, 1851)*
4)*Aphelinus argiope* Walker, 1839
5)*Aphelinus asychis* (Walker, 1839) ○
6)*Aphelinus desantisi* Hayat, 1972

1- Caucasus: A region located at the border of Europe and Asia, between Black Sea and Caspian Sea, includes also portions of northwestern Iran and northeastern Turkey.

7)*Aphelinus flaviventris* Kurdjumov, 1913
8)*Aphelinus gossypii* Timberlake, 1924
9)*Aphelinus humilis* Mercet, 1927
10) *Aphelinus maidis* Timberlake, 1924
11) *Aphelinus mali* Haldeman, 1851
12) *Aphelinus paramali* Zehavi & Rosen, 1989 ○
13) *Aphelinus perpallidus* (Gahan, 1924)
14) *Aphelinus semiflavus* Howard, 1908 ○
15) *Aphelinus varipes* (Förster, 1841)

II. Genus *Aphytis* Howard, 1900

16) *Aphytis abnormis* (Howard, 1881) *
17) *Aphytis africanus* Quednau, 1964
18) *Aphytis aonidiae* (Mercet, 1911) ○
19) *Aphytis chrysomphali* (Mercet, 1912) ○
20) *Aphytis diaspidis* (Howard, 1881) ●
21) *Aphytis hispanicus* (Mercet, 1912)
22) *Aphytis holoxanthus* DeBach, 1960*
23) *Aphytis lepidosaphes* Compere, 1955
24) *Aphytis libanicus* Traboulsi, 1969 ○
25) *Aphytis lingnanensis* Compere, 1955
26) *Aphytis maculicornis* (Masi, 1911) ○
27) *Aphytis melinus* DeBach, 1959
28) *Aphytis mytilaspidis* (Le Baron, 1870) ○
29) *Aphytis neuter* Yasnosh and Myartseva, 1971*
30) *Aphytis paramaculicornis* DeBach & Rosen, 1976●
31) *Aphytis proclia* (Walker, 1839) ○

III. Genus Cales Howard, 1907*

32) *Cales noacki* Howard, 1907*

IV. Genus *Centrodora* Förster, 1878

*33) Centrodora amoena, Förster, 1878**

V. Genus *Coccobius* Ratzeburg, 1852

34) *Coccobius annulicornis* (Ratzeburg, 1852) ○
35) *Coccobius contigaspidis* (Yasnosh, 1968)
36) *Coccobius danzigae* (Yasnosh, 1977)
37) *Coccobius diaspidis* (Howard, 1907)
38) *Coccobius flaviceps* (Girault & Dodd, 1915)
39) *Coccobius flaviventris* (Howard, 1910)
40) *Coccobius fulvus* (Compere & Annecke, 1961)
41) *Coccobius fusciventris* (Girault, 1913)
42) *Coccobius indefinitus* (Yasnosh & Myartseva, 1972)
43) *Coccobius mesasiaticus* (Yasnosh & Myartseva, 1971) ●
44) *Coccobius multicolor* (Girault, 1915)
45) *Coccobius nigriceps* (Girault, 1913)
46) *Coccobius pullus* Prinsloo, 1995
47) *Coccobius reticulatus* (Compere & Annecke, 1961)
48) *Coccobius testaceus* Masi, 1909
49) *Coccobius viggianii* (Yasnosh, 1974)
50) *Coccobius varicornis* (Howard, 1881)

VI. Genus *Coccophagoides* Girault, 1915

51) *Coccophagoides similis* (Masi, 1908)

VII. Genus *Coccophagus* Westwood, 1833

52) *Coccophagus bivittatus* Compere, 1931
53) *Coccophagus ceroplastae* (Howard, 1895)
54) *Coccophagus cowperi* Girault, 1917
55)*Coccophagus differens* Yasnosh, 1966
56)*Coccophagus lutescens* Compère, 1931
57)*Coccophagus lycimnia* (Walker, 1839)
58)*Coccophagus proximus* Yasnosh, 1966
59)*Coccophagus pseudococci* Compere, 1933
60)*Coccophagus pulchellus* Westwood, 1833*
61)*Coccophagus rusti* Compère, 1928
62)*Coccophagus scutellaris* (Dalman, 1825) ○
63)*Coccophagus semicircularis* (Förster, 1841) ●
64)*Coccophagus silvestrii* Compere, 1931

VIII. Genus *Encarsia* Förster, 1878

65)*Encarsia acaudaleyrodis* Hayat, 1976 ○
66)*Encarsia alemansoori* Rasekh & Polaszek, 2010 ○
67)*Encarsia aleurochitonis* (Mercet, 1931)
68)*Encarsia aurantii* (Howard, 1894) ○
69)*Encarsia axacaliae* Abd-Rabou & Ghahari, 2007 ○
70)*Encarsia azimi* Hayat, 1980 ○
71)*Encarsia bennetti* Hayat, 1984
72)*Encarsia berlesei* (Howard, 1906) ○
73)*Encarsia bimaculata* Heraty & Polaszek, 2000
74)*Encarsia brimblecombei* (Girault, 1933) ●
75)*Encarsia cibcensis* Lopez Avila, 1987 ○
76)*Encarsia citrina* (Craw, 1891) ○
77)*Encarsia clypealis* (Silvestri, 1928)
78)*Encarsia dialeurodis* Hayat, 1989
79)*Encarsia dialeuroporae* Viggiani, 1985
80)*Encarsia diaspidicola* (Silvestri, 1909)*
81)*Encarsia elegans* Masi, 1911 ○
82)*Encarsia elongata* (Dozier, 1937)
83)*Encarsia fasciata* (Malenotti, 1917) ○
84)*Encarsia formosa* Gahan, 1924 ○
85)*Encarsia gautieri* (Mercet, 1928)
86)*Encarsia gigas* (Chumakova, 1957)
87)*Encarsia hamata* Huang & Polaszek, 1998 ○
88)*Encarsia inaron* (Walker, 1839) ○
89)*Encarsia indigoferae* Polaszek & Manzari, 2008 ○
90)*Encarsia inquirenda* (Silvestri, 1931)
91)*Encarsia intermedia* (Ferriere, 1961) *
92)*Encarsia lahorensis* (Howard, 1911) ○
93)*Encarsia lehri* Yasnosh, 1989
94)*Encarsia lipaleyrodes* Krishnan & David, 1996
95)*Encarsia longifasciata* Subba Rao, 1984
96)*Encarsia longivalvula* Viggiani, 1985
97)*Encarsia lounsburyi* (Berlese & Paoli, 1916) ○
98)*Encarsia lutea* (Masi, 1909) ○
99)*Encarsia luteola* Howard, 1895
100)*Encarsia macoensis* Abd-Rabou & Ghahari, 2007 ○
101)*Encarsia macroptera* Viggiani, 1985
102)*Encarsia margaritiventris* (Mercet, 1931)
103)*Encarsia maritima* Jasnosh, 1989
104)*Encarsia mineoi* Viggiani, 1982 ○
105)*Encarsia mohyuddini* Shafee & Rizvi, 1982
106)*Encarsia opulenta* (Silvestri, 1928)
107)*Encarsia* sp. (nr. *perflava* Hayat, 1989)
108)*Encarsia pergandiella* Howard, 1907 ○

109)*Encarsia perniciosi* (Tower, 1913) ○
110)*Encarsia porteri* (Mercet, 1927)
111)*Encarsia protransvena* Viggiani, 1985 ○
112)*Encarsia shutovae* Yasnosh, 1973
113)*Encarsia smithi* (Silvestri, 1926)
114)*Encarsia sophia* (Girault & Dodd, 1915) ○
115)*Encarsia tricolor* Förster, 1878

IX. Genus *Eretmocerus* Haldeman, 1850

116)*Eretmocerus adustiscutum* Krishnan & David,1996○
117)*Eretmocerus aleuroviggianus* Abd-Rabou & Ghahari, 2011●
118)*Eretmocerus breviclavus* Subba Rao, 1984 ○
119)*Eretmocerus cadabae* Viggiani, 1982 ○
120)*Eretmocerus corni* Huldeman, 1850
121)*Eretmocerus debachi* Rose & Rosen, 1992 ○
122)*Eretmocerus* sp. nr. *delhiensis* Mani, 1941
123)*Eretmocerus diversiciliatus* Silvestri, 1928 ○
124)*Eretmocerus eremicus* Rose & Zolnerowich, 1997
125)*Eretmocerus flavus* Krishnan & David, 1996 ○
126)*Eretmocerus hederae* Abd-Rabou & Ghahari, 2011●
127)*Eretmocerus longiscapus* Hayat, 1972 ○
128)*Eretmocerus mundus* Mercet, 1931 ○
129)*Eretmocerus neobemisiae* Yasnosh, 1974 ○
130)*Eretmocerus neomaskelliae* Abd-Rabou & Ghahari, 2005 ○
131)*Eretmocerus nikolskajae* Myartseva, 1973 ○
132)*Eretmocerus ostovani* Ghahari & Abd-Rabou, 2005 ○
133)*Eretmocerus persiangulfus* Abd-Rabou & Ghahari, 2011 ○
134)*Eretmocerus serius* Silvestri, 1927 ○
135)*Eretmocerus trialeurodis* Hayat, 1998 ○

X. Genus *Marietta* Motschulsky, 1863

136)*Marietta carnesi* (Howard, 1910) *
137)*Marietta leopardina* Motschulsky, 1863
138)*Marietta picta* (André, 1878) ○
139)*Marietta zebrata* (Mercet, 1916)

XI. Genus *Proaphelinoides* Girault, 1917*

140)*Proaphelinoides elongatiformis* Girault, 1917*

XII. Genus *Pteroptrix* Westwood, 1833

141)*Pteroptrix bicolor* Howard, 1898
142)*Pteroptrix bicolor* (Howard, 1898) ○
143)*Pteroptrix lauri* (Mercet, 1911)
144)*Pteroptrix macropedicellata* (Malac, 1947)
145)*Pteroptrix maritima* Nikols'kaya, 1952*
146)*Pteroptrix smithi* (Compere, 1953) *

Family Azotidae Nikols'kaya and Yasnosh, 1966

I. Genus *Ablerus* Howard, 1894

1)*Ablerus aleuroides* (Hussain & Agarwal, 1994)
2)*Ablerus amarantus* Girault, 1932
3)*Ablerus aonidiellae* Hayat, 1974
4)*Ablerus atomon* Walker, 1847
5)*Ablerus bharathius* Subba Rao, 1984
6)*Ablerus bifasciatus* Girault, 1913
7)*Ablerus celsus* (Walker, 1839)
8)*Ablerus chionaspidis* (Howard, 1914)
9)*Ablerus chrysomphali* (Ghesquière, 1960)
10)*Ablerus perspeciosus* Girault, 1916
11)*Ablerus promacchiae* Viggiani & Ren, 1993

Family Eriaporidae Ghesquiere, 1955

I. Genus *Euryischia* Riley, 1889

Euryischia sp.

II. Genus *Myiocnema* Ashmead, 1900

1)*Myiocnema comperei* Ashmead, 1900

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Occurrence and efficacy of natural compounds of the pomegranate whitefly, *Siphoninus phillyreae* (Hemiptera: Aleyrodidae) and its parasitoid, *Eretmocerus parasiphonini* (Hymenoptera: Aphelinidae) in Egypt

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Abstract:

The pomegranate whitefly, Siphoninus *phillyreae* (Haliday) (Hemiptera: Aleyrodidae) is a dangerous pest of pomegranate in different locations in Egypt. The aim of this research was to evaluate the effect of botanical extracts on *S. phillyreae* and its parasitoid, *Eretmocerus parasiphonini* Evans and Abd-Rabou (Hymenoptera: Aphelinidae) on pomegranate (*Punica granatum* L.) as well as the distribution of this pest in Egypt. During the present work, S. *phillyreae* was recorded distributed and occurred in four governorates. These are Assuit, Daqahylia, Giza, Kafr El-Shikh and Qalyubiya. The results also indicated that, in the first season, the average reduction of the three compounds (Jojoba oil, *Peacilomyces fumosoroseus* and Sulfur) gave moderate toxic effect against *S. phillyreae*, percent reduction ranged between (39-45%) and while its parasitoid, *E. parasiphonini*, percent reduction ranged between (72-81%). Azadirachtin compound gave 56% and 72% for *S. phillyreae* and its parasitoid, *E. parasiphonini* mortality, respectively. On the other hand, malathion gave high efficacy against *S. phillyreae* (75%) and E. *parasiphonini* (93 %). In the second season, the average reduction of the three compounds (Jojoba oil, *Peacilomyces fumosoroseus* and Sulfur) gave moderate toxic effect against *S. phillyreae,* percent reduction ranged between (41-53%) and while its parasitiod *E. parasiphonini*, percent reduction ranged between (72-76%). Azadirachtin compound gave 63% and 63% for *S. phillyreae* and its parasitoid, *E. parasiphonini* mortality, respectively. On the other hand, malathion gave high efficacy against *S. phillyreae* (85%) and *E. parasiphonini* (95 %).

Introduction

The pomegranate whitefly, *Siphoninus phillyreae* (Haliday) (Hemiptera: Aleyrodidae) is one of the most economic pest infested pomegranate in Egypt. Heavy infestation caused leaf wilt, early leaf drops and smaller fruit (Abd-Rabou, 1998). It is distributed in 28 countries specially in Palaearctic region (Bellows *et al.*, 1990) and distributed in three governorates in Egypt (Abd-Rabou, 2001b). Recently, *Eretmocerus parasiphonini* Evans and Abd-Rabou (Hymenoptera: Aphelinidae) recorded associated with *S. phillyreae* in Egypt (Evans and Abd-Rabou, 2005). Abd-Rabou and Ahmed (2007) studied the distribution of this pest in Egypt.

In recent years whiteflies have developed resistance to many conventional insecticides throughout the world, especially organophosphates and pyrethroids (Horowitz *et al*., 2004 and Fernandez *et al*., 2009).

So, in modern agriculture and an increasingly regulated world, natural plant-based insecticides can be a feasible plant pest management method and an attractive alternative to synthetic chemical insecticides because botanicals reputedly pose little threat to the environment, non-target organisms or to human health (Isman, 2006). A number of plant substances have been considered for use as insecticides, antifeedants or repellents, which include terpenes, flavonoids, alkaloids, phenols, and other related compounds (Adeyemi, 2010). Several factors, however, appear to limit the success of botanicals, most notably regulatory barriers. In this context, plant-derived products are best suited for use in organic food production and in the production and postharvest protection of food in developing countries (Isman, 2006 and Dayan *et al*. , 2009).

Some of botanical extracts potential allows up to 90% success in pest control within agroecological management, having the advantage of preserving natural enemies (Abreu Júnior, 1998). Several studies have shown that neem products are safe for beneficial insects (Schmutterer, 1990).

The aim of this work is to study the efficacy of botanical extracts on the pomegranate whitefly, *S. phillyreae* and its parasitoid, *E. parasiphonini* with emphasis on distributions status in Egypt.

Materials and methods

1. Distribution of *Siphoninus phyllireae* in Egypt:

Infested leaves of pomegranate were examined in the field using a pocket magnification lens. Infested leaves were collected from pomegranate trees from different locations in Egypt during 2017-2018. The leaves collected and placed separately in paper bags for further examination in the laboratory. Identification of *S. phyllireae* was done by examining fourth larval instar in Canada Balsam (according Abd-Rabou, 2001b).

2. Efficacy of natural compounds on *Siphoninus phyllireae* and its parasitoid, *Eretmocerus parasiphonini* on pomegranate:

The experiments were carried out to evaluate of the five compounds Jojoba oil, *Peacilomyces fumosoroseus*, Sulfur, Azadirachtin and Malathion) on *S. phillyrea* and associated parasitoid, *E. parasiphonini* on pomegranate at Giza Governorate. When the numbers of *S. phillyreae* and its parasitoid were high during July.

2.1. The experiments comprised five compounds:

2.1.1. Jojoba oil: Al kanz 2000 70% WE The application rate 10 ml /LW.

2.1.2. Sulfur WP S8 the application rate 2.5 mg/Lw.

2.1.3. *Paecilomyces fumosoroeus* (Priority)**:** An entomopathogenic fungi: 1 $\times 10^8$ unite/cm^3 (100 million), containing the fungus *P. fumosoroeus*, used at a rate of 5ml/Lw

2.1.4. Azadirachtin Azadirachtin *(Azadirachtin indica)* The application rate 5ml/Lw

2.1.5. Malathion 57% EC, a chemical insecticide of the common name Malathion and the chemical name, O, O-dimethyl-S- (1,2-dicarbethoxyethyl) dithio-phosphate. It was applied at a rate of 1.5 ml/ Lw

Each treatment conducted in 1/4 Fadden. One quarter of Fadden was also used as an untreated check (control). Spraying was applied at the rate of per plant which was accomplished by the use of a Knapsack sprayer Cp-20 of 20-liter capacity. Pre-spraying counts were made just before spraying.

The post spraying counts were made after 3, 7 and 15 days from application. Random samples of 120 leaves were picked up from each replicate. A total number of 40 infested leaves for each treatment thus examined. By means of a stereoscopic microscope insect whitefly and its parasitoid were inspected.

2.2. Statistical analysis:

The percent reduction of infestation was statistically calculated according to the equation of (Henderson and Tilton, 1955).

$$\% \text{ mortality} = 100 \left[1 - \frac{Ta \times Cb}{Tb \times Ca}\right]$$

Where:

Ta = Post treatment insect counts

Cb = Untreated insect count before treatment

Tb = Pretreatment counts

Ca = Untreated insect count after treatment.

Results and discussion

1.Distribution of *Siphoninus phyllireae* in Egypt:

During the present work this species was recorded distributed and occurred in four governorates. These are Assuit, Daqahylia, Giza, Kafr El-Shikh and Qalyubiya. Tables (1-2) indicated that the numbers of population were reached maximum in Assuit governorate with 6421 and 6544 individuals / 80 leaves during October, 2017 and 2018. Followed by Giza governorate with 2100 and1998 individuals / 80 leaves during October, 2017 and 2018. The lowest numbers recorded in Qalyubiya with 1004 and 988 individuals / 80 leaves during October, 2017 and 2018.

These results observed the five areas of Egypt surveyed were distinctive in their locations as well as their weather. Assuit and Giza were highly abundant with *S. phyllireae*, both of these areas are nile river valley. South of nile Delta with Assuit about 300 Km south of Giza. Higher temperature in Assuit may correlate to higher whitefly. Abd-Rabou (2001b) recoreded this species distributed in three Governorates, these are, Assuit, Behira and Sinai.

Table (1): Distribution and occurrence **of *Siphoninus phyllireae* in Egypt during 2017**

Inception date	Kafr El-Shikh	Giza	Daqahylia	Qalyubiya	Assuit
June	750	1200	985	587	2059
July	841	1425	1345	698	3210
Aug.	956	1687	1541	842	4522
Sep.	1451	1894	1652	945	5500
Oct.	1654	2100	1756	1004	6421
Total	5653	8306	7279	4076	16212
Mean	1130.4	1661.2	1455.8	815.3	3242.4
%	11.3	16.61	14.55	8.15	32.42

Table (2): Distribution and occurrence **of *Siphoninus phyllireae* in Egypt during 2018**

Inception date	Kafr El-Shikh	Giza	Daqahylia	Qalyubiya	Assuit
June	633	1125	1001	455	2145
July	754	1500	1124	610	3321
Aug.	832	1612	1235	695	4462
Sep.	1241	1795	1478	758	5461
Oct.	1455	1998	1650	988	6544
Total	4915	8030	6488	3506	21933
Mean	983	1606	1297.6	701.2	4386.6
%	9.83	16.06	12.97	7.2	43.86

2. Efficacy of natural compounds on *Siphoninus phyllireae* and its parasitoid, *Eretmocerus parasiphonini* on pomegranate:

2.1. Efficacy of natural compounds on *Siphoninus phyllireae* and its parasitoid, *Eretmocerus parasiphonini* on pomegranate during the first season (2017):

In the first season, the average pre-spraying counts of larval stages of *S. phillyreae* and the average number of the parasitoid, *E. parasiphonini* are o.3-4.5 / leaf (Table,3). Results in Table (4) indicated that in the first season (2017), the average reduction of the three compounds (Jojoba oil, *P. fumosoroseus* and Sulfur) gave moderate toxic effect against *S. phillyreae*, percent reduction ranged between (39-45%) and while its parasitoid, *E. parasiphonini*, percent reduction ranged between (72-81%). Azadirachtin compound gave 56% and 72% for *S. phillyreae* and its parasitoid, *E. parasiphonini* mortality, respectively. On the other hand, ***Malathion*** gave high efficacy against *S. phillyreae* (75%) and *E. parasiphonini* (93 %). (Table, 4).

2.2. Efficacy of natural compounds on *Siphoninus phyllireae* and its parasitoid, *Eretmocerus parasiphonini* on pomegranate during the second season (2018):

In the second season, the average pre-spraying counts of larval stages of *S. phillyreae* and the average number of the parasitoid, *E. parasiphonini* are o.3-4.6 / leaf (Table, 5). Results in Table (6) indicated that in second year (2018), the average reduction of the three compounds (Jojoba oil, *P. fumosoroseus* and Sulfur) gave moderate toxic effect against *S. phillyreae*, percent reduction ranged between (41-53%) and while its parasitiod, *E. parasiphonini*, percent reduction ranged between (72-76%).

Azadirachtin compound gave 63% and 63% for *S. phillyreae* and and its parasitoid, *E. parasiphonini* mortality, respectively. On the other hand, malathion gave high efficacy against *S. phillyreae* (85%) and *E. parasiphonini* (95 %) (Table, 6). In the present work the traditional compound, malathion gave high efficacy against *S. phillyreae* ranged between (75-85%) and *E. parasiphonini* (93-95 %) during the two years under consideration. Abdel-Salam *et al.* (1971), Abdel-Salam *et al.* (1972), Shaheen *et al.* (1973), Darwish and Farghal (1990), Radwan *et al.* (1990), Mohamed *et al.* (1992), Hegab and Moawad (1994) and Hassan (1996) evaluated the efficiency of some traditional compounds as spray for the control of the whitefly. The results gave effective control and the mortality ranged from 87.95 to 96.75%. Kumar *et al.* (2005) tested the efficacy of two different commercial neem products (NeemAzal T/S 1% azadirachtin and NeemAzalU 17% azadirachtin) against the whitefly. Results indicated that reduction ranged from 74 to 82%. Results here research observed the mortality of Azadirachtin compound gave 56 -63% and 63-72% for *S. phillyreae* and its parasitoid, *E. parasiphonini* during the two years of the investigation, respectively. Azadirachtin-A (Aza-A) also recorded as an effective control measure of the whitefly by Badary (1997) and Swaran et al. (2008).

Also, during the present work Azadirachtin gave moderate mortality ranged between 56 -63% during the first and second years of the investigation, respectively. Abd-Rabou (2001a) tested Neemazal 3ml/L on the parasitoids of the whitefly on different host plants
and in different locations in Egypt. Results observed the present parasitism reduced from 37.1 to 24.5% for the *parasitoid.* Here the mortalities ranged from 64.17% to 61.30%. Successful parasitism was the lowest when adult parasitoids were introduced after dipping second instars in the *Melia azedarach* L. fruit extract and when whitefly nymphs were dipped in extract 2 d after parasitism. However, the level of parasitism in parasitized nymphs dipped in extracts 4 and 8 d after parasitism was comparable with that of the control. The number of dead whitefly nymphs in combined treatments declined as the age of whitefly nymphs at application increased, with a concomitant increase in successful parasitism (Abou-Fakhr and McAuslane, 2006).

Simmons and Abd-Rabou (2005) stated that the compounds when were sprayed on the crops at the rates of 5 ml/liter for jojoba oil, 1.5 to 2.5 ml/liter for M-Pede®; and 2 to 3 ml/liter for NeemAzal®. Regardless of concentration, parasitism by either *Encarsia sophia* (Hymenoptera: Aphelinidae) or *E. mundus* was low (< than 5% by each of 2 species). Parasitism was relatively high (~25-40% by each of two species) for crops treated with either NeemAzal® or M-Pede® at the lowest concentrations. In this investigation, results in indicated that in the first and second seasons (2013-2014), the average reduction of the three compounds (Jojoba oil, *Peacilomyces fumosoroseus,* Sulfur) gave moderate toxic effect against *S. phillyreae,* percent reduction ranged between (39-53%) and while its parasitiod *E. parasiphonini*, percent reduction ranged between (72-81%). Azadirachtin compound gave 56% and 72% for *S. phillyreae* and and its parasitoid, *E. parasiphonini* mortality, respectively.

Table (3): Average number of the *Siphoninus phyllireae* and parasitoid on pomegranate trees pre and after application of various control agents during season, 2017.

Treatment	Rate of Applic. /L.W	Pre spraying count					Average number after:														
							One week					Two weeks					Three weeks				
		1st	2nd	3rd	4th	P.	1st	2nd	3rd	4th	P.	1st	2nd	3rd	4th	P.	1st	2nd	3rd	4th	P.
Malathion	1.5 ml/L.	3.8	3.6	3.5	3.2	0.3	0.4	0.5	0.6	0.9	0.1	0.4	0.5	0.5	0.7	0.1	0.1	0.3	0.3	0.3	0.1
Azadirachtin	5 ml/L.	4.5	3.7	3.6	3.4	0.4	1. 7	1.9	1.9	2.09	0.2	1.1	1.6	1. 8	1.9	0.1	1.1	1.4	1.6	1.6	0.1
Jojoba oil	10 ml/L.	3.9	3.8	3.6	3.4	0.3	1.7	2.2	2.3	2.39	0.1	1.9	1.9	2.1	2.2	0.1	1.2	1.6	1.9	1. 9	0.1
Sulfur	2.5mg/Lw.	3.7	3.5	3.4	3.3	0.4	1.9	2.2	2.4	2.5	0.1	1.9	2.0	2.0	2.3	0.1	1.4	1.8	1.9	2.0	0.1
Paecilomyces fumosoroeus	5 ml/L.	3.9	3.8	3.5	3.4	0.4	2.3	2.4	2.4	2.5	0.1	2.2	2.3	2.2	2.4	0.1	1.6	1.9	2.0	2.2	0.1
Control	-	4.7	3.8	3.6	3.4	0.4	4.5	3.7	3.5	3.4	0.4	4.5	3.8	3.3	3.4	0.4	3.9	3.5	3.4	3.3	0.3

Table (4): Reduction percent induced by application various control agents for management the *Siphoninus phyllireae* and parasitoid on pomegranate trees during season 2017.

Treatment	Rate of Applic. /L.W	Reduction percent after:															Mean Total %	
		One week					Two weeks					Three weeks						
		1st	2nd	3rd	4th	P.	1st	2nd	3rd	4th	P.	1st	2nd	3rd	4th	P.	W.	P.
Malathion	1.5	88.5	85.3	81.3	73.2	89.1	90.	86.5	83.9	79.1	93.1	95.9	94.3	90.4	90.2	96.0	75	93
Azadirachtin	5 ml/L.	68.1	48.7	43.1	40.4	57.3	68.9	55.8	45.7	43.9	76.6	70.3	58.8	52.5	51.2	80.7	56	72
Jojoba oil	10 ml/L.	54.4	41.4	35.3	29.6	69.2	50.4	46.4	36.5	34.2	79.2	62.8	52.4	42.2	42.6	80.7	45	77
Sulfur	2.5	45.6	36. 6	28.0	25.6	75.0	45.1	41.8	35.6	31.8	84.2	54.7	43.2	41.2	36.9	86.5	40	81
Paecilom-yces fumosoroeus	5 ml/L.	38.0	36.1	29.8	25.3	62.2	40.8	38.8	33.1	28.8	74.0	49. 8	42.5	39.9	34.3	78.6	39	72

Table (5): Average number of the *Siphoninus phyllireae* and parasitoid on pomegranate trees pre and after application of various control agents during season, 2018 .

Treatment	Rate of Applic. /L.W	Pre spraying count					Average number after:														
							One week					Two weeks					Three weeks				
		1st	2nd	3rd	4th	P.	1st	2nd	3rd	4th	P.	1st	2nd	3rd	4th	P.	1st	2nd	3rd	4th	P.
Malathion	1.5 ml/L.	4.4	3.9	3.7	3.5	0.4	0.5	0.6	0.8	0.8	0.1	0.2	0.3	0.4	0.3	0.1	2.0	1.9	1.8	1.8	0.1
Azadirach-tin	5 ml/L.	4. 6	3.9	3.8	3.7	0.3	1.7	1.4	1.5	1.9	0.1	1.4	1.1	1.3	1.5	0.1	0.2	0.3	0.3	0.3	0.1
Jojoba oil	10 ml/L.	4.3	4.1	3.9	3.7	0.3	2.1	2.1	2.1	2.1	0.1	2.0	1. 8	1.9	2.0	0.1	1.2	1.1	1.3	1.3	0.1
Sulfur	2.5 mg/Lw.	4.0	3.8	3.7	3. 6	0.3	2.3	2.0	2.0	2.2	0.1	2.0	1.9	2.9	2.1	0.1	1.9	1.8	1. 9	1.8	0.1
Paecilom-yces fumosoroeus	5 ml/L.	4.3	4.0	3.8	3. 7	0.4	2.5	2.9	2.1	2.4	0.1	2.2	2.1	2.2	2.2	0.1	1.9	1.8	2.0	2.0	0.1
Control	-	4. 5	4.2	3.9	3.8	0.4	4.5	3.7	3.5	3.6	0.4	4.5	4.0	3.8	3.7	0.4	2.1	2.2	2.1	2.1	0.4

Table (6): Reduction percent induced by application various control agents for management the *Siphoninus phyllireae* and parasitoid on pomegranate trees during season 2018.

Treatment	Rate of Applic. /L.W	Reduction percent after:																
		One week					Two weeks					Three weeks					Mean Total %	
		1st	2nd	3rd	4th	P.	1st	2nd	3rd	4th	P.	1st	2nd	3rd	4th	P.	W.	P.
Malathion	1.5	88.4	82.6	76.8	75.5	9	95.3	91.2	90.3	90.3	95	95.4	93.4	90.6	90.0	97	88.3	95
Azadirach-tin	5 ml/L.	63.1	61. 9	55.7	46.2	5	69.3	68.6	64.7	57.1	64	73.0	71.1	66.7	64.1	74	63	63
Jojoba oil	10	51.7	42. 5	40.2	38. 5	69	54.8	51.2	49.2	43.8	78	55.0	52.2	50.9	49.2	82	53	76
Sulfur	2.5	44.5	41.3	37.7	35.8	68	50.8	45.1	44.3	38.8	75	51.5	50.2	45.9	42.3	79	44	74
Paecilomyces fumosoroeus	5 ml/L.	43.4	39.9	33.6	32.3	67	49.3	41.0	40.8	38.3	74	49.8	43.7	42.9	39.8	77	41	72

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Effect of different soil fungi on biological aspects of the oribatid mite *Nothrus silvestris* (Acari: Oribatida) in the laboratory

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Abstract:

Nothrus silvestris Nicolet (Acari: Oribatida: Nothridae) is a beneficial soil mite, considered as fungivorous grazer feeding on different kinds of soil fungi. In the present study, the feeding and reproductive biology of *N. silvestris* were recorded. Mites reared on nine different species of fungi isolated from tested soil under laboratory conditions in preequipped rearing vials. Data obtained showed that, *N. silvestris* preferred feeding on *Rhizoctonia solani* and *Alternaria alternate*. *Fusarium oxisporium* showed intermediate preferences, while rejected the other tested fungi as food items. Duration of development of *N. silvestris* extended to eight months when fed on young cultures of *R. solani* fungus, the average life span of adults reared on *R. solani* was 220.51±0.09. The longevity of females' *N. silvestris* was 145 days. All mites used in this experiment laid eggs, indicating that *N. silvestris* is thelytokous.

Introduction

Soil oribatid mites (Acari: Oribatida) are considered to be the most diverse and numerically the dominant group among soil micro-arthropods' mesofauna in all soil types. They have a great importance in improving the soil structure, they regulate decomposition rate (Walter and Behan-Pelletier, 1999), affect nutrient cycling and play an important role in soil fertility (Hartenstein, 1962). Finally, oribatid mites can control populations of pathogens which are related to their feeding habits (Crossley, 1977 and Enami and Nakamura, 1996). The development time for oribatid mites is long, lasting from several months to two years in temperate forests; they are characterized by low fecundity and low metabolic rates (Norton, 1994 and Behan-Pelletier, 1999).

Nothrus silvestris Nicolet (Acari, Oribatida, Nothridae) is a dominant oribatid species in Egyptian soils and considered to be a panphytophagous family feeding on decaying plant materials or fungi (Siepel, 1990). This species was classified as fungivorous grazer feeding on fungi, but its life cycle and developmental period still unknown due to its longitivity. Most species of Nothridae are parthenogenetic, sexual species are unknown (Siepel, 1990 and Norton *et al*., 1993).

From these perspectives, aims of the present study are to detecting the feeding biology of *N. silvestris* when reared on nine different species of soil fungi, and so monitoring its developmental period when feeding on the highly preferred food item.

Materials and methods

Soil samples were collected by steel corer of size (10 ×10 ×5 cm) from soil in Fesha-Sleem village, El-Gharbeia Governorate, Egypt vegetated with eggplants. Mites were extracted by Berleses' funnels and then mounted into lactic acid for identification for one to three weeks according to (Krantz, 1978). On the other hand, tested fungi were isolated from the same collected soil samples, purified on Potato Dextrose Agar (PDA) medium and identified according to Gilman (1957).

Isolated fungi were presented as food items as circular cuts on small agar discs of about (5 mm Ø) to five individuals of tested mite in plastic cups of (1.5 cm high x 2.5 cm in diameter) for five replicates to each fungus. The culture cups were pre-equipped; filled to their half by a layer of plaster of Paris "gypsum-charcoal" mix in a ratio (9:1). The surfaces of the medium were covered by filter paper perforated with non-deep hole. Finally, all culture vials were incubated in the dark at room temperature and moistened at 3-day intervals with 1 ml of distilled water to keep the humidity at a constant level (Schneider and Maraun, 2005).

Palatability of offered fungi to tested mite was examined daily by counting the number of fecal pellets deposited in close vicinity to each fungus. The breeding behavior and postembryonic development of tested oribatid mite were recorded weekly. The various developmental stages and total duration in days from egg to adult were monitored.

For statistical analysis, the relationship between preferability and suitability of the fungus for sustaining tested mite population growth was analyzed by (Pearson's correlation co-efficient). Developmental period of different stages and oviposition were determined.

Results and discussion

1.Feeding behavior of tested mite:

Data obtained showed that, there are nine species of fungi inhabit tested soil samples including; *Rhizoctonia solani, Alternaria alternata, Fusarium oxisporium, Aspergillus fumigates, Penicillium italicum, Penicillium digitatum, Aspergillus niger, Trichderma viride and Verticellium lecanii.*

Results showed a remarked difference in the palatability of offered fungi (Figure, 1). However, culture cups containing *R. solani* and *A. alternata* showed the highest consumption rates to tested mite among all offered fungi as indicated by the number of fecal pellets excreted, while *F. oxisporium* showed intermediate preferences. Finally, species of *A. fumigates, P. italicum, P. digitatum, A. niger, T. viride* and *V. lecanii* respectively showed less or no palatability. Furthermore, culture vials containing *R. solani* and *A. alternata* food items were renewed twice a week with no starvation occurs under filter paper substrate. While the plastic vials containing less preferred fungi were no renewed for long time. Tested mite when obligated to feed on a certain type of fungi of less or no palatability; they showed more starvation under filter paper and some mortality occurred in culture jars of *T. viride* and *V. lecanii* where they captured in the fungal threads. These results are compatible with study of Hartenstein (1962) who reported that, *N. biciliatus,* markedly differ in their feeding reactions to different foods, however rejected feeding on *Penicillium* sp. and *Aspergillus fumigatus*. Furthermore Saichuae *et al.* (1972) reported that *N. biciliatus* preferred feeding on yeasts and *Alternaria* sp. during their study.

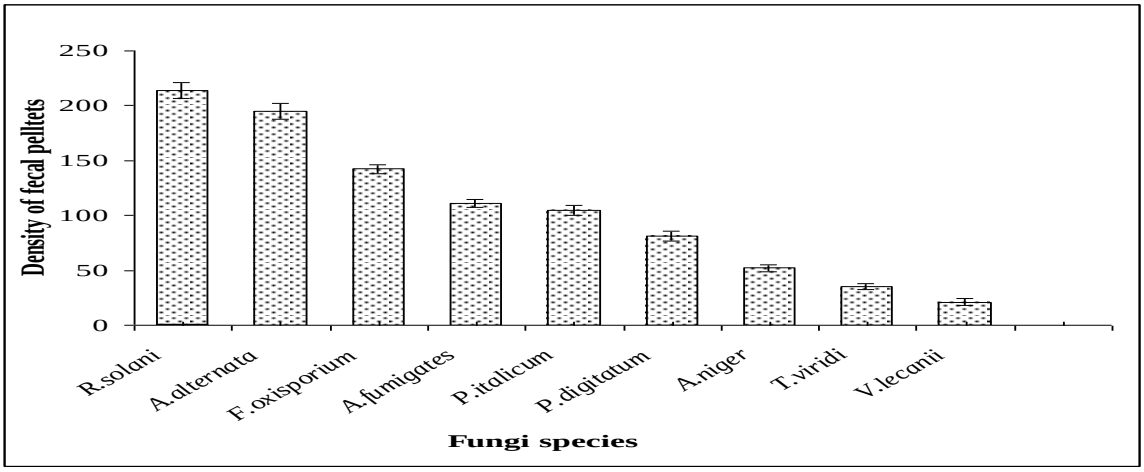

Figure (1): Numbers of fecal pellets deposited by *Nothrus silvestris* mite per day when feeding on nine different fungi in the rearing vials **(**Data are mean of five replicates ± standard deviation**)**

2. Developmental pattern of tested mite under different feeding guilds:

Some measure of the effect of suitable diets on the fecundity of *N. silvestris* was obtained in the following experiment, the palatable fungi *R. solani* and *A. alternata* showed high suitability for sustaining good growth of tested mite. Slight changes in developmental pattern may be observed among unpalatable fungi when concerned for sustaining growth of the tested mite. They showed low numbers of eggs and larvae and without any protonymphs, with respect to the mortality of some adults of mite in the rearing vials.

Figure (2) showed the relationship [positive correlation (Pearson's correlation coefficient) R^2= 0.93, P < 0.005] between preferability of tested fungi as food items and their suitability for sustaining good growth of *N. silvestris* mite. That is evaluated when the number of fecal pellets deposited on each fungus and the number of emerged instars on each fungus after 30 days of rearing. Additional points should be noted. Firstly, some foods, such as *F. oxisporium*, *A. fumigates* did not support good mite growth and development in spite of being consumed.

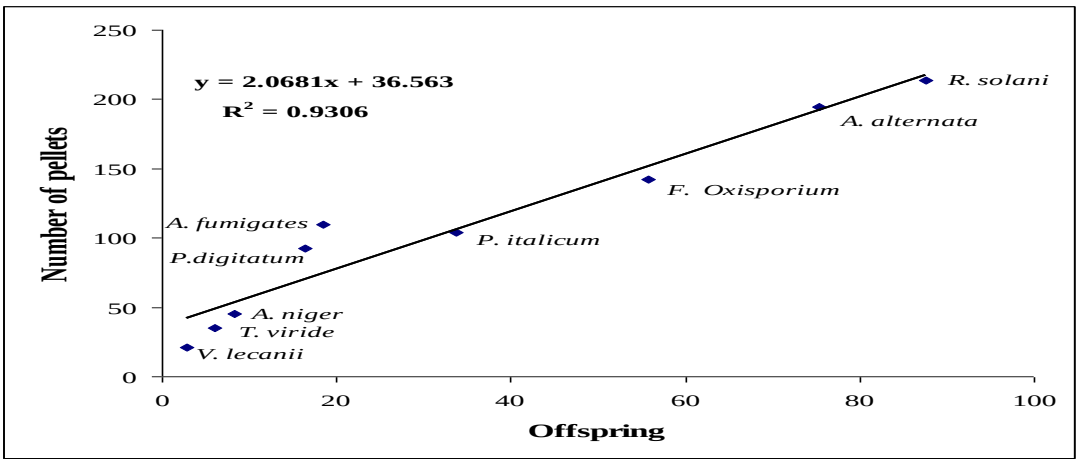

Figure (2): The relationship between preferabilty of nine tested fungi and their suitability to support growth of *Nothrus silvestris* mite (data the number of fecal pellets deposited from feeding on each fungus against the number of all offspring formed on each fungus after 30 days of rearing).

3.Immature survival and developmental times:

The developmental stages of *N. silvestris* include egg, larva, protonymph and deutonymph and tritonymph, each growth stage was determined by the presence of exuviae. The duration (in days) of egg and larval stage was the lowest, the deutonymphal and tritonymphal stages were the highest and are of approximately equal duration (Table, 1). The average life span of adults reared on *R. solani* was 220.51±0.09. The experiment was carried out at room temperature. The developmental period of *N. silvestris* was long to that reported for this species. No mortality was found on immature stages, which indicates the high possibility of survivorship of immature stages of *N. silvestris*. Some mortality of *N. silvestris* found on *A. niger T. viride and V. lecanii* due to starvation. A white colored integument on dorsal surface of *N. silvestris* was observed on *R. solani* food. This difference may be determined by variations on abiotic conditions, food intake and age.

Table (1): Duration (in days) of developmental stages of *Nothrus silvestris* feed on *Rhizoctonia solani*

Developmental stages	Number	Development time (days)
Egg	3.1±0.05	2.30±0.15
Larva	4.3±0.19	8.26±0.17
Protonymph	13.2±0.11	14.19±0.21
Deutonymph	20.05±0.12	23.12±0.34
Tritonymph	26.04±0.09	27.31±0.09
Life cycle		75.18±0.093
Life span		220.51±0.09

4. Adult life parameters:

The biological parameters of adults, preoviposition period together with other female adult periods and longevity are shown on (Table, 2). Preoviposition lasted for 9-11 days. Oviposition occurring approximately 5 weeks, and oviposited 4 months after emergence of the adult. The longevity of females' *N. silvestris* was 145.33± 0.34 days. The first eggs were laid approximately within the fifth or sixth day of rearing. The average number of eggs laid per female was 2-4 eggs per time. Adult of *N. silvestris* reached the highest rate of egg lying on the tenth day. All mites used in this experiment laid eggs, indicating that *N. silvestris* is thelytokous. The average pre-oviposition, oviposition and post-oviposition periods were 9.55±0.34, 121.78 ± 0.85and 14 ± 0.18 days, respectively. Survival rates of adults were very high; the longest-lived individual died at 145 day.

Table (2): Duration (in days) of preoviposition, oviposition and postoviposition periods, longevity (days) of adult *Nothrus silvestris* on *Rhizoctonia solani*.

Stage	Mean ± SD
Preoviposition	9.55±0.34
Oviposition	121.78 ± 0.85
Postoviposition	14 ± 0.18
Longevity	145.33± 0.34
Generation period	84.73± 0.17

In a brief description of the general features of *N. silvestris* adults; they have a strong and dark exoskeleton with distinct ventral marks and plates (Photo, 1). The newly emerged instars are dramatically different than adult and appear to vary in size. Larva is having small body, which is creamy white in color, body is soft and without any sclerotization, it also possessed three pairs of legs and is very sluggish in movement (Photo, 2). Protonymph is easily distinguished from larva by its larger body size, body is creamy in color, and integument is ornamented with some punctations and possessed four pairs of legs (Photo, 3). Deutonymph is distinguished by its slightly bigger size with four pairs of legs, integument is provided with more punctations and possessed long notogastral setae (Photo, 4). Finally, Tritonymph is characterized by its larger body size, the notogastral setae is longer and body is more turgid and colored pale brown (Photo, 5). Fecal pellets of *N. silvestris* deposited from feeding on *R. solani* within feeding cups

were examined in (Photo, 6) consisted of crushed hyphae of fungus, fungal propagules within food bolus and mucoid substance. Photo (7) showed the adult and immatures of *N. silvestris* mite while wondering on the filter paper substarate of the feeding vials. Emerged immature of *N. silvestris* emerged from feeding on fungal food cut were showed in Photo (8).

That is important to understand the niche differentiation between oribatid mite species according to the availability of their preferred food in their habitat and the influence of oribatid mite species on the dispersion of its relative soil fungi. Binding the relationship between palatability of the fungus as food item and its suitability to support mite's population growth is important in regulating the soil ecosystem and improving soil quality.

It is concluded that the present work about the biology and feeding behavior of *N. silvestris* has contributed to increase knowledge about this mite and its potential as a beneficial mite in soil fertility, but many aspects need further study to fully use its potential in soil improvement. The effect of palatability and suitability of a fungus for sustaining mite population growth is an important issue to elucidate the possible high species richness of tested oribatid mite in soil in relation to availability of their preferred fungi in their niche

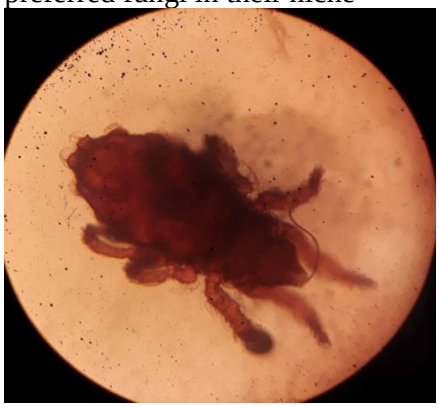

Photo (1): Microscopic photo of adult *Nothrus silvestris* mite.

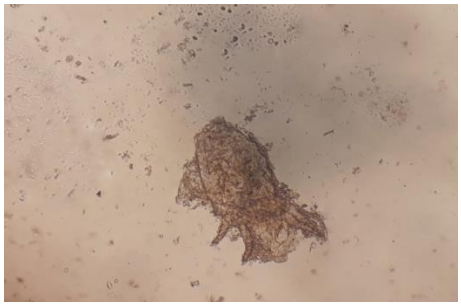

Photo (2): Newly emerged hexapod larva of *Nothrus silvestris* at 20x magnification

Photo (3): The octapod protonymph stage of *Nothrus silvestris*. At 20x magnification**.**

Photo (4): The octapod deutonymph stage of *Nothrus silvestris* at 20x magnification

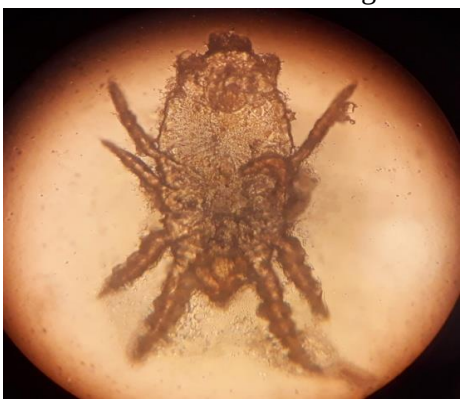

Photo (5): The octapod tritonymph stage of *Nothrus silvestris* at 20x magnification

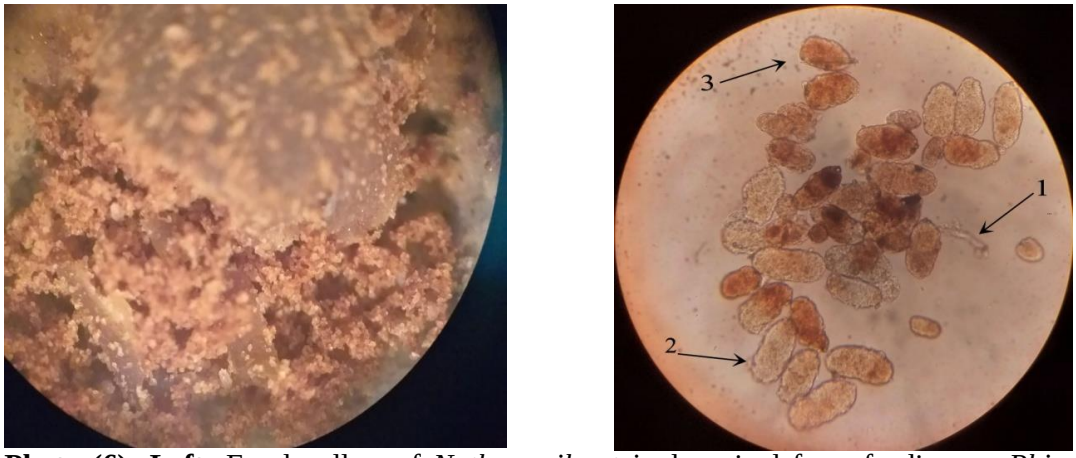

Photo (6): Left: Fecal pellets of *Nothrus silvestris* deposited from feeding on *Rhizoctonia solani*, consisted of (1) crushed hyphae (2) food bolus consisting of fungal propagules (3) mucoid substance at 20x magnification. **Right:** Fecal pellets of *Nothrus silvestris* deposited on *Rhizoctonia solani* within feeding cups, at 4x magnification

Photo (7): Adult and immature of *Nothrus silvestris* mite while wondering on the filter paper substarate of the feeding vials at 4x magnification

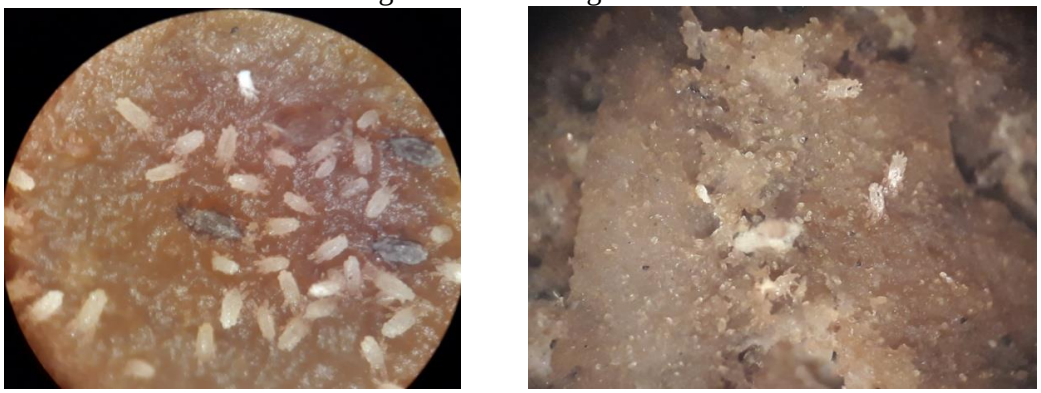

Photo 8): Emerged immature of *Nothrus silvestris* on fungal food cut at 4x magnification.

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Ecological studies of California red scale, *Aonidiella aurantii* (Hemiptera: Diaspididae) infested *Citrus sinensis* in Giza Governorate

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Abstract:

The California red scale, *Aonidiella aurantii* (Maskell) (Hemiptera: Diaspididae) is considered a key pest of citrus that has spread during the last decades up to cover a vast extension of agricultural landscapes. It was detected in *Citrus sinensis* var. balady of a private orchard located at El-Saff, area, Giza Governorate. During two years 2014 and 2015, *A. aurantii* population dynamics and seasonal trends were studied on this *Citrus* variety. The results indicated that, population of *A. aurantii* recorded three activity peaks of abundance and three overlaping generations/year. In the first year of study three peaks of infestation were recorded in mid-May, mid-August and October first, while in the second year, these peaks were observed during May first, August first and October first. The first generation of first year started from February first till the mid- May. The second generation was extended from mid-May till the mid-August, third generation was indicated on mid -August till the mid- December. *A. aurantii* showed the same trend with the second year and had three generations. The duration of the first one was extended from mid-January to May first and the second generation lasted from May first to August first, while the third generation from August first till mid-December. The calculated infestation rates of *A. aurantii* were high in summer, spring and autumn months, whereas, relatively low rate of infestation were recorded with winter months in both years. There was positive significant relationship between metrological factors and the total population of *A. aurantii* and a simultaneous occurrence of the total population of *A. aurantii*, while relative humidity relations was negative in first season and positive in the second season but insignificant in both.

Introduction

Citrus come second only to grapes in planting production of fruit trees worldwide (Spiegel-Roy and Goldschmidt, 1996) and the most important fruit crops in Egypt. Its plantations reached nearly 395.731 feddans producing 3.730.685 tons in Egypt, according to the 2011 statistics of the

Egyptian Ministry of Agriculture, The California red scale *Aonidiella aurantii* (Maskell) (Hemiptera: Diaspididae) is one of most important pests infested citrus trees in different parts of the world (Karaca, 1998; Claps *et al*., 2001 and Abd-Rabou, 2009). This pest instars its mouthparts deep into plant tissue and sucks sap from parenchyma cells. Prolonged infestation may cause leaf drop and defilation and dieback of twigs and eventually large branches. Maturing fruit can become completely encrusted with scales; developing scales form prominent pits on young fruit which are still evident when the fruit matures. Such fruit tend to dry out and fall off. Even the trunk can become heavily infested (Bedford, 1998). Considerable differences in the population densities of this pest were recorded in different parts of the world Selim,1993 and Morsi,1999 in Egypt; Yarpuzlu *et al*. (2008) in Turkey and Kaiju (2013) in Youxi county of Fujian province, Chinese.

The present study was conducted throughout two successive seasons from early January, 2014 till December, 2015. The scope of the study included the seasonal changes in the population densities of the California red scale, *A. aurantii* on *C. sinensis* var. balady in private orchard located at El-Saff area, Giza Governorate, duration and number of generations under the field conditions as well as the effect of daily means of temperature and relative humidity on its activity to select an effective program for its control.

Materials and methods

1. Location and sampling;

The present work was carried out on *C. sinensis* of private orchard (called Shaarany orchard) located at El-Saff area, Giza Governorate for two year extending from early January, 2014 until December,2015. The selected orchard received the normal agricultural practices without application any control measures before and during the period of study. Ten trees were selected at the grove infested with *A. aurantii* Selected trees were approximately similar in size, shape, height and vegetation. Samples were picked up at two-week intervals throughout the study. Samples size was 20 leaves representing cardinal directions (east-west-north-south) and tree core. The samples were packed in polyethylene bags with minute holes then transferred directly to the laboratory for examination, using stereoscopic microscope binocular.

2.Meteorological data:

To reveal the relation between climatic condition and fluctuation of *A. aurantii* population, means of daily temperature, relative humidity and wind at Giza Governorate were obtained from the Meteorological Station of the Agricultural Research Center, Egypt and the half monthly mean was calculated.

3.Statistical analysis:

All parameters concerning *A. aurantii* population density on balady orange trees were reduced to three-specific means and these means were used in statistical analysis. All data were evaluated statistically using ANOVA and means compared using Duncan's Multiple Range Test at $P<0.05$). The relationship between the population density of *A. aurantii* and both temperature (Maximum and minimum temperature) and relative humidity (R.H.) were tested using simple correlation and multiple regression analysis. All statistical analyses were done using the software package Costat (Costat, 2005).

Results and discussion

1.General trend of population fluctuation of *Aonidiella aurantii* on *Citrus sinensis* trees:

Results represented in Table (1) and illustrated in Figure (1) showed the half monthly means of nymphs and adults (females) and total population density of *A. aurantii* infesting *C. sinensis* var. balady in Giza Governorate during 2014 year. Density of *A. aurantii* nymphs on citrus trees was low during January, February and

March then began to increase gradually to form a small significant peak on May first (888 nymphs/20 leaves/tree), then two large approximately equal peaks on August first (1854 nymphs/20 leaves/tree) and the beginning of October (1960 nymphs/20 leaves/tree). Also, three peaks of adult females were observed on mid-May (621 adult females /20 leaves/tree), mid-August (1387 adult females/20 leaves) and mid-October (1550 adult females /20 leaves/tree).

Overall combined numbers of individuals (Nymphs and adult females) on balady citrus leaves indicated that activity of *A. aurantii* extended from February to November with a small activity peak on May first (1239 individuals/ 20 leaves/tree), peak of intermediate population density during mid-August (2725 individuals /20 leaves/tree) and the large peak on mid-October (3075 individuals /20 leaves/tree). Results of the second year of investigation (2015) as represented in Table (1) and Figure (2) showed that general population trends, number of peaks of nymphs and adult females of *A. aurantii* were similar to those in the previous year, (2014). Density of *A. aurantii* nymphs on citrus leaves have significant peak on May first (634 nymphs/20 leaves/tree) and two large peaks on mid-July (1094 nymphs/20 leaves/tree) and mid-September (1570 nymphs/20 leaves/tree). The three peaks of adult females were observed on May first (475 adult females/20 leaves/tree), August first (919 adult females/20 leaves/tree), and mid-October (1189 adult females /20 leaves/tree).

Table (1): Half monthly mean counts of *Aonidiella aurantii* **of different stages, on** ***Citrus sinensis*** **trees during two years 2014 and 2015.**

Date of inspection	Mean number of individuals/20 leaves						Temp.				R.H. %	
	2014			2015			2014		2015			
	Nymph	Adult	Total	Nymph	Adult	Total	Max.	Min.	Max.	Min.	2014	2015
01-Jan	107	160	267	125	158	283	18.6	10.2	20.06	11.5	68	56.44
15-Jan	84	104	188	91	124	215	21	11.06	15.07	8.6	50.06	51.47
01-Feb	60	57	117	88	30	118	19.73	10.53	20.19	11.25	60.2	49.31
15-Feb	148	42	190	96	43	139	21.38	11.69	19.73	10.6	62.15	42.33
01-Mar	197	83	280	126	101	227	23.2	13.87	18.62	9.77	44.87	57.77
15-Mar	240	126	366	181	136	317	24.56	13.63	23	13.2	53.31	58.73
01-Apr	330	178	508	297	191	488	26.6	14.73	24.44	13.25	46.13	48.44
15-Apr	481	300	781	514	247	761	30.33	17.8	24.33	14	45.87	48.27
01-May	888	351	1239	634	475	1109	30.33	19.87	28	15.27	40.53	41.53
15-May	578	621	1199	448	410	858	32.19	20.13	29.2	17.33	44.5	50.27
01-Jun	498	410	908	369	319	688	32.19	20.13	33.63	20.19	44.5	41.56
15-Jun	466	325	791	502	398	900	32.67	21.47	31.27	20.4	45	51.47
01-Jul	537	297	834	777	509	1286	35.13	22.53	33.07	22.4	44.87	47.87
15-Jul	1090	368	1458	1094	757	1851	34.8	23.13	32.67	22.4	53.2	55.4
01-Aug	1854	512	2366	906	919	1825	33.63	23.44	35.94	23.81	54	49
15-Aug	1338	1387	2725	697	520	1217	34.67	24.27	37.27	26.73	53.13	47.8
01-Sep	1150	909	2059	803	593	1396	35.44	24.56	35	25.31	56.13	56.19
15-Sep	1519	835	2354	1138	684	1822	33.73	23.87	35.13	24.4	51.87	57.87
01-Oct	1960	780	2740	1570	895	2465	33.13	22.93	35.47	24.87	49.73	44.53
15-Oct	1525	1550	3075	727	1189	1916	29.73	19.07	31.6	21.93	55.4	58.2
01-Nov	1053	1104	2157	488	816	1304	28.19	19.06	29.63	20.25	51.13	58.38
15-Nov	992	810	1802	318	378	696	26.2	16.53	25.53	16.67	53.6	68.47
01-Dec	515	527	1042	274	300	574	22.13	14.2	24.6	15.33	64.6	59.73
15-Dec	273	408	681	139	199	338	23.47	13.73	19.93	11.33	57.53	63.8
Total	17883	12244	30127	12402	10391	22793						
Average	745.1	510.2	1255	516.8	433	949.7	28.46	18.02	27.64	17.53	52.1	52.7

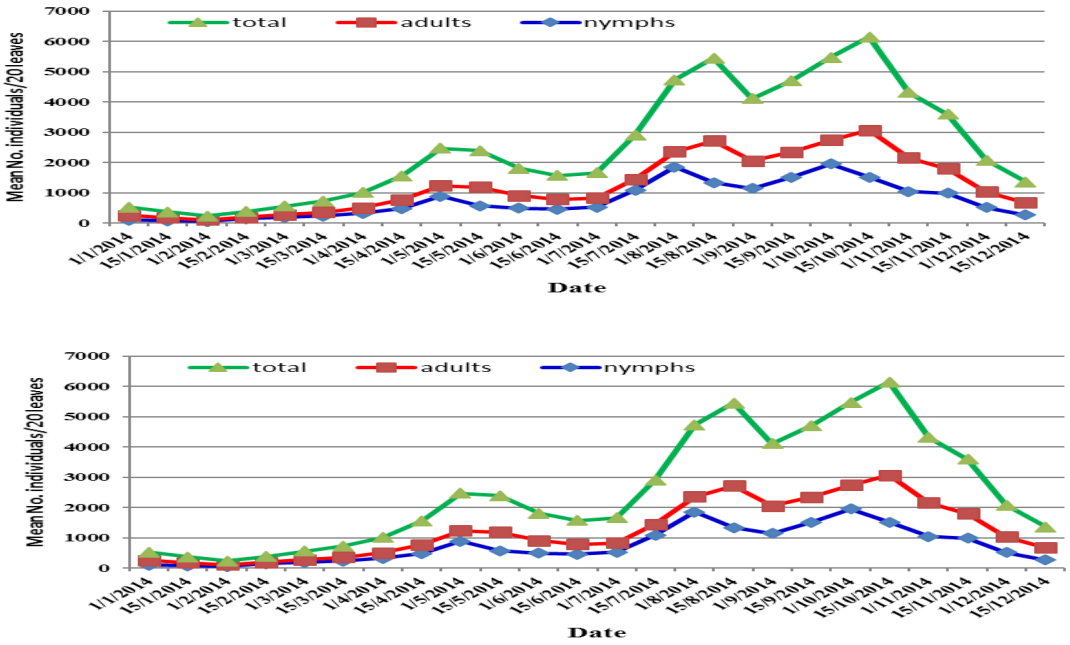

Figure (1): Half monthly mean counts of *Aonidiella aurantii* **of different stages on** ***Citrus sinensis*** **trees during the first year (2014).**

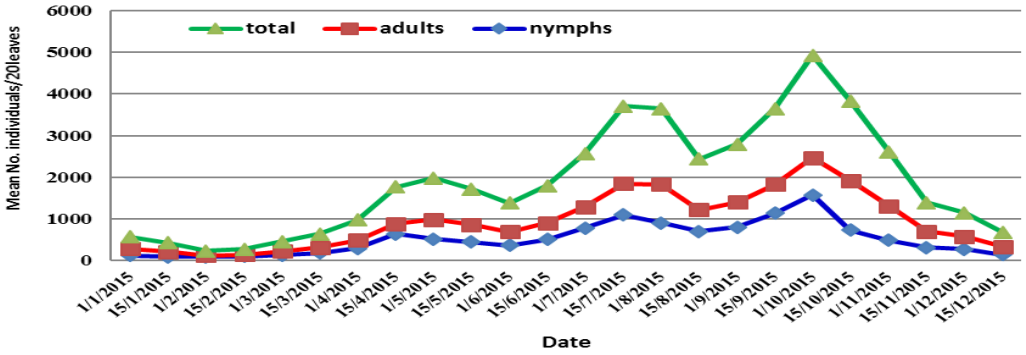

Figure (2): Half monthly mean counts of *Aonidiella aurantii* **of different stages on** ***Citrus sinensis*** **trees during the second year (2015).**

The total numbers of individuals (nymphs and adult females) on citrus leaves indicated that activity of *A. aurantii* extended from February to December with three activity peaks on May first (1109 individuals/20 leaves/tree), mid-July (1851 individuals/20leaves/ tree) and October first (2465 individuals /20 leaves/tree). Generally, the obtained results in the first and second year of study showed that, the insect population reached maximum during August in the two years, while it highest population level recorded in October. The pest population reached its minimum level in winter during mid-January and February first in the two seasons.

These results are consistent with that obtained by Selim (2014) stated that population of *A. aurantii* had three annual peaks on Balady orange during the two successive seasons at Giza governorate and four peaks on Succari orange. The obtained results of Farghaly *et al* .(2016) showed that, during the first season of investigation, *A. Aurantii* had three peaks of nymphs representing overlapping generations per season, which occurred in the first and second years (2011/2012 and 2012/2013). The 1st peak appeared in March, the 2nd

peak was observed in June while, the 3rd peak was in Oct. The first peak of crawlers is observed around the end of May, the second at the end of August and the third around November depending on the climatic conditions (Ripollés, 1990; Rodrigo and García-Marí, 1992). From September 2009 to August 2010, *A. aurantii* was able to produce 3 important peaks, one in the autumn, the second one in the winter season, third one in the spring and the fourth one in the summer period (Belguendouz-Benkhelfa *et al*., 2013).

2.Number and duration of annual field generations:

The number of generations of *A. aurantii* under the field conditions was taken from the annual number of peaks of nymphs. The number of annual generations of *A. aurantii* during the two years on citrus trees is graphically illustrated in Figures (3 and 4). *A. aurantii* had three overlapping generations (Figure, 3); the first generation took about three months and half, started from 1st of February till the mid of May 2014 (the maximum number of nymphs occurred on the mid of May). Duration of the second generation was nearly three months (extended from mid of May till the mid of August), its peak was indicated on 1st of August. Third generation was indicated on mid of August till the mid of December. Its peak was recorded on 1st October. This means that both first and second generations continued over 90 days each compared with the third generation which continued for 120 days.

As for the results of the second year 2015 (Figure, 4); *A. aurantii* showed the same trend and had three generations. The duration of the first one was about three months and half (extended from mid of January to 1st of May) its peak attained on the 1st of May. The second generation lasted for about three months from 1st of May to 1st of August, with the peak on the mid July. The third generation took about four months and half (from 1st of August till mid December) its peak was evident in 1st October.

Selim (2014) concluded that California red scale insect had three generations per year during February-May, April-August and August-December. While in the second year, these generations were during March-June, May-October and October-March. These results were agreed with Habib *et al*. (1972); Selim (1993) and Morsi (1999) in Egypt, who found that this insect had 3-4 generations per year on citrus, Yarpuzlu *et al*. (2008) in Turkey, Kaiju (2013) in Youxi county of Fujian province, Chinese, mentioned that three generations of red scale may develop annually on citrus. Rizk *et al*. (1978) stated that *A. aurantii* have five annual generations in Middle Egypt. Moustafa (1992) reported that the california red scale have 3-4 generations which varied according to host and zone of trees.

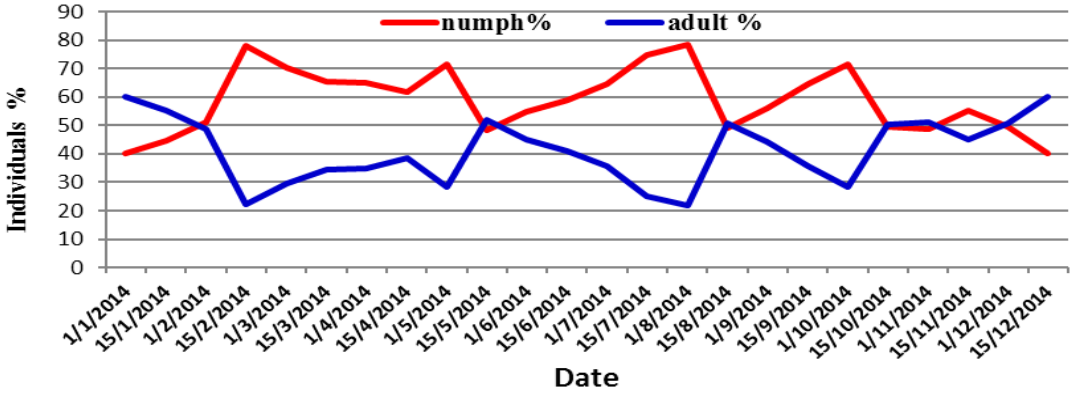

Figure (3): Annual generations and their durations of *Aonidiella aurantii* on *Citrus sinensis* trees, at Giza Governorate during the first year (2014).

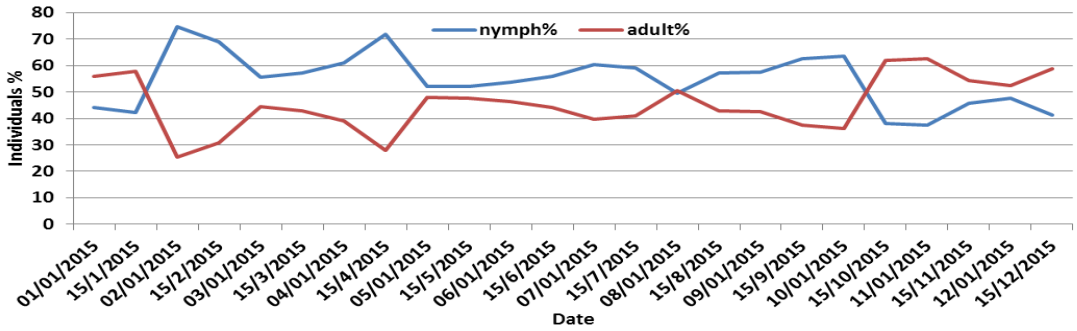

Figure (4): Annual generations and their durations of *Aonidiella aurantii* on *Citrus sinensis* trees, at Giza, Governorate during the second year (2015).

3.Effect of prevailing hygrothermic conditions on the population densities of *Aonidiella aurantii*:

The measured relationships between the population densities of *A. aurantii* and the main weather factors (Maximum and minimum temperatures and relative humidity) were studied during two studied years, (2014-2015) in Giza governorate as in Table (2).

3.1. Effect of daily maximum temperature:

Results in the Table (2) showed that, there are positive significant correlation between the total insect population activity and maximum temperature (r=0.658 and 0.845) in both years, (2014-2015). The partial regression coefficient value (P.reg= 23.56 and 18.74) showed highly positive significant in the two years.

3.2. Effect of the night minimum temperature:

The effect of minimum temperature on the total population during two years of study (Table, 2) indicated highly positive significant correlation during the two years (r=0.842and 0.872) respectively. The single effect of this factor on the total population activity appeared from (P.reg = 13.51and 10.93) which was positive significant effect.

3.3. Effect of daily mean relative humidity:

Daily mean relative humidity (Table, 2) had negative relation, insignificant on the total population (r = -0.047) in 1st year but positive relation insignificant (r = 0.083). The single effect of this factor on the total population activity appeared from the partial regression coefficient value (P.reg = 52.54 and 53.53) which was positive insignificant effect in both years.

3.4. The combined effect of daily mean temperature and humidity: -

The combined effect of climatic factors on California red scale, *A. aurantii* during the two years of study (Table, 2) was significant (F=14.193 and 9.110) and the explained variance (E.V) presented (68% and 57.7%) during the two years of study. In general, the population densities of *A. aurantii* depend on the temperature and relative humidity. According to (Abdelrahman, 1974), low temperatures are the most determinant factor for the abundance and distribution of the scale *A. aurantii* and the duration of the life-cycle of *A. aurantii* increases under the influence of low temperatures. El-Shouny (1987) stated that winter low temperature plays a great role in population reduction during winter and produces the greatest mortality in this respect. Population increases are observed under conditions of low humidity when temperatures are below 30oC and high humidity when temperatures are higher (McLaren, 1971). According to Bodenheimer (1951), optimum conditions for the development of the scale are temperatures between 23 and 27.5°C and 70 – 80% de R.H.

Table (2): Effect of both temperature and relative humidity on Aonidiella aurantii total population on citrus leaves at Giza Governorate, Egypt during the two studied years (2014-2015).

Statistical Parameters	First year (2014)			Second year (2015)		
	Temperature		R.H.%	Temperature		R.H.%
	Tmax.	Tmin.		Tmax.	Tmin.	
Simple correlation						
Corr.Coef. (r)	0.658 ±0.16	0.842±0.12	-0.047±2.13	0.845±0.11	0.872 ±0.10	0.083±0.21
Probability(p)	< 0.0005	< 0.0001	0.8287	0.0001	0.0001	0.7005
Correlation significant	Yes	Yes	No	Yes	Yes	No
Partial Regression						
Partial Regres. Coef (b)	23.56± 3.06	13.51± 2.34	52.54 ± 5.17	18.74±2.68	10.93 ± 2.12	53.53± 5.38
Regression Coefficient r^2	0.433	0.563	0.002	0.714	0.761	0.007
F-value	16.8	28.363	0.048	55.02	69.935	0.152
Probability (p)	< 0.0005	< 0.0001	0.8287	0.0001	0.0001	0.7005
Regression significant	Yes	Yes	No	Yes	Yes	No
Combined factors						
E.V (Explained variance)	68			57.7		

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Abundance and generation determination of the seychelles fluted scale, *Icerya seychellarum* (Monophelibidae: Hemiptera) infested mango trees at Qaluybyia Governorate

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Abstract:

The seasonal abundance of the seychelles fluted scale, *Icerya seychellarum* (Westwood) (Monophelibidae: Hemiptera) was studied for two years (September first, 2012 until mid-August, 2014) on mango trees at Qaluybyia Governorate. The obtained results showed that *I. seychellarum* has four peaks and presence of three overlapping generations in both years under field conditions. Over the first and second years the first generation (winter/autumn) started from September first until mid-February, 2013 as the terminal of the first generation (marked by maximum population of adult females). The following count showed that most of these females were in ovipositing stage in a much-synchronized fashion (which indicates the optimal condition for the development of *I. seychellarum*. The second generation (spring) started from mid- February and continued until the date of mid- May 2013. Therefore, the mid- May was considered as the end point of this generation and start point for the third generation (summer) which continued to the next year. Reviewing proved that the obtained results, it could be that the first generation continued over 165 days, also the second generation continued 90 days compared with the third one which continued 90 days. Also, there were positive relationship between metrological factors and the total population of *I. seychellarum* (The higher the temperature, the greater total population of *I. seychellarum*, while the lower the temperature, the lower total population of *I. seychellarum*). Four peaks of *I. seychellarum* total population simultaneous with moderate and high temperatures. While the low temperatures (from December first until the end of February) the population of *I. seychellarum* was low due to its hibernation as adult females. The data showed simultaneous occurrence of the total population of *I. seychellarum* and its associated predator, *Rodalia cardinalis* (Mulsant) (Coleoptera: Coccinellidae).

Introduction

Mango (*Mangifera indica* L.) is of the most important and popular fruits in Egypt (Attia, 2010). Mango is tropical/sub tropical fruit with highly significant economic importance, the fruit rich in antioxidants and recommended to be include in the daily diet due to its health benefits such as reduce risk of cardiac disease, anti cancer, and anti viral activities (Sivakumar and Yahia, 2011).

The seychelles fluted scale, *Icerya seychellarum* (Westwood) is a polyphagous phloem-feeding coccid belongs to the family: Monophelibidae, order: Hemiptera. They feed on the underside of leaves sucking out plant sap. At high infestation levels, serious damage resulting in early leaf drop and yield reduction is caused by the feeding of this insect, but the major damage is caused by the production of large amount of honeydew upon which saprophytic fungi develop, which fluctuates with photosynthesis and respiration (Zaki *et al.,* 2013 and El-Sayed, 2015) and otherwise reduces the quality of the plant causing considerable economic injury, moreover, high population of *I. seychellarum* can reduce the vigor of the plant, making it susceptible to other pests (Osman, 2005). Population of *I. seychellarum* showed four and three annual generations on mango trees in Giza and Qena Governorates, respectively (Abdel-Rahman *et al.,* 2007 and Bakry, 2009). Also, the four tested factors (maximum temperature, mean temperature, minimum temperature and mean relative humidity) simultaneously were responsible for about 32.8-65% of this insect activity (Sayed, 2008).

Rodalia cardinalis (Mulsant) (Coleoptera: Coccinellidae) is a specialist predator that has a very restricted prey range, one that is probably limited to the family Monophlebidae, and possibly the tribe Iceryini. Strong prey fidelity by *R. cardinalis* has two major advantages in a classical biological control program: (1) high safety results because little threat is posed to non-target species because they are unsuitable food sources, and (2) high levels of population suppression occur because tight ecological and biological linkages ensure that maximum feeding and reproductive pressure are maintained on the target because *R. cardinalis* is unable to attack and breed on other prey species (Hoddle, 2004).

The present work was carried out to study ecological aspects of *I. seychellarum* determines its generations under the studied conditions using age structure method and the proper timing for its control as well as dynamics of R. *cardinalis*.

Materials and methods

1. Seasonal fluctuation of *Icerya seychellarum* in Qaluybyia Governorate:

The present work was carried out for two successive years in heavy infested mango orchards during (September first, 2012 to mid-August, 2014) in (El-Qanater area) Qaluybyia Governorate.

The seasonal fluctuation of *I. seychellarum* population was carried out on 12 trees similar in size, shape and vegetation. Biweekly samples of 120 leaves were picked up (10 leaves/tree) from the four directions of each tree divided in three replicates. The collected samples were put in paper bags and transferred to the laboratory for inspection with stereo-microscope. The population of *I. seychellarum* per each sample was sorted into their developmental stages (nymphs, adult females and oviposting females). The total number of the individuals in each sample was taken as the population index. Obtained data was pooled for each inspection, direction and leaf surface. Any observed predator individual was recorded and counted. Identification of true mealybugs insects and their predator was done by taxonomy specialists at Scale Insects and Mealybugs Research Department, Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt.

2. Age structure calculation:

To calculate the age structure per sample, the mean number of each stage was divided by the total and multiplied by 100. This way gave each stage a percent proportion of the total per sample regardless the total number of presented insects (*i.e.* population density). The number of generations was determined using the obtained data throughout the two successive years using the age-structure technique per sample over the year.

Generation was defined, as the time required for an insect to complete its life cycle (*i.e.* egg to egg). In the case of monophelibid, eggs were oviposited under the female in ovisac until they hatch and crawl out. Oviposting females were defined as females with ovisac. The presence of oviposting females (*i.e.* the transformation of adult females to oviposting females) was considered in this study as presence of the egg stage. This phenomenon was used to determine the end of each generation and the beginning of the next one (El-Amir, 2009).

3. **Meteorological factors**

Weather factors data assumed to affect studied insects (*i.e.* maximum and minimum daily temperatures and mean percentage of daily relative humidity) were obtained for the Qaluybyia area from the Egypt-Weather Underground https://www.wunderground.com/global/EG.html. Obtained data was summarized for each fourteen days previous to the sampling date. Considered weather factors means over each determined generation was calculated and presented.

Results and discussion

1.Seasonal abundance of *Icerya seychellarum*:

Data in (Figures, 1 and 2) illustrated that nymphs, adult females and oviposting female stages curves had four peaks during two years. Nymphs recorded on [(mid - October, March first, mid- June and August first with 45, 37, 30 and 34 nymphs/leaf) and (mid - October, mid - March, June first and August first with 52, 38, 35 and 37 nymphs 4/leaf)], respectively.

Also, adult females recorded [(on mid (September, December and April) and October first with 5, 9, 12 & 10 adult females/leaf) and (on mid (September, November and April) and October first with 9, 17, 12 and 10 females/leaf)], respectively. Finally, oviposting females recorded on (first of October, March, June and August with 11, 5, 9 and 10 oviposting females/leaf) and (first of October, March, June and August with 12, 8, 9 and 9 oviposting females/leaf), respectively.

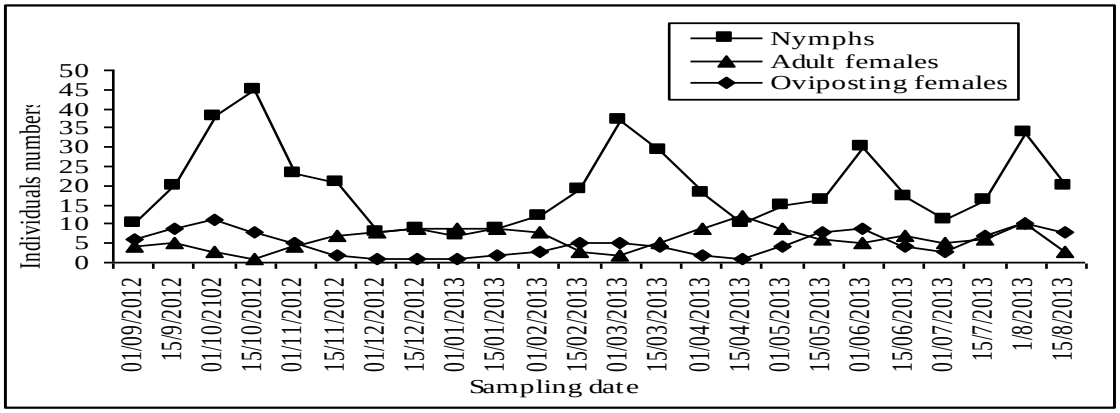

Figure (1): Seasonal abundance of *Icerya seychellarum* on mango trees during 2012-2013.

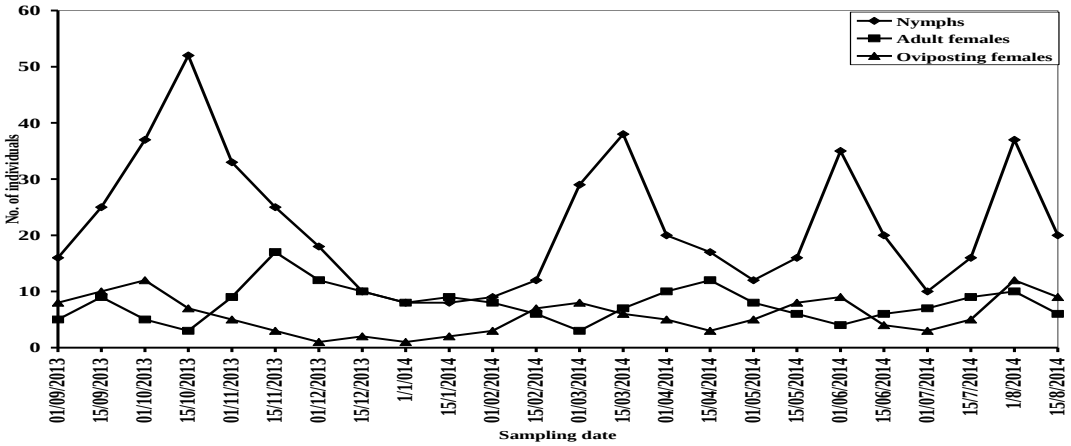

Figure (2): Seasonal abundance of *Icerya seychellarum* on mango trees during 2013 2014.

Population of *I. seychellarum* had four annual peaks on five mango cultivars during the two successive seasons at Giza Governorate (El-Said, 2006). Seasonal fluctuations of *I. seychellarum* recorded four activity peaks on mango. These peaks occurred in March, June, August and Sepetmber/ October during the two successive seasons at Giza governorate, Egypt (Abdel-Rahman *et al*., 2007).

2.Age structure:

The results of applying the age structure technique to the seasonal data of *I. seychellarum* obtained from the Qaluybyia location over the two years on mango were graphically illustrated in Figures (3 and 4). Obtained trend over both years indicated the occurrence of three generations for *I. seychellarum* on mango trees at this location. Over the first and second years the first generation (winter/autumn) started from 1st September first 2012 until mid-February 2013 as the terminal of the first generation (marked by maximum population of adult females). The following count showed that most of these females were in ovipositing stage in a much-synchronized fashion (which indicates the optimal condition for the development of *I. seychellarum*. The second generation (spring) started from mid-February and continued until the date of mid-May 2013. Therefore, the mid-May was considered as the end point of this generation and start point for the third generation (summer) which continued to the next year. Reviewing proved that the obtained results, it could be that the first generation continued over 165 days, also the second generation continued 90 days compared with the third one which continued 90 days. *I.seychellarum* had three generations in May, August and October on mango during the two successive seasons at Qena Governorate (Bakry, 2009).

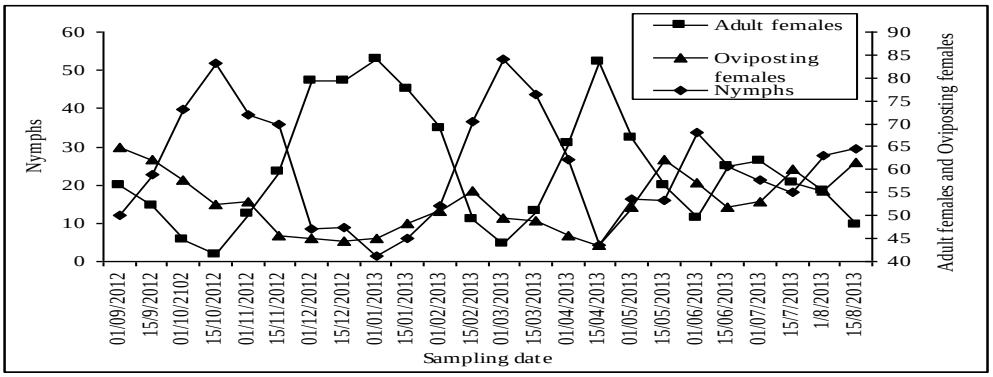

Figure (3): Age structure of *Icerya seychellarum* on mango trees 2012/2103

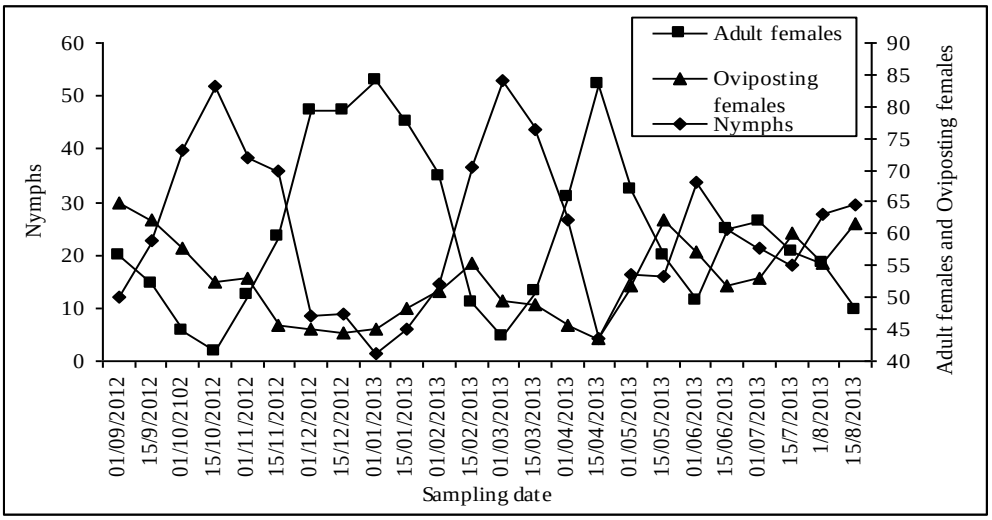

Figure (4): Age structure of *Icerya seychellarum* on mango trees 2013/2014

3.Relationship between the metrological factors and total population of *Icerya seychellarum*:

Ilustrated data in (Figures, 5 and 6) proved that there was positive relationship between metrological factors and the total population of *I. seychellarum* (The higher the temperature, the greater total population of *I. seychellarum*, while the lower the temperature, the lower total population of *I. seychellarum*). Four peaks of *I. seychellarum* total population simultaneous with moderate and high temperatures. While the low temperatures (from December first until the end of February) the population of *I. seychellarum* was low due to its hibernation as adult females after this time the adult females transformed to ovipositing females as an indicator to next peak and generation.

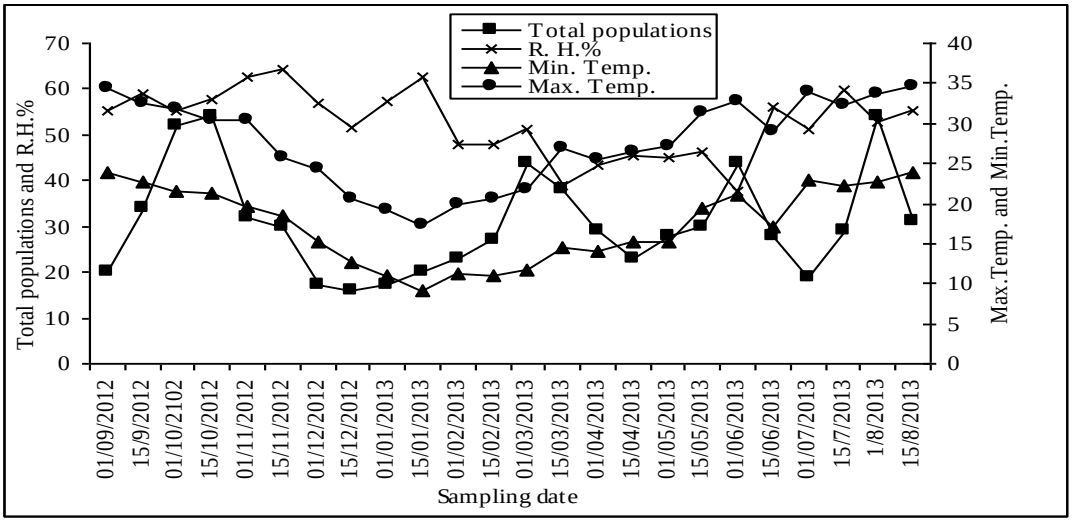

Figure (5): Relationship between Max., Min. Temp., R.H. % and total population of *Icerya seychellarum* during 2012/2013

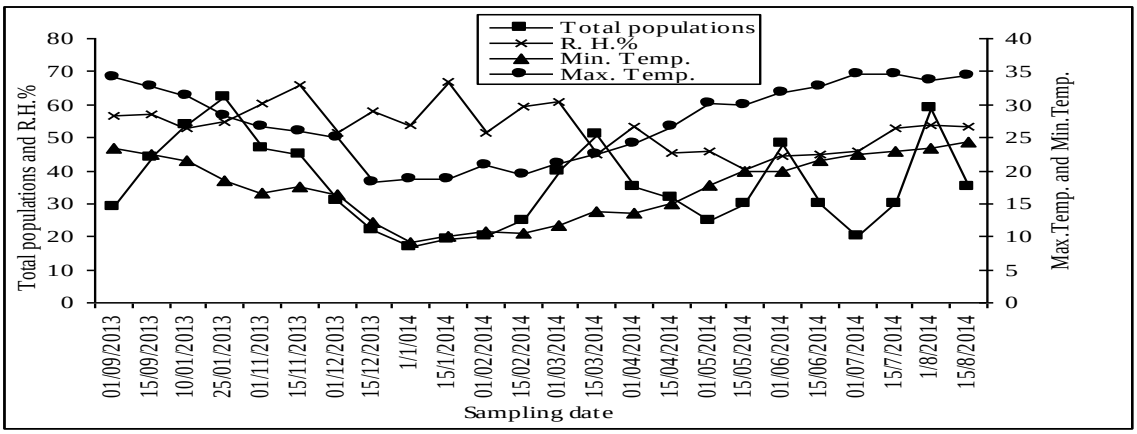

Figure (6): Relationship between Max., Min. Temp., R.H. % and total population of *Icerya seychellarum* on mango 2013/2014

The effect of temperature on *I. seychellarum* activity on five mango cultivars was positive and the effect of the daily mean relative humidity was negative during the two successive seasons of investigation at Giza Governorate (El-Said, 2006). Population density of *I. seychellarum* on mango trees showed positive with temperature during the two successive seasons at Giza governorate. The effect of daily mean relative humidity was negative for both years of investigation (Abdel-Rahman *et al*., 2007).

4. Relationship between the total population of *Icerya seychellarum* and *Rodalia cardinalis*:

Data in (Figures, 7 and 8) illustrated that there was simultaneous occurrence of the total population of *I. seychellarum* and its associated predator *R. cardinalis*.

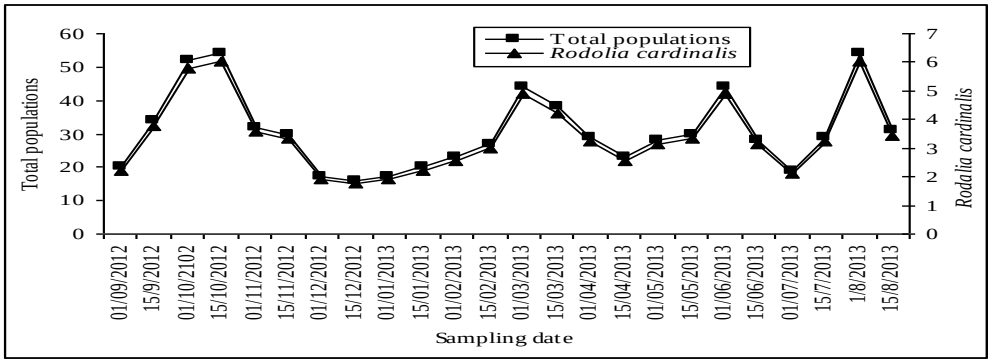

Figure (7) Relationship between the total population of *Icerya seychellarum* and *Rodalia cardinalis* during 2012-2013.

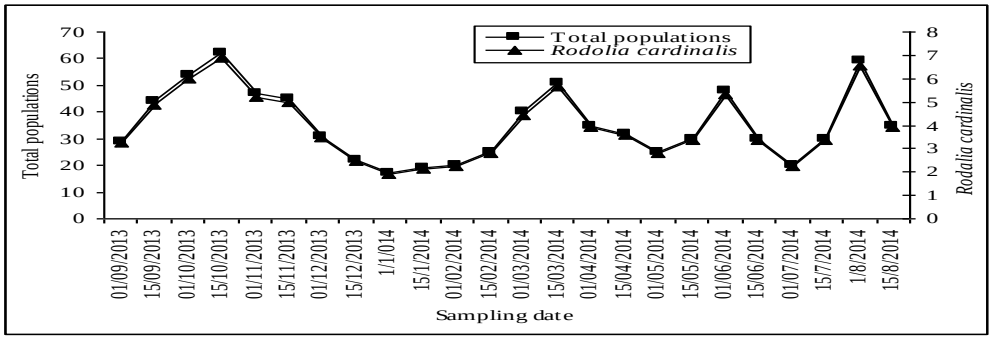

Figure (8) Relationship between the total population of *Icerya seychellarum* and *Rodalia cardinalis* during 2013-2014

R. cardinalis has four peaks annually were recorded in 15th Mar. 15th Jul., 15th Oct. and 1st Nov. during the two years on guava leaves in associate on with *I. seychellarum* at Egypt (El-Sherbeny, 2004). *R. cardinalis* the main dominant insect predator on *I. seychellarum* (Abdel-Mageed, 2005). Predators, *Rodalia* spp. are highly effective for the control of *Icerya* spp. (Hirose, 2006).

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Factors affecting on infestation of apple trees with pinhole beetle, *Hypothenemus eruditus* (Scolytinae: Curculionidae: Coleoptera) at Menoufia Governorate, Egypt

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Abstract:

Hypothenemus eruditus Westwood (Scolytinae: Curculionidae: Coleoptera) is considered the most widespread and abundant scolytine in the world. The aim of this is to study the effect of the factors, moisture content of apple branches, different heights from ground surface and dominant weather factors on infestation of apple trees with *H. eruditus*. The results indicated, these factors obviously detected the following:

1) The highest infestation was recorded for branches with 26.9% moisture content for cutting branches to 7days ago.
2)The highest number of entrance holes recorded for branches at height 150- 200cm.
3)Population fluctuation of H. eruditus beetle during activity periods revealed that the beetles are abundant all year. The number of attracted beetles to intact apple branches, estimated by number of entrance holes, appeared six and five peaks of population density during two successive years of study (2017 and 2018).
4)Seasonal activity of attracted beetles detected that the highest percentages of entrance holes were recorded during the summer followed by the spring or autumn then the winter. The highest monthly percentage of entranced beetles recorded 15.63% during July (2017) and 14.67% during August (2018), while the lowest percentage showed at January of both two seasons. Weather factors showed clear different effects on population fluctuation of beetles

Introduction

The pinhole beetle, *Hypothenemus eruditus* Westwood (Scolytinae: Curculionidae: Coleoptera) (tiny beetle) is considered a "super-generalist," recorded from an unusually broad range of host species and plant tissues and is abundant in most tropical and subtropical regions, and consequently, it is widely collected (Wood ,1982). It is one of the important

pests that attack many species of fruit and wooden trees. The infestation of *H. eruditus* beetles causes the death and dryness of infested branches and twigs, the color of tree branches become fading and reddish brown. In Egypt, Willcocks (1924); Batt(1999b) and Hashim (2009) reported that *H. eruditus* beetle infested mulberry, fig, mango and sesseban causing death to branches and twigs. As well as the pinehole borer, *H. eruditus* infested citrus trees, *Ficus* spp, *Poinciana* sp, *Acacia* sp, *Hibscus* sp, and *pitosoporum* sp (Hammad ,1961). Also, Girgis (1987) surveyed *H. eruditus* in Alexandria, Beheira, Gharbia, Menoufia, Qalubia and Minia Governoratesand he recorded this beetle on plum, apple, pear, *Fig sycomorus*, *Fig carica*, mango, olive, citrus, white poplar, lebbek, sessban, royal poinciana and mulberry trees. The same author found that *H. eruditus* attacked small branches (less than 6cm diameter) and preferred the weakened branches of several hosts comprising fruit and wood trees.

In addition to that Batt *et al*. (1993) recorded the *H. eruditus* beetles on sweet lemon, mandarin, lemon and kumquat trees; furthermore, they mentioned that the highest percentage of infestation recorded at Sharkia Governorate, while the lowest percentage of infestation was in Beni-Suef Governorate. The infestation percentages on pear, apple, plum, peach and apricot trees reached 37%, 28%, 19%, 13%, 3% respectively by *H. eruditus* beetles at Kafer alaem village, Berkt El-Saba district, Menoufia Governorate (Batt,1999 a).

In Germany, Blunck (1954) mentioned that *Ficus sp*., *Citrus* sp., *Vitis vinifera* (Grapevine) and *Acacia* sp. are host plants to *H. eruditus*. It is also attacked seedlings cocoa trees and caused the damage and death to them (Batt,1999a) and is *H. eruditu* spread in the area from Michigan (USA) to Argentina (Wood ,2007).

In Turkey, Akşit *et al.* (2005) recorded *H. eruditus* as a new pest on fig (*Ficus carica*) trees in Aydın province, while Tuncer *et al.* (2017) surveyed the bark beetle *H. eruditus* on hazelnut orchards in Aydın, Mersin, Samsun provinces. In India, Keshavareddy *et al.* (2007) recorded *H. eruditus* beetle for the first time on jack fruits *(Artocarpus heterophyllus*) trees.

Bastos and Lima (1981) found that *H. eruditus* [*H. obscures* (Miiller)] (beetles attack shoots of Manicoba (*Manihot glzivoii*), while Zelaya *et al*., 1984 stated that *H. eruditus* was trapped in plantations of (*Pinus oocarpa* and *Pinus caribaea*) in Barazil.

Beardsley (1990) and lÖbl and Smetana (2011) mentioned that some hosts such as coffee berries, nutmeg (Myristica fragrans Houtt.), macadamia nuts (Macadamia sp.), cocoa, tamarind, and jackfruit were attacked by *H. eruditus* (*H. obscures*) pest. Other authors had listed *H. eruditus* (*H. obscures*) infested coffee berries (eg.: Da Costa Lima (1956); Le Pelley (1968); Kathleen *et al.* (1994) and Constantino *et al*., 2011).

Previous studies on scolytid beetles (Coleoptera: Scolytidae) by many researchers such as Graham and Werner (1956); Chapman (1962) and (1963); Russo (1963); Charars (1976); Charars *et al.* (1978), Moeck *et al.* (1981); Girgis (1987) and Batt (1989) indicated that several factors play an essential part affecting on infestation by scolytids, these factors included weakened, dead or healthy branches, odors constituents of wood, volatile chemicals (primary attraction by terpenes give off by the tree), physiological conditions, excreta and chemical changes in the tree tissues by attack the first beetles, as well as moisture content which has important role in attraction of beetles to cut logs(branches) used as host trap for mechanical control of scolytid beetles. Other important factors have most influences on the infestation of orchards fruit trees with wood borers, these factors comprise the attack density of insect

population and meteorological conditions which include field temperature and relative humidity for surrounding air with the trees.

The objective of the present work is to study the effect of temperature, relative humidity, moisture content, height of attacked branches on infestation of *H. eruditus* beetles to apple trees at Menoufia Governorate, Egypt. As well as the possibility to use the apple branches as host traps (logs) to control of this pest.

Materials and Methods

Infested apple orchard (about 5 feddans, 12 years old) with pinehole beetles, *H. eruditus*, was chosen at Al-Khatatba location, Sadat district, Menoufia Governorate during October 2016. The experimental area not treated with any chemical treatments throughout the period of this work. The current study is interested with definition each of the suitable moisture content of apple branches, suitable height to attract the highest number of beetles, the determine the seasonal activity and population fluctuation of beetles under effects of field temperature and relative humidity.

To determine the suitable moisture content of apple branches for attract the beetles, intact apple branches of about 1.5 diameter were cut on different periods (28, 21, 14, 7,3 and 0 days) and divided to cuttings of 50cm length. One cutting from each period was gathered to making one group tied together. 20 groups were tied on the trunk of infested trees with *H. eruditus* (each group on infested tree), these groups were examined continually for 2weeks and the entrance holes in each cutting were recorded. The moisture contents corresponding with the number of days after cutting were determine using heat oven at 105 C° and percentage of moisture content (MC%) was calculated as follow:

$$MC\% = \frac{\text{Fresh wood weight} - \text{Dry wood weight}}{\text{Fresh wood weight}} \times 100$$

The suitable moisture content which attracted the highest number of beetles (entrance holes) used to definition the suitable timing for cut the intact apple branches as host traps.

The intact apple branches (1.5diameter) were cut and left to suitable timing to obtain required moisture content, the branches were divided to cuttings (50cm length). Each five cuttings were hanged on branches of tree at different heights of regions (0-50, 50-100,100-150, 150-200, 200-250 and 250-300cm) for 20 trees and left 2 weeks, the number of entrance holes at each height were recorded to definition the suitable height to attract the highest number of beetles.

After definition the suitable height, 20 groups from intact branches with suitable timing of cut (each group contain 5 cutting x 50cm length) were hanged on 20 infested trees at suitable height, these groups were replacing each 2 weeks. Continued examination was made, the weakly number of entranced holes was recorded throughout the period from the first of January 2017 to the ending December 2018.

The seasonal activity and population fluctuation of attracted beetles and the effect of dominant factors of field temperature and relative humidity on beetle population was studied. Statistical analysis of obtained data was made according **SAS program (2003).**

Results and discussion

1.The effect of moisture content of apple branches on number attracted beetles:

The number of attracted *H. eruditus* beetles was determined with number of entrance holes in apple branches cut on different periods as a result in the change of moisture content to attacked branches.The number of entrance holes at different moisture contents (corresponding number of days after cutting) was recorded in Table (1), the highest number of entrance holes was recorded at moisture content 26.9 % (seven days after cutting), while the least numbers of entrance holes were

recorded at moisture content at 50.98 % and 11.7% (0 and 28 days after cutting , respectively).

Statistical analysis for moisture contents of apple branches cut at different periods detected highly significant differences between obtained values of moisture contents of branches at different periods after cutting (F= 1714.9), six statistically groups were recorded for wood moisture contents (LSD= 0.88), Table (1). Also, highly significant differences between numbers of attracted beetles (entrance holes) to apple branches which cut at different periods (various moisture content), F =79.86, five statistically groups were observed between numbers entrance holes on apple branches, (LSD = 0.87), Table (1).

Table (1): Effect of moisture content of apple branches on initial infestation of *Hypothenemus eruditus* borer

Number of days after cutting	Wood moister content		Number of entrance	
	Mean ±SD	Range	Mean± SD	Range
0	50.98 ±1.60 a	48.8 - 53.6	3.4 ± 1. 96 c	0-6
3	41.4 ± 2.55 b	37.1 - 46.7	5.3± 1.75 b	3-8
7	26.9 ± 2.04 c	24.2 - 30.1	11.4 ±2.16 a	7-15
14	19.7 ±1.63 d	16.7 - 22.6	5.7± 1.75 b	4-11
21	14.6± 0.75 e	15.8 – 13.5	4 ± 1.41 c	1-7
28	11.7 ±0.69 f	10.4 – 12.7	1.8 ± 0.83 d	1-3
F	1714.9		79.86	
LSD	0.88		0.87	

These results were agreed with the obtained results by Okil (1982) who found that the suitable moisture content to infest *Poinciana regia* branches by *Sinoxylon sudanicum* Lesne. beetles were ranged from 13.6 to 35.6%. As well as, El-Sebay (1984) mentioned that the highest number of *Dinoderus bifoveolatus* Woll. beetles were attracted to bamboo wood at 39.4 % moisture content (at 0 day to storage period), while the lowest number of beetles was recorded at 9.4% moisture content (at 40 days to storage period). Also, Batt (1989) found that the percentage 32.12 % moisture content of plum branches showed the highest number of *scolytus amygdale* Guer. beetles at 7days after cutting, while the percentage 48.83% moisture content (at 0 day after cutting) attracted the lowest number of beetles. Whereas, Mohamad (2002) reported that the percentage 28.57% moisture content attracted the highest number of *Dinderus minutes* Fab. beetles, while the lowest number was recorded at moisture content of 37.68%

2. Effect of different heights on number of entrance holes in apple branches:

The number of entrance holes of *Hypothenemus eruditus* beetles attracted to apple branches on different heights was illustrated in Table (2). The highest number of entrance holes *H. eruditus* in apple branches was ranged 7-14 holes with a mean 11.4 $\pm$1.93 holes, recorded at height 150-200cm, followed by 4-10 entrance holes with a mean 7.7 $\pm$1.59 at the height 100-150cm then 5-9 entrance holes with a mean 7.2 $\pm$ 1.58 recorded at the height 200-250cm,1-7 entrance holes with a mean 5.5 $\pm$ 1.70 at the height 250 -300cm and 3-8 entrance holes with a mean 5.2 $\pm$ 1.40 at the height 50 -100cm, while the least number entrance holes ranged 1-5 entrance holes with a mean 2.7 $\pm$ 1.03 at the height 0-50cm.

Statistical analysis for numbers entrance holes recorded on different heights showed highly significant differences (F=70.36), four statistical groups were obtained between the number of entrance holes on different heights, (LSD = 0.83), Table (2).

Table (2): Number of entrance holes of *Hypothenemus eruditus* beetles attracted to apple branches trees (as host trap) on different heights.

Height cm.	Number of entrance holes		Statistical groups			
	Range	Mean ± SD				
0-50	1-5	2.7 ± 1.03				d
50-100	3-8	5.2 ± 1.40			c	
100-150	4-10	7.7±1.59		b		
150-200	7-14	11.4± 1. 93	a			
200-250	5-9	7.2 ± 1.58		b		
250-300	1-7	5. 5 ± 1.70			c	
F	70.36					
LSD	0.83					

Terren and De Simon (1983) reported that the most of scolytid beetles were caught at 1.5-2.5 m above the ground, while few of them at higher than 4m by using pheromone traps. The largest numbers of *H. eruditus* trapped were recorded at 1.5m, while the least number of beetles trapped were found at 0.5m on plum trees (Girgis ,1987). As well as, Batt (2008) showed that regions of 2m to 3m above ground on pear trees were preferred to attack *H. eruditus* beetles. Also, the largest numbers of *H. eruditus* beetles were found at the range of 100 to 150Cm above ground on *Pinus taeda* L trees in Santa Maria city, Rio Grande do Sul state, Southern Brazil (Machado and Costa, 2017).

3. Population fluctuation and seasonal abundance of *Hypothenemus eruditus* beetles:

3.1. Occurrence periods:

Data illustrated in Figure (1) show population fluctuation of *H. eruditus* beetles entranced in apple branches, in cultivated apple orchard at Al-Khatatba location, Sadat district, Menoufia Governorateduring 2017 and 2018. Activity of attracted beetles to apple branches showed that the beetles were abundant throughout the year, population density during 2017 appeared six occurrence periods and six peaks of entrance beetles recorded at the 2nd week of April, the 1st week of June, the 2nd week of July, the 2nd week of August, 3rd week of September and the 4th week of October, while during 2018 the number of entrance beetles detected five occurrence periods and five peaks of population density recorded at the 3rd week of April, the 2nd week of June, the 2nd week of July, the 3rd week of August and 3rd week of October**.** The occurrence periods of beetles detected different duration of activity periods during seasonal occurrence of beetles. In 2017 year, the highest duration was 19weeks recorded during the 1st occurrence period, from 1st week of January until the 3rd week of May, followed by 10 weeks recorded during 6th occurrence period, from the 3rd week of October until the 4th week of December, the durations of other occurrence periods ranged 4-5 weeks. In 2018 year, the highest duration of occurrence periods recorded 18 weeks observed through the 1st occurrence period extended from the 1st week of January until the 2nd week of May, followed by the 5th occurrence period which recorded 10 weeks occupied the period from 3rd week of October until the 4th week of December, while the lowest duration was 5weeks, recorded during the 3rd occurrence period extended from the 1st week of July to 1st week of August, Table (3). Girgis (1987) reported that the *H.eruditus* beetles had four occurrence periods on plum trees at Shibin El-Kom, Menoufia Governorate: the 1st occurrence appeared from late March to early June (11weeks) , the 2nd occurrence started from the end May to mid August (12weeks), the 3rd occurrence showed from mid August to early October (8weeks) and the 4th occurrence started from early October to early November (6weeks), while Girgis *et al.*, 1991 revealed that *H.eruditus* (*H obscures*) beetle had four generations on Mulberry trees at Shibin El-Kom, Menoufia Governorate started from early or late January and ended late December and showed four peaks of emerged beetles during (early or mid April), (early or mid June), (late July or early August) and (mid or late September).

Table (3): Seasonal occurrence periods of *Hypothenemu eruditus* beetle attracted to apple branches used as traps during 2017 and 2018 years

Occurrence periods				
2017 year				
No.	**From**	**To**	**Duration (week)**	**Peak time**
1	1st week of Jan.	3rd week of May	19	2nd week of April
2	4th week of May	4th week of Jun.	5	1st week of Jun.
3	1st week of Jul.	1st week of Aug.	5	2nd week of Jul.
4	2nd week of Aug.	2nd week of Sep.	5	2nd week of Aug.
5	3rd week of Sep.	2nd week of Oct.	4	3rd week of Sep.
6	3rd week of Oct.	4th week of Dec.	10	4th week of Oct
Total	-------	--------	48	--------
2018 year				
No.	**From**	**To**	**Duration (week)**	**Peak time**
1	1st week of Jan.	2nd week of May	18	3rd week of April
2	3rd week of May	4th week of Jun.	6	2nd week of Jun.
3	1st week of Jul.	1st week of Aug.	5	2nd week of Jul
4	2nd week of Aug.	2nd week of Oct	9	3rd week of Aug
5	3rd week of Oct.	4th week of Dec.	10	3rd week of Oct
Total	-------	--------	48	--------

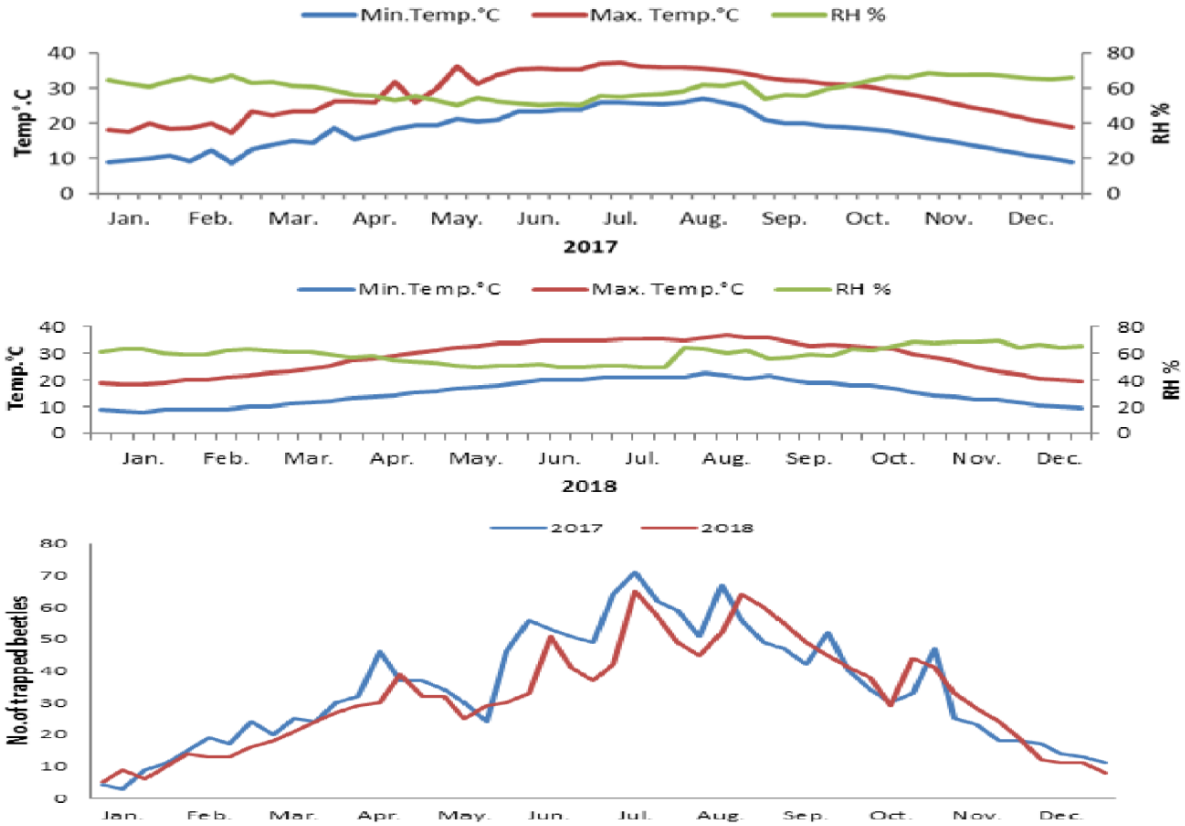

Figure (1): Seasonal flight activity of *Hypothenemus eruditus* estimated by number of attracted beetles to apple branches affected with changes in filed temperature and relative humidity during 2017 and 2018, years at Sadat district, Menoufia governorate.

3.2. Seasonal abundance:

The seasonal and monthly percentages of *H. eruditus* beetles attracted apple branches are cleared in Table (4). In 2017, highest percentage of entrance (40.29 %) was recorded during the summer followed by spring (30.22 % entrance), autumn (17.22 % entrance), while the lowest percentage was 12.27 % entrance recorded during winter. In 2018, highest percentage was 41.43 % entrance recorded also during the summer followed by spring (26.83 % entrance), autumn (19.79% entrance) while the lowest percentage (11.69 % entrance) recorded during the winter. The monthly abundance of entrance beetles in Table (4), during 2017 indicated that the highest entrance percentage was 15.63% recorded during July, followed by 13.61% entrance during August, 12.76%, 11.05%, 9.28%, 8.73%, 8.18%, 6.04%, 5.13 % entrance during, June, September, April, October, May, March and November respectively, while the lowest densities of entrance beetles recorded during February (4.58% entrance) December (3.36% entrance) and January (1.65% entrance) .

During 2018, the highest percentage of entrance during recorded during August (14.67% entrance), followed by 14.14%, 12.62%.10.76%, 10.09%, 8.63%, 7.44%, 6.91%, 5.98% entrance recorded during, July, September, June, October, April, May, November and March respectively, while the lowest entrance percentage showed during February (3.72% entrance) December (2.79 % entrance) and January (1.99 % entrance).

Table (4): Monthly population and percentages of *Hypothenemus eruditus* beetles attracted of apple branches during different seasons of 2017 and 2018 at Al-Khatatba, Menoufia Governorate.

Season	Months	2017		2018	
		Numbers of entrance beetles	Entrance percentage	Numbers of entrance beetles	Entrance percentage
Winter	Jan.	27	1.65	30	1.99
	Feb.	75	4.58	56	3.72
	Mar.	99	6.04	90	5.98
	Total	**201**	**12.27**	**176**	**11.69**
Spring	Apr.	152	9.28	130	8.63
	May.	134	8.18	116	7.44
	Jun.	209	12.76	162	10.76
	Total	**495**	**30.22**	**408**	**26.83**
Summer	Jul.	256	15.63	213	14.14
	Aug.	223	13.61	221	14.67
	Sep.	181	11.05	190	12.62
	Total	**660**	**40.29**	**624**	**41.43**
Autumn	Oct.	143	8.73	152	10.09
	Nov.	84	5.13	104	6.91
	Dec.	55	3.36	42	2.79
	Total	**282**	**17.22**	**298**	**19.79**
General total		1638	100	1506	100

4. The effect of whether factors on population fluctuation of attracted *Hypothenemus eruditus* beetles:

The effect of dominant factors (minimum and maximum temperatures °c and percent of Relative Humidity) on number of entrance *H. eruditus* beetles during different months, estimated by correlation "r", between different weather factors and population of attracted beetles to apple branches during the different activity periods detected highly significant and positive correlation between averages of both minimum and maximum temperatures with numbers of attracted beetles (r =0.933 and 0.904 respectively), while the correlation was negative between RH% and number of beetles (r = - 0.608) during 2017year. Also, the data obtained during 2018 year showed that the correlation was highly significant and positive, where the r values was 0.916 and 0.918 for minimum and maximum temperature, respectively; while no correlation was obtained between the relative humidity and population density of beetles (r = - 0.391), Table (5).

Table (5): Simple correlation (r) and simple regression (b) of the weather factors with the number of attracted beetles of Hypothenemus *eruditus* during 2017 and 2018 years.

year	2017		2018	
Weather factors	Simple correlation (r)	Simple regression (b)	Simple correlation (r)	Simple regression (b)
Min.Temp °c	0.933	2.942	0.916	3.242
Max.Temp°c	0.904	2.504	0.918	2.424
RH%	-0.608	-1.922	-0.391	-1.04

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Susceptibility of soybean varieties to infestation of cotton leaf worm *Spodoptera littoralis* (Boisduval) (Lepidoptera: Noctuidae) and their relation to climatic factors with emphasis on leaves characteristic

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Abstract:

Susceptibility of five soybean varieties (Giza 21, Giza 22, Giza 35, Giza111 and Crawford) to infestation of cotton leaf worm *Spodoptera littoralis* (Boisduval) (Lepidoptera: Noctuidae) were studied under natural field conditions at the experimental farm of the Faculty of Agriculture, Benha University, Egypt during two successive seasons, 2015 and 2016. The relationship between phytochemical components and anatomical characters of leaves were also studied. Results showed that, Crawford variety was highly infested by *S. littoralis* as number of larvae/100 plants and rate of leaflets soybean feeding damage. While the susceptibility of Giza 21 variety recorded the lowest number of larvae/100 plants and rate of leaflets soybean feeding damage during the two successive seasons. Statistical analysis showed positive correlation between population of *S. littoralis* with minimum and maximum temperature during the two seasons. On the other hand, the relative humidity had insignificant negative effects in both seasons. Phytochemical analysis had significant positive effect among the leaflet of the five studied varieties and the total of protein, carbohydrates and phenols. While there was insignificant negative effect between leaflet contained of phosphate and potassium and insect population. The anatomical characters of the leaflet of five soybean varieties and the population of *S. littoralis* were correlated significantly positive for all leaf morphological and anatomical characteristics on the five soybean varieties.

Introduction

Soybean (*Glycine max* (L.) Mirrill) is one of the most important leguminous crops in many countries and reached a prominent position among other crops in the world. Seeds contain high nutritional value about 40% protein and 20% edible oil, besides minerals and vitamins, It also supports many industries because of soybean oil is used as raw material in manufacturing of antibodies, paints, varnishes, adhesives, lubricants etc. and used as protein supplement in human diet, cattle and poultry feed.

In 2015, in Egypt, the soybean cultivated area reached about 33.974 feddans which produced about 46.843 tons of grains with an average yield of 3.6 ton/feddan. In Qalyoubia Governorate, the soybean cultivated area reached about 132 feddans which produced about 204 tons of grains with an average yield of 1.5 ton/feddan (Anonymous, 2015).

Under field conditions, soybean plants are subjected to be attacked by many pests, among the most common and important pests, cotton leaf worm, *Spodoptera littoralis* (Boisduval) (Lepidoptera: Noctuidae) is considered the main leaf feeding insect attacks soybean plants, causing large loss in yield . Lutfallah *et al.* (2003) showed that 12 soybean genotypes studied could be grouped into three categories: High resistant to the cotton leaf worm (2genotypes, H2L24 and L86-K73, while intermediate resistant genotypes were (8 genotypes, Giza 83. H1L2/10, H11L6, H1L3/12, H16, H1L4/32, Giza 21 and Lamar variety and highly susceptible genotypes (2 genotypes, Crawford and Clark). Genotypes were significantly different in almost all studied traits in both seasons, the most tolerant genotype to cotton leaf warm (10.0 and 9.9%) were L159L2 and L159L7 in 2011 and 2012 growing seasons, respectively, While the lowest tolerant genotypes were L132 and Black Seed in both two seasons (El-Garhy *et al.*,2013). Alakhder *et al*. (2015) results revealed significant differences among the tested soybean genotypes for all studied traits. They found that three genotypes H 19 L 96, H 4 L 24 and H 32 were considered as the best with high yield and lowest pests' infestation; in contrast H 1 L 1, L 127 with highest infestation and lowest yield genotype.

The present work is to study the population fluctuation of *S. littoralis* on five soybean varieties during two seasons 2015 and 2016. As well as susceptibility of these soybean varieties to infestation of *S. littoralis* and their relationship to climatic factors and some leaflet characteristics such as (phytochemical components and anatomical characters).

Materials and methods

1. Field experiments:

Field experiments were carried out at the experimental farm of Faculty of Agriculture, Moshtohor, Benha University, Qalyoubia Governorate. An area of about 1/2 feddan was divided into 20 equal plots of about 10.5 m^2 each. All plots were arranged in complete randomized design. Each variety was divided into four replicates. The five studied soybean varieties (Giza 21, Giza 22, Giza 35, Giza111 and Crawford) were sown at 25th May in 2015 season and at the first of June, 2016 to evaluate it against *S. littoralis* under natural infestation. All the tested varieties were exposed to normal field condition without using insecticide during the experimental period. The population densities of *S. littoralis* were estimated.

2. Population densities of cotton leaf worm, *Spodoptera littoralis*:

The population densities of *S. littoralis* on five soybean varieties were counted after 18 days from planting. Sampling of 25 plants taken at random from each plot to calculate the number of larvae and percentage of leaf feeding damage of leaflet area with *S. littoralis* infestation (Figure,1) according to Hunt and Jarvi (2009).

$$\text{Percentage of leaflet area damage} = \frac{\text{Score1}\times\text{No. of leaflets} + \text{Score2}\times\text{No. of leaflets} + \ldots\ldots}{\text{Total No. of infested leaflets}}$$

The rating system uses levels from 1 to 6 where:

Score (1)= few number of pin holes to 10%of leaflet area damage.

Score (2) =upto 20 %leaflet area damage.

Score (3) =21-30% leaflet area damage.

Score (4) =31-40% leaflet area damage.

Score (5) =41-50% leaflet area damage.

Score (6) =more than 50% leaflet area damage.
Soybean Defoliation Levels

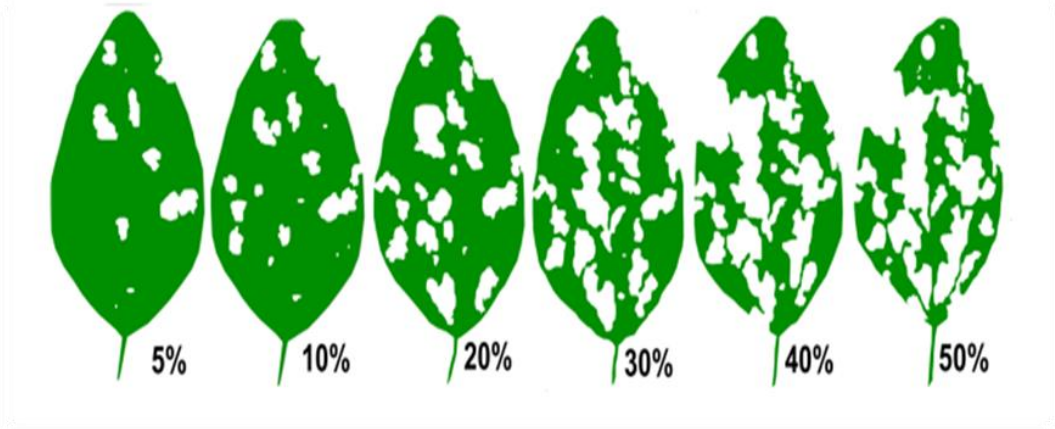

Figure (1): Graphic representations of various levels of soybean leaf defoliation (Hunt and Jarvi, 2009).

3.Phytochemical components:

The relationship between infestation rate of *S. littoralis* and phytochemical components on five soybean varieties through vegetative growth stage during 2015 and 2016 seasons, to determine carbohydrates and total protein contents according to the methods of Pregl (1945) and Michel *et al*. (1956). Also, the amount of total phenolics was determined by Folin-Ciocateu method as modified by Singleton and Rossi (1965). Moreover, inorganic phosphate was determined as described by Rockstein and Herron (1951), potassium was described by Amin and El-Halafawy (2001 and 2002).

4. Anatomical characteristics:

The anatomical characteristics of the tested varieties were studied by using the methods described by **Jackson (1973).** To study the different measurements (in micron mm) of thickness of cuticle layer, thickness of epidermis layer, thickness of central tissue (palisade tissue and spongy tissue), were determined at Botany Department, Faculty of Agriculture Moshtohor, Benha university.

5. Statistical analysis:

The collected data were subjected to proper statistical analysis of (F) test according to **Fisher (1954)**, to compare between means L.S.D at .0.05 level of probability was used according to **Duncan (1955).**

Results and discussion

1. Population fluctuation of *Spodoptera littoralis* infested soybean varieties:

Population density of *S. littoralis* was studied under field condition on five tested soybean varieties (Giza 21, Giza 22, Giza 35, Giza 111 and Crawford) during two successive seasons 2015 and 2016. The regular weekly inspection of the number of larvae/100 plants and rate of leaflets soybean feeding damage on soybean plants were recorded during the whole period of soybean plants from the first inspection (18^{th} June) to the final one (13^{th} August) during the two studied seasons.

1.1. The first season 2015:

Data presented in Table (1) showed the fluctuations in the population densities of *S. littoralis* on five tested soybean varieties during 2015 season. The presence of *S. littoralis* larvae on five varieties extended from the 3^{rd} week of June, up to the 2^{nd} week of August. The highest peak of *S. littoralis* recorded during the 4^{th} week of July (67.5, 57.5, 55, 52.5 and 3735) larvae/100 plants on (Crawford, Giza 111, Giza 22, Giza 35 and Giza 21), respectively. The highest no. of larvae/100 plants recorded with Crawford variety with average of 44.44 larvae/100 plants., while

Giza 21 recorded the lowest number 24.44 larvae/100 plants.

Data in Table (2) summarized the weekly percentage of leaflets soybean feeding damage by *S. littoralis* larvae (in the form of holes) revealed that the highest percentage feeding damage was recorded with Crawford Variety 28.2% followed by Giza 35, Giza 111 and Giza 22 with 25, 25 and 24.4%, respectively. while the Giza 21 was the lowest one recording 23.4% of leaflets soybean feeding damage.

1.2. The second season 2016:

Data in Table (3) revealed approximately (as the first season) by the presence of *S. littoralis* larvae. The highest peak of *S. littoralis* larvae was recorded during the 3rd week of July by 230 larvae/100 plants for Giza 21 variety and 4th week of July 212.5, 207.5, 232.5 and 297.5 for Giza 22, Giza 35, Giza 111 and Crawford, respectively.

At the two studied seasons, (2015 and 2016) the abundance *S. littoralis* larvae was recorded from the beginning of vegetative stage and populations increased dramatically from the late vegetative stage until crop maturity. The highest variety harbouring *S. littoralis* larvae infestation was Crawford with 193.33 larvae/100 plants. Also, the weekly percentage of leaflets soybean feeding damage by *S. littoralis* larvae was summarized in Table (4) the data revealed that the highest percentage feeding damage was in Crawford variety with 16.9% followed by Giza 22, Giza 35 and Giza 111 were 16.5, 16 and 15.8%, respectively. These results agree with Lutfallah *et al*. (2003) evaluated 12 soybean varieties and found that the Crawford variety was highly susceptible to the cotton leaf worm. Saleh (2013) indicated that the Crawford variety was highly susceptible to the cotton leaf worm.

Statistical analysis of the data showed that the interaction of the five tested soybean varieties to infestation with *S. littoralis* larvae and the percentage of leaflets soybean feeding damage during the two seasons 2015and 2016 varied significantly from variety to another.

Table (1): Effect of certain soybean varieties on population density of *Spodoptera littoralis* larvae/100 plants at Moshtohor region, Qalyoubia Governorate during 2015 season.

Investigation dates	Varieties					Temp.		R.H. %
	Giza 21	Giza 22	Giza 35	Giza 111	Crawford	Min.	Max.	
18/6/2015	10±0.40	15±0.28	10±0.61	15±0.28	20±0.40	22.3	39.9	45.5
25/6/2015	15±0.28	25±0.64	20±0.40	25±0.28	30±0.40	21.3	32.2	52.2
2/7/2015	20±0.40	37.5±0.47	27.5±0.47	35±0.28	42.5±0.62	22.3	33.1	59.1
9/7/2015	22.5±0.25	40±0.25	37.5±0.75	40±0.40	50±0.40	23.3	35	53.4
16/7/2015	35±0.64	52.5±0.62	50±0.70	52.5±0.85	62.5±0.85	24.1	37	54.2
23/7/2015	37.5±0.25	55±0.28	52.5±0.62	57.5±1.03	67.5±0.94	25	40.8	35.2
30/7/2015	42.5±0.85	45±1.04	42.5±0.85	45±0.28	57.5±0.75	25.5	38.4	57.8
6/8/2015	22.5±0.47	35±0.64	25±0.64	32.5±0.94	42.5±0.62	24.7	39.9	47.7
13/8/2015	15±0.28	20±0.25	15±0.28	17.5±0.47	27.5±0.47	25.9	36.2	57.6
Total	220	325	280	320	400			
Mean	24.44 d	36.11 b	31.11 c	35.56 b	44.44 a			
F. Value	24.027*							
L.S. D	4.622							

Means followed by the same letter are not significantly at 0.05 DMRT

Table (2): Percentage of leaflets soybean feeding damage in different varieties with *Spodoptera littoralis* larvae at Moshtohor region, Qalyoubia Governorate during 2015 season.

Investigation dates	Varieties				
	Giza 21	Giza 22	Giza 35	Giza 111	Crawford
18/6/2015	10.37	3.62	5	3.62	4.82
25/6/2015	10.37	11.62	3.62	6.87	13.25
2/7/2015	21.62	13.5	21.5	16.75	30.12
9/7/2015	24.25	29.62	29.87	33.12	31.25
16/7/2015	24.87	31	31.65	33.62	33.87
23/7/2015	36.25	32.25	36.75	35	36.75
30/7/2015	29.25	30.5	26.87	29.87	29.87
6/8/2015	30.87	32.62	34.75	35	35.37
13/8/2015	23.5	34.75	35.5	31.75	38.75
Total	211.35	219.48	225.5	225.6	254.05
Mean	23.4 c	24.4 c	25.0 b	25.0 b	28.2 a
F. value	9.608*				
L.S. D	7.785				

Means followed by the same letter are not significantly at 0.05 DMRT

Table (3): Effect of certain soybean Varieties on population density of *Spodoptera littoralis* larvae /100 plants at Moshtohor region, Qalyoubia Governorate during 2016 season.

Investigation dates	Varieties					Temp.		RH %
	Giza 21	Giza 22	Giza 35	Giza 111	Crawford	Min.	Max.	
18/6/2016	42.5±0.41	57.5±0.54	52.5±0.96	57.5±0.41	42.5±0.81	23.4	37.3	51
25/6/2016	87.5±1.02	80±0.61	92.5±1.13	82.5±0.41	102.5±0.96	24.4	39.4	59.9
2/7/2016	105±1.92	122.5± 1.29	117.5±1.47	125±0.90	150±0.61	24.4	36	61.2
9/7/2016	170±0.35	147.5±0.96	165±1.82	157.5±0.96	195±0.90	24.3	36.6	57.2
16/7/2016	230±1.5	172.5±0.89	195±1.82	190±0.79	230±1.27	24.2	37.2	47.1
23/7/2016	177.5±1.88	207.5±0.41	232.5±1.51	222.5±0.89	272.5±1.78	23.8	34.5	55.6
30/7/2016	137.5±1.81	212.5±1.55	207.5±0.81	232.5±1.91	297.5±0.89	24.6	35.9	60.2
6/8/2016	105±1.88	170±1.54	160±1.27	175±1.03	252.5±1.08	23.6	39.5	49.5
13/8/2016	70±1.35	125±1.55	107.5±0.75	127.7±1.49	197.5±0.85	25.2	36.3	62.7
Total	1125	1295	1330	1370.2	1740			
Mean	125.00 d	143.89 c	147.78 bc	152.24 b	193.33 a			
F.value	7.306*							
L.S. D	16.45							

Means followed by the same letter are not significantly at 0.05 DMRT

Table (4): Rate of leaflets soybean feeding damage in different varieties with *Spodoptera littoralis* at Moshtohor region, Qalyoubia Governorate, during 2016 season.

Investigation dates	Varieties				
	Giza 21	**Giza 22**	**Giza 35**	**Giza 111**	**Crawford**
18/6/2015	13.5	13.87	17.1	17	10.6
25/6/2015	11.75	12.5	14.6	10.1	20.6
2/7/2015	18.37	18.25	9.6	14.5	12.5
9/7/2015	18.25	25.25	24.1	20.2	9
16/7/2015	16.12	14.12	16.3	15.3	20.6
23/7/2015	12.87	17.32	15.1	15.3	19.3
30/7/2015	17.62	12.75	17.6	23.2	21.1
6/8/2015	12.62	22	17.1	15.2	24
13/8/2015	9.5	12.75	12.5	11.5	14.2
Total	130.6	148.8	144	142.3	151.9
Mean	14.5 c	16.5 ab	16 b	15.8 b	16.9 a
F. value	2.087*				
L.S. D	7.43				

Means followed by the same letter are not significantly at 0.05 DMRT

2. Correlation of climatic factors with population density of *Spodoptera littoralis* larvae on five varieties:

This study involved the seasonal fluctuation of the investigated pest in relation to certain weekly mean of the weather factors, (maximum temperature, minimum temperature, mean relative humidity (RH %) obtained from Experimental Research Station at Moshtohor, Faculty of Agric, Benha, Univ, Qalyoubia Governorateduring two successive agricultural 2015 and 2016 seasons.

Data in Table (5) showed the simultaneous effect of the two selected weather factors on the population density of *S. littoralis* larvae on five varieties through 2015 and 2016 seasons. The results showed negative correlation between no. of *S. littoralis* larvae in different varieties and maximum temperature in the 2nd season. Also, the mean percentage of relative humidity had insignificant negative effects in the both seasons. Patait *et al.* (2008) reported that the population of *Spodoptera litura* Fabricius (Lepidoptera: Noctuidae) was influenced positively by forenoon relative humidity and negatively by minimum temperature and afternoon relative humidity.Also, Khan and Talukder (2017) found positive correlation between population of *S. litura* and temperature (maximum and minimum). On the other hand, there was a negative correlation between population of *S. litura* and relative humidity.

Table (5): Correlation values between climatic factors and population density of *Spodoptera littoralis* larvae on five varieties during 2015 and 2016 seasons.

Seasons	Correlation (Temp. and RH %)		Varieties				
			Giza 21	Giza 22	Giza 35	Giza 111	Crawford
2015 season	Mean No. of *S. littoralis*		24.44	36.11	31.11	35.56	44.44
	Min Temp.	Correl.(r)	0.557	0.354	0.372	0.330	0.430
		P	0.119	0.350	0.324	0.386	0.248
	Max Temp.	Correl.(r)	0.364	0.212	0.228	0.237	0.268
		P	0.336	0.584	0.555	0.539	0.485
	RH%	Correl.(r)	-0.114	-0.195	-0.213	-0.257	-0.209
		P	0.771	0.616	0.583	0.505	0.590
2016 season	Mean No. of *S. littoralis*		125	143.89	147.78	152.24	193.33
	Min Temp.	Correl.(r)	0.000	0.085	0.012	0.087	0.200
		P	1.00	0.828	0.975	0.825	0.606
	Max Temp.	Correl.(r)	-0.322	-0.447	-0.449	-0.453	-0.353
		P	0.398	0.228	0.225	0.220	0.352
	RH%	Correl.(r)	-0.348	-0.089	-0.161	-0.102	-0.027
		P	0.359	0.820	0.679	0.795	0.945

P. =Probability Correl (r)=correlation coeffecient

3. Correlation between phytochemical components in the five soybean varieties and mean infestation of *Spodoptera littoralis* larvae:

Data in Table (6) show mean count of *S. littoralis* larvae infested five soybean varieties (Giza 21, Giza 22, Giza 35, Giza 111 and Crawford) at vegetative stage during the second growing season and their relation to the level of certain phytochemical components in the leaves of the concerned varieties, total protein, carbohydrate, total phenolics, phosphate and potassium. Data showed that Crawford variety which had by the highest number of *S. littoralis* 193.3 larvae/ 100 plants contained the highest amount of carbohydrates and total phenols 15.48 and 2.05 mg/100 g**.**, respectively. While it recorded the low amount of total protein, phosphate and potassium were 17.5, 0.39 and 81.5**(**mg/100 g**)**, respectively. On the other hand, leaves of Giza 21 variety which had the lowest seasonal mean number of *S. littoralis* 125 larvae/ 100 plants contained the highest contained of potassium and phosphate 92.6 and 0.51**(**mg/100 g**)**, respectively and had the low amount of total protein 15.75, moderate rate of carbohydrates 15.26 **(**mg/100 g**)**.

Table (6): Correlation between phytochemical components in the five soybean varieties and mean infestation rate of *Spodoptera littoralis* larvae during 2016 season.

2016 season						
Varieties	**Mean no. of insects**	**Total protein**	**Carbohydrates**	**Total phenolics**	**Phosphate**	**Potassium**
Giza 21	125	15.75 a	15.26 a	2.01 a	0.51 a	92.6 a
Giza 22	143.89	17.5 a	14.04 a	2.03 a	0.42 a	80 a
Giza 35	147.78	19.68 a	14.27 a	1.99 a	0.39 a	91.7 a
Giza 111	152.24	18.81 a	14.94 a	2 a	0.28 a	58.8 a
Crawford	193.3	17.5 a	15.48 a	2.05 a	0.39 a	81.5 a
F. value	7.306*	101.24	8.18	12.74	112.83	3034.6
L.S. D	16.45	5.88	2.44	0.68	0.32	74.2
Correl.(r)		0.251	0.386	0.645	-0.427	-0.245
P		0.684	0.552	0.240	0.473	0.692

4. Correlation between anatomical characters in the five soybean varieties and mean infestation rate of *Spodoptera littoralis* larvae during 2016 seasons:

Correlation between the anatomical characters of five tested soybean varieties and infestation rate with *S. littoralis* are in (Table, 7 and Figure, 2). The correlation between the population density of *S. littoralis* larvae infesting the five tested soybean varieties (Giza 21, Giza 22, Giza 35, Giza 111 and Crawford) and the layers of leaves, i.e. thickness of upper and lower cuticle, upper and lower epidermis, palisade tissue, spongy tissue and No. of phloem and wood in vascular bundle and their correlation coefficient values were studied.

The tabulated data in Table (7) showed the correlation values between the anatomical characters of leave fr five soybeen varities and population of *S. littoralis*. The calculated (r) values were significantly positive fr spngy tissue and number of wood vascular bundle (0.172 and 0.050, respectively). On the other hand, this relation was insignificantly negative in case of cuticle upper and lower; upper and lower epidermis, palisade tissue and phloem vascular bundle as the correlation coefficient values were (-0.581 and -0.695), (-0.396 and -0.642), (-0.268) and (-0.050), respectively.

These results are in a harmony with those obtained by Nautiyal *et al.* (2015) found a negative significant correlation was noticed between leaf thickness and per cent leaf damage of soybean.

Table (7): Correlation values between anatomical characters in five soybean varieties and mean infestation rate of *Spodoptera littoralis* larvae during 2016 season.

varieties	**Mean No. of *S. littoralis***	**Cuticle**		**Epidermis in**		**Palisade tissue**	**Spongy tissue**	**Vascular**	
		Upper	**Lower**	**Upper**	**Lower**			**phloem**	**wood**
Giza 21	125	9.90	8.10	16.20	16.20	58.50	81.90	90.00	365.4
Giza 22	143.89	8.10	6.30	27.00	22.50	87.30	103.50	85.50	283.50
Giza 35	147.78	6.30	5.40	18.00	13.50	58.50	63.00	141.30	369.00
Giza 111	152.24	8.10	5.40	22.50	14.40	85.50	58.50	40.50	211.50
Crawford	193.3	7.20	5.40	13.50	9.90	54.00	90.00	90.00	356.40
Correl.(r)		-0.581	-0.695	-0.396	-0.642	-0.268	0.172	-0.053	0.050
P		0.305	0.193	0.510	0.243	0.663	0.829	0.932	0.936

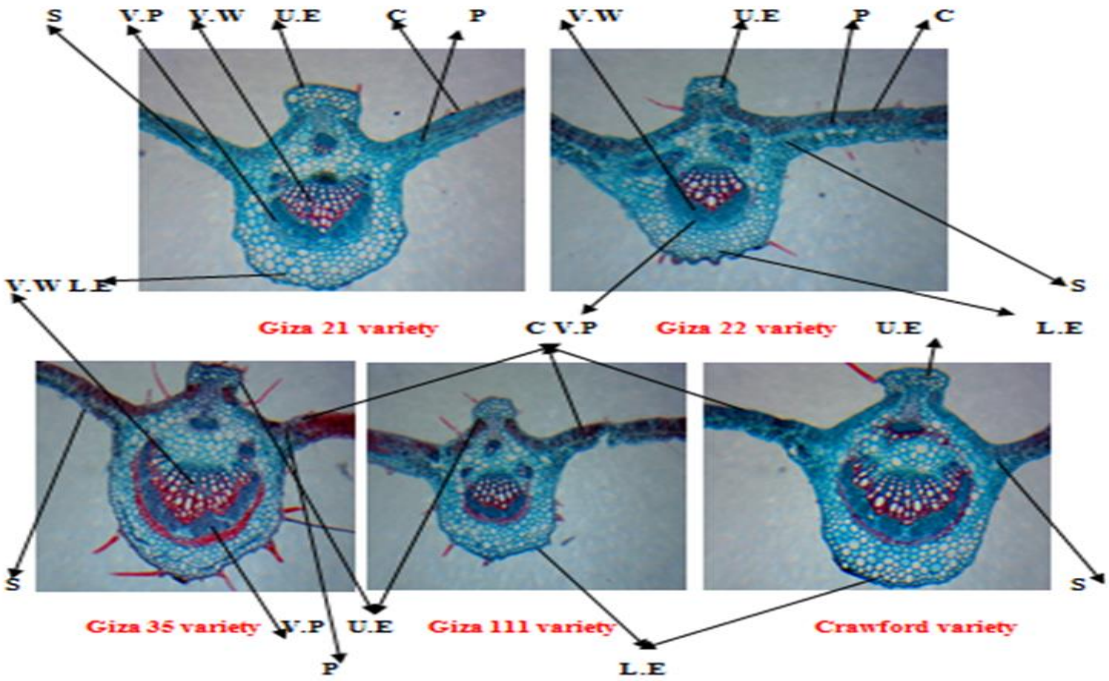

Figure (2): Anatomical characters of tested soybean varieties.
C= Cuticle U. E= Upper Epidermis L.E= Lower Epidermis in micron
P= Palisade tissue S= Spongy tissueV.P= Vascular bundle (Phloem)
V.W= Vascular bundle (Wood)

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Efficiency assessment of modified defined chemical compounds for controlling varroa mite , *Varroa destructor* (Parasitiformes : Varroidae) in Egyptian apiaries

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Abstract:

Varroa mites, *Varroa destructor* Anderson and True man (Parasitiformes : Varroidae) are external parasites that attack both honey bees and brood. They suck the blood from both the adults and developing brood, especially drone brood. This weakens and shortens the bee's life. Emerging brood may be deformed with missing legs or wings. Untreated infestations of varroa mites will increase and may kill colonies. If the colonies are not examined for mites, losses may be mistaken for winter mortality or queenlessness. The present work is to study, the efficacy of the two chemical compounds, Bayvarol and VarroKiller acaricides were tested separately against the varroa mite, within the honey bee colonies located in the stations of the Beekeeping Research Department in four Egyptian Governorates as a reevaluation of them after their development by the companies producing them. Both compounds showed their qualitative superiority in the treatment of the colonies under study and reduce the infection of parasite on the adult bees below the minimum levels compared with the untreated colonies, and Bayvarol was a more superior than VarroKiller compound.

Introduction

Varroa mite, *Varroa destructor* Anderson and Truman (Parasitiformes : Varroidae) , is external parasite attacks three casts of the honeybee colony, *Apis mellifera* L. (Hymenoptera: Apidae) , at their different ages preferred to the drone broods for its rich with nutritional substances due to its largest body sizes and the longer stage in contrast with the workers and the queen, and the parasite destroys the honeybee colony if mite was not noted and early controlled, since their individuals feed on the host haemolymph causing impotent and very weakness to the generated honeybee, furthermore, deformity in their wings and that makes the honeybees not able on the flying and not able on the performance with their various jobs and activities, and finally a lot of honeybee individuals die of what overall leads to acute decrease of the honeybee population and subsequently to negative or diminishing returns from the honeybee's economic result, so what was said by Anderson and Trueman (2000) and by Al-Abbadi and Nazer (2003) was a true or a fact that they agreed about the parasitic bee mite *V. destructor* is the most devastating pest of honeybee and causes high economic losses in beekeeping industry worldwide.

So, many experiments and investigates were performed by chemically controlling of this parasite using several materials and compounds by various manners inside the colonies in several countries due to eradication of varroa mites from the honeybee colonies or at least that to decreasing of its damages.

Since, over the last 15 years, the most noted synthetic acaricides against *V. destructor* are the organophosphate coumaphos (Checkmite, Asuntol and Perizin), the pyrethroids tau-fluvalinate (Apistan, Klartan and Mavrik) and Flumethrin (Bayvarol), as well as the formamidine amitraz (Ritter, 1988; Milani and Barbattini, 1988 and Milani and Lob, 1998).

Tau-fluvalinate acts at the voltagegated sodium channels while coumaphos, an acetylcholinesterase inhibitor, interferes with nerve signaling and function. Most of these pesticides are easy to apply, economically convenient, and do not require refined knowledge of the mites' biology. Furthermore, as lipophilic substances they are mainly absorbed by the bees' wax (Bogdanov *et al*., 1998; Wallner, 1999 and 2000), thus not directly jeopardizing the honey. However, they are persistent and accumulate after repeated treatments.

Therefore, these miticides also possess some disadvantages: They may harm bees when bees are simultaneously exposed to multiple compounds stored in wax (Wallner, 2005; Chauzat *et al*., 2009 and Johnson *et al*., 2009). They can sustainably pollute the honey and other bee products (Wallner, 1999; Nasr and Wallner, 2003; Schroeder *et al*., 2004; Martel *et al*., 2007 and Lodesani *et al*., 2008).

For Asuntol, residues in honey were found, that exceeded the EU Maximum Limit of Residue (MLR). Contamination of bee's wax even persists through commercial recycling. Because several types of wax residues also may have some effect on mites in the sealed cells (Fries *et al*., 1998), they are likely to create acaricide resistance, thus causing unrecognized failure of control in the field and serious damage to beekeeping. While in Egypt that many different chemical compounds as Mavrik acaricide (Abd El-Wahab and Ebada, 2006) were used as strips for controlling *Varroa destructor* mite.

In this present study, the chemical compounds, Bayvarol and VarroKiller were loneness used against Varroa mites inside the colonies at stations of the honeybee research department that belonged to four Egyptian Governoratesas returning back the evaluation after developing these two compounds by the own producer companies.

Materials and methods

These evaluating experiments were conducted for controlling varroa mites (***V. destructor***) in definite number of honeybee colonies by using two chemical cures according to the following plan;

1. Chemical treatments used:

1.1. Bayvarol strips; each strip contains 3.6 mg Flomethrin as an active ingredient, imported by Cairo Chemicals Company and used from October to December in the experimental colonies.

1.2. VarroKiller strips; each strip contains 3.6 mg Flomethrin as an active ingredient (Molecular formula is C28H22Cl.2FNO3), used from March to May the experimental colonies.

2.Honeybee colonies treated:

The present investigation was carried out through October to December, in four localities which were Dokki\ Giza, Gemmeza\ Gharbeiia, Manzala\ Daqahlia and Dakhla\ New Valley Governorates. Nine colonies of hybrid Carniolan honeybee (***A. mellifera Carnica***) infested with varroa mites were chosen in each locality and divided to three groups, three replicates each, the 1st and 2nd groups were

treated with Bayvarol strips for along 28 days by the following dosages;
One strip / replicates of 1st group
Two strips / replicates of 2nd group
Whereas the 3rd group used as a control (untreated colonies).

On the other side, the VarroKiller treatment was carried out through March to May in the same four localities which were previously mentioned. Nine colonies of hybrid Carniolan honeybee (***A. mellifera Carnica***) infested with varroa mites were chosen in each locality and divided to three groups, three replicates each, the 1st and 2nd groups were treated with VarroKiller strips for along 28 days by the following dosages;
One strip / replicates of 1st group
Two strips / replicates of 2nd group
Whereas the 3rd group used as a control (untreated colonies).

However, at every different place of both two presented experiments for along five weeks that estimated the means of vival varroa mites on adults' workers of honeybee before and after treating, then the reduction percentages of infesting with Varroa mites were calculated by using of Henderson and Tilton equation (1955) which is;

$$\% \text{ Reduction} = \left(1 - \frac{T_a \times C_b}{T_b \times C_a}\right) \times 100$$

T_a = after Treatment Tb = before Treatment
C_a = after control C_b = before control

Also, the fall Varroa mite numbers were estimated and represented over the five weeks, all data were statistical analyzed in a randomized complete block design (ANOVA) by MSTAT-C version 1.41 (Sendecor and Cochran, 1980). All means were compared by Duncan's multiple range test at level 0.05 (Duncan, 1955).

Results and discussion

Data in Table (1) it clear that the grand mean of reduction percentage (%reduction) in survival numbers of varroa mite was 71.2 % ± 5.9 inner the honeybee colonies which treated with Bayvarol strips in the end of experiment and that means the decrease of survival numbers of Varroa mite on the honeybee adults approximately to more than third of the counting before the experiment whereas;

At the Governorates level, the treating with number of two Bayvarol strips had significantly surpassed on the treating with number only one strip of the Bayvarol acaricides, since treating with two strips gave a general mean of %reduction in survival numbers of varroa mite on the honeybee adults equaled 78.0% ± 6.5, while the treating with one strip gave a general mean of %reduction in survival numbers of varroa mite on the honeybee adults equaled 64.5% ± 5.4.

In this connection, the station which was the exalt was Gemmeza/ Gharbeiia Governorate which significantly surpassed over the other three Governorates respect to both of the two treatments whether by one strip or by two strips, whereas that station gave against each of them the means of %reduction in survival numbers of varroa mite on the honeybee adults equaled 69.0% and 83.7% successively and what paralleled a total mean of %reduction was 76.3% ± 10.4.

But Dokki / Giza Governorate was the significantly lowest of all Governorates in %reduction, since it gave against each of the treating with one strip and two strips the following means values; 57.1% and 68.6% consecutively and what paralleled a total mean of %reduction was 2.9% ± 8.2.

The previous results were comparison with the untreated honeybee colonies as a negative control which resulted a very slight change of the excluded mites by a general mean of change percentage (% change) equaled 8.7% ± 2.4, and those resulted relationships were represented and showed on the following Figure (1).

Table (1) Effect of using Bayvarol strips on the mean survival number of varroa mites / 100 honeybee workers

Governorate		Giza (Dokki)			New Valley (Dakhla)			Gharbeiia (Gemmeza)			Daqahlia (Manzala)			Grand Mean of %Reduction ± S.D.	L.S.D. Value at 0.05
Number of Strips	Replicate / Varroa numbers	Before treatment	After treatment	% Reduction	Before treatment	After treatment	% Reduction	Before treatment	After treatment	% Reduction	Before treatment	After treatment	% Reduction		
One	1	13.5	7.5	40.2	16.0	7.0	50.5	12.0	2.0	81.6	15.0	4.5	68.0	**60.0 ± 18.4**	
	2	9.5	3.5	60.3	13.5	2.5	79.0	10.0	3.0	66.8	12.0	5.0	55.5	**65.4 ± 10.2**	
	3	18.5	5.5	68.0	10.2	3.0	66.7	10.0	4.0	55.7	15.0	3.0	78.6	**67.3 ± 9.4**	
	Mean	**13.8**	**5.5**	**57.1**	**13.2**	**4.2**	**64.0**	**10.7**	**3.0**	**69.0**	**14.0**	**4.2**	**68.0**	**64.5^{B} ± 5.4**	
Two	1	10.5	5.0	48.7	22.0	2.5	87.1	7.9	1.9	73.4	9.5	1.0	88.8	**74.5 ± 18.5**	**0.911**
	2	7.5	2.0	71.3	16.5	4.0	72.5	8.5	0.0	100.0	12.0	2.0	82.2	**81.5 ± 13.3**	
	3	13.0	2.0	83.4	15.5	3.0	78.1	10.0	2.0	77.9	10.0	3.0	68.0	**76.8 ± 6.5**	
	Mean	**10.3**	**3.0**	**68.6**	**18.0**	**3.2**	**79.9**	**8.8**	**1.3**	**83.7**	**10.5**	**2.0**	**79.7**	**78.0^{A} ± 6.5**	
Total Mean ± S.D.		**12.1 ± 2.5**	**4.3 ± 1.8**	**2.9^{c} ± 8.2**	**15.6 ± 3.4**	**3.7 ± 0.7**	**71.9^{b} ± 11.3**	**9.8 ± 1.3**	**2.2 ± 1.2**	**76.3^{a} ± 10.4**	**12.3 ± 2.5**	**3.1 ± 1.6**	**73.8^{b} ± 8.3**	**71.2 ± 5.9**	
-ve control	1	14.3	13.2	7.7	12.0	11.5	4.2	19.5	18.0	7.7	20.0	19.0	5.0	**6.1 ± 1.8**	
	2	12.0	10.9	9.2	9.7	8.1	16.5	14.0	11.7	16.4	13.8	12.6	8.7	**12.7 ± 4.4**	
	3	15.6	15.0	3.9	6.4	5.4	15.6	10.0	9.5	5.0	18.2	17.0	6.6	**7.8 ± 5.4**	
	Mean	**14.0**	**13.0**	**7.1**	**9.4**	**8.3**	**11.7**	**14.5**	**13.1**	**9.7**	**17.3**	**16.2**	**6.4**	**8.7 ± 2.4**	

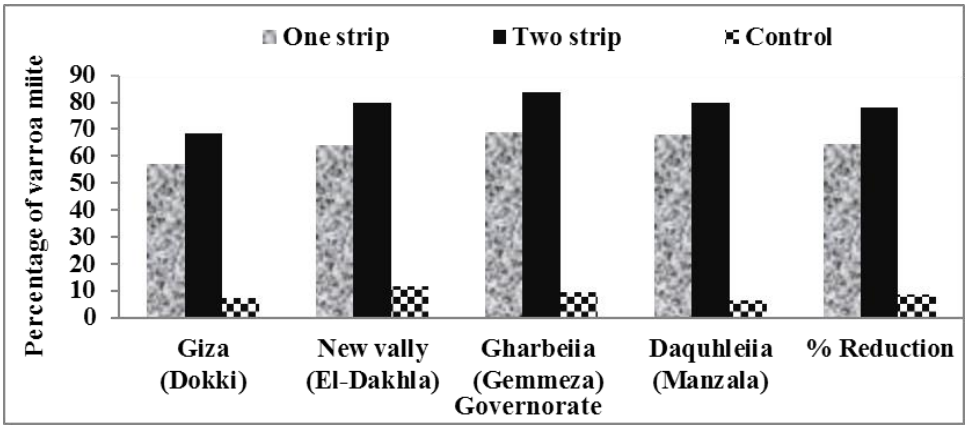

Figure (1): Percent reduction of varroa mite after treating the honeybee colonies with Bayvarol strips.

When taking up the readings which presented in Table (2) it was found that confirming the previous results, because table; 2 holds or makes a comparison between the numbers of used Bayvarol strips against varroa mite as the fallen numbers, since we generally find the using of two Bayvarol strips had exceeded on only one strip with respect to the fallen varroa numbers at every Governorates.

Generally, there were a gradually and a regular decreasing of the fallen mite numbers against one strip or two strips over the five weeks inner the experiment colonies at every Governorate, whereas the result of 1st week had significantly surpassed over the other weeks of this experiment in the fallen varroa mites and wined 154.1mites as a grand mean, while the last week wined 40.6mites.

In this connection, Gemmeza/ Gharbeiia Governorate was the highest and Dokki/ Giza Governorate was the lowest of the Governorates, whereas both of them gave a general mean of the fallen mites against using two Bayvarol strips equaled 170.9and 57.1 individuals successively. In obverse that Frilli (1989) evaluated the effect of coumaphos (Preizin), fluvalinate (Apistan), flumethrin (Bayvarol), powder of Thymol and Formic acid against *V. jacobsoni* in honey bee colonies in Italy and they found that mortality reached 95% for Bayvarol. As it is shown from the numerals in this Table (2), there were somewhat a small approaching to the results of both Manzala / Daqahlia and Gemmeza / Gharbeiia from each other, while it was observed that same approaching of both Dakhla / New Valley and Dokki / Giza with respect to results of the fallen mites against using one strip or two strips of Bayvarol each separately.

Table (2): Mean of the fallen varroa mites weekly after treating the honeybee colonies with Bayvarol strips

Governorate	Week / Number of Strips	1st	2nd	3rd	4th	5th	General mean ± Sd
Giza (Dokki)	**1**	83.3	66.6	51.4	23.0	6.7	**42.3±31.3**
	2	123.3	83.3	67.1	28.3	12.3	**57.1±44.3**
New Valley (Dakhla)	**1**	106.3	66.7	55.3	43.3	10.3	**54.2±35.0**
	2	180.0	99.0	75.8	55.0	26.0	**81.8±58.4**
Gharbeiia (Gemmeza)	**1**	129.0	118.0	78.0	77.3	66.0	**90.9±27.9**
	2	269.0	244.0	148.0	125.0	114.3	**170.9±71.4**
Daqahlia (Manzala)	**1**	120.0	98.0	66.3	45.0	29.0	**67.2±37.4**
	2	221.6	160.0	129.3	89.0	60.0	**124.8±63.0**
General mean	**1**	**109.7**	**87.3**	**62.8**	**47.2**	**28.0**	**63.7±32.3 b**
	2	**198.5**	**146.6**	**105.1**	**74.3**	**53.2**	**108.7±58.2 a**
Grand mean ± Sd		**154.1±62.8 A**	**117.0±41.9 B**	**83.9±29.9 C**	**60.7±19.2 D**	**40.6±17.8 E**	**86.2±31.8**

On the other hand, data in Table (3) clear that the grand mean of %reduction in survival numbers of varroa mite was 46.0% ± 8.7 inner the honeybee colonies which treated with VarroKiller strips in the end of experiment and that means the decrease of survival numbers of varroa mite on the honeybee adults for nearly half of the census before the experiment whereas;

At the Governorate level, the treatment was significantly higher with the number of 2 strips VarroKiller on the treatment with the number of single bar, since treating with two strips gave a general mean of %reduction in survival numbers of varroa mite on the honeybee adults equaled 50.8% ± 10.7, while the treatment with one tape gave a general mean of the reduction rate in the live census of varroa mites on the adult bees equaled 41.3% ± 8.4.

The highest in this regard was Dokki / Giza Governorate, which was significantly higher than the other three Governorates in both labs, with either one tape or two tapes, whereas that station gave against each of them the means of %reduction in the live census of varroa mite on the honeybee adults equaled 53.5% and 60.7%

successively as paralleled a total mean of %reduction was 57.1% ± 5.1.

While Manzala / Daqahlia station was the least significant Governorate in the reduction ratio, where the ratios mean against one strip and two strips were 35.0% and 38.5% respectively, which equivalent to a total mean of reduction rate equaled 36.7% ± 2.5.

The previous results compared with the untreated colonies as a control, which gave a very small change in the excluded varroa population by an average of %change as 11.5% ± 6.9. These relationships were represented in Figure (2).

Table (3): Effect of using VarroKiller strips on the mean survival number of varroa mites / 100 honeybee workers

Governorate		Giza (Dokki)			New Valley (Dakhla)			Gharbeiia (Gemmeza)			Daqahlia (Manzala)			Grand Mean of %Reduction ± S.D.	L.S.D. Value at 0.05
Number of Strips	Varroa numbers / Replicate	Before treatment	After treatment	% Reduction	Before treatment	After treatment	% Reduction	Before treatment	After treatment	% Reduction	Before treatment	After treatment	% Reduction		
One	1	9.6	5.7	52.8	10.2	5.8	35.6	10.4	5.9	41.3	10.4	5.9	36.6	**41.6 ± 7.9**	0.574
	2	8.1	4.6	54.9	6.3	3.8	31.7	9.0	5.4	37.9	9.0	5.4	32.9	**39.3 ± 10.7**	
	3	10.6	6.1	54.3	9.8	5.2	39.9	9.9	5.8	39.4	9.9	5.8	34.5	**42.0 ± 8.5**	
	Mean	**9.4**	**5.5**	**53.5**	**8.8**	**4.9**	**36.9**	**9.8**	**5.7**	**39.8**	**9.8**	**5.7**	**35.0**	**41.3^{B} ± 8.4**	
Two	1	8.2	4.3	58.3	9.7	4.0	53.3	10.3	4.7	52.8	10.3	4.7	48.9	**53.3 ± 3.8**	
	2	8.5	4.1	61.7	10.3	3.7	59.3	9.9	6.0	37.3	9.9	6.4	27.7	**46.5 ± 16.7**	
	3	10.7	5.1	62.1	8.7	2.9	62.2	9.9	5.3	44.6	9.9	5.3	40.1	**52.3 ± 11.6**	
	Mean	**9.1**	**4.5**	**60.7**	**9.6**	**3.5**	**58.7**	**10.0**	**5.3**	**45.2**	**10.0**	**5.5**	**38.5**	**50.8^{A} ± 10.7**	
Total Mean ± S.D.		**9.3 ± 0.2**	**5.0 ± 0.7**	**57.1^{a} ± 5.1**	**9.2 ± 0.6**	**4.2 ± 1.0**	**47.8^{ab} ± 15.4**	**9.9 ± 0.1**	**5.5 ± 0.3**	**42.5^{b} ± 3.8**	**9.9 ± 0.1**	**5.6 ± 0.1**	**36.7^{c} ± 2.5**	**46.0 ± 8.7**	
-ve control	1	15.6	11.4	26.9	12.0	10.4	13.3	8.8	8.0	9.1	11.8	10.1	14.4	**15.9 ± 7.7**	
	2	11.8	10.0	15.3	11.2	9.8	12.5	9.1	9.0	1.1	10.4	9.6	7.7	**9.1 ± 6.2**	
	3	9.3	7.8	16.1	10.0	9.3	7.0	8.8	8.7	1.1	9.1	8.3	8.8	**8.3 ± 6.2**	
	Mean	**12.2**	**9.7**	**20.4**	**11.1**	**9.8**	**11.1**	**8.9**	**8.6**	**3.8**	**10.4**	**9.3**	**10.6**	**11.5 ± 6.9**	

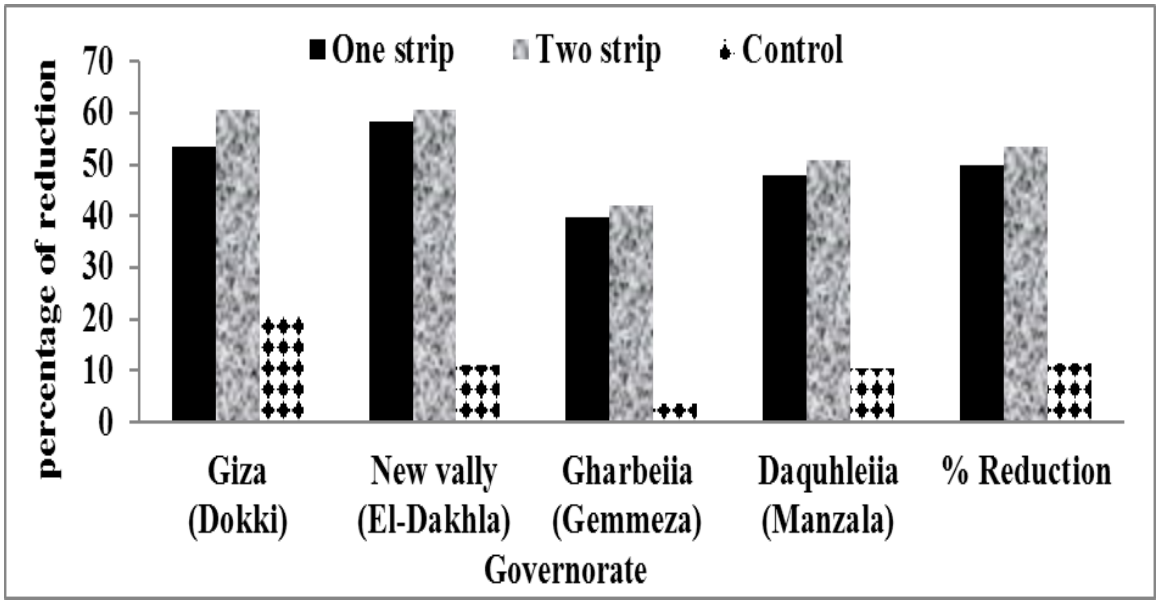

Figure (2): Percent reduction of varroa mites after treating the honeybee colonies with VarroKiller strips.

When taking up the readings which presented in Table (4), it was found that confirming the previous results, because Table (4) holds or makes a comparison between the numbers of used VarroKiller strips against their effect on varroa as the fallen numbers, since we generally find the using of two VarroKiller strips had exceeded on single tape with respect to the fallen varroa numbers at every governorate.

Generally there were a gradually and a regular decreasing of the fallen mites numbers against one strip or two strips over the five weeks inner the experiment colonies at every Governorate, whereas the result of 1st week had significantly surpassed over the other weeks of this experiment in the fallen varroa mites and wined 56.3mites as a grand mean, while the other four weeks primary from 2nd week to 5th week had wined 34.7, 26.9, 12.9 and 10.4 mites as grand means, respectevily.

In this connection, Dokki / Giza Governorate was the highest and Manzala / Daqahlia Governorate was the lowest of the Governorates, whereas both of them gave a general mean of the fallen mites against using two VarroKiller strips equaled 76.4 and 16.8 individuals successively.

As it is shown from the numerals in this Table (4), there were an approaching to the results of both Manzala / Daqahlia and Gemmeza / Gharbeiia from each other whether to using single tape or two strips, while it was observed a spacing or a high gap between Dakhla / New Valley and Dokki / Giza with respect to results of the fallen mites against using one strip or two strips of VarroKiller each separately, and generally there were a gradually and a regular decreasing of the fallen mites census against one strip or two strips over the five weeks inner the experiment colonies at every Governorate.

Data presented in Table (5) cleared that surpassed of Bayvarol compound on VarroKiller in the fallen varroa mites weekly, whereas Bayvarol attained 86.2 mites as a general mean, while VarroKiller achieved to 28.3 mites as a general mean.

Table (4): Mean of the fallen varroa mites weekly after treating the honeybee colonies with VarroKiller strips

Governorate	Week / Number of Strips	1st	2nd	3rd	4th	5th	General mean ± Sd
Giza (Dokki)	1	118	55.3	55	25	20	**54.7 ± 39.0**
	2	150	100	75.8	33	23	**76.4±51.7**
New Valley (Dakhla)	1	26.1	19.3	10.1	5.8	4.6	**13.2±9.2**
	2	44.5	26.6	18.8	7.9	7	**21.0±15.5**
Gharbeiia (Gemmeza)	1	23.8	16.4	9.7	5.4	5.1	**12.1±8.0**
	2	42.4	24	16.4	9.7	8.3	**20.2±13.9**
Daquhleiia (Manzala)	1	18.9	14.8	10.9	6.6	5.9	**11.4±5.5**
	2	26.3	20.9	18.6	9.8	8.7	**16.9±7.5**
General mean	1	**46.7**	**26.5**	**21.4**	**10.7**	**8.9**	**22.9±15.2 b**
	2	**65.8**	**42.9**	**32.4**	**15.1**	**11.8**	**33.6±22.0 a**
Grand mean ± Sd		**56.3±13.5 A**	**34.7±11.6 B**	**26.9±7.8 C**	**12.9±3.1 D**	**10.4±2.1 D**	**28.3**

Table (5): Comparison between Bayvarol and VarroKiller compounds in fallen varroa mite numbers over the experiment weeks

Compound	Number of strips	Weeks 1st	2nd	3rd	4th	5th	General mean ± Sd
Bayvarol	1	109.7	87.3	62.8	47.2	28.0	**63.7±32.3**
	2	198.5	146.6	105.1	74.3	53.2	**108.7±58.2**
General mean ± Sd		**154.1±62.8**	**117.0±41.9**	**83.9±29.9**	**60.7±19.2**	**40.6±17.8**	**86.2±31.8^{A}**
VarroKiller	1	46.7	26.5	21.4	10.7	8.9	**22.9±15.2**
	2	65.8	42.9	32.4	15.1	11.8	**33.6±22.0**
General mean ± Sd		**56.3±13.5**	**34.7±11.6**	**26.9±7.8**	**12.9±3.1**	**10.4±2.1**	**28.3±18.6^{B}**

In spite of the experiment periods, Grobov (1977) observed in temperate climates, where winter limits brood rearing, the female mites may remain on the adult bee for 5-8 months, during, which time they-are inactive. the infestation percentage by the *Varroa jacobsoni* is from about 5% of bees in spring to about 16% in August and 20% in September. Assuming only ten cycles of reproduction of varroa mites in one season and there is usually enough brood. informed that the climatic differences can affect varroa population. In Mediterranean climates mite populations have been observed to grow very rapidly (Frili, 1989). In Minia, Egypt, it was reported that the population density of varroa mite infested honeybee colonies varied considerably at localities in different months, the maximum number of mites was recorded in May as 1011 mites /colony, but Ashroba locality had the highest average number of mites (mites/100 bees) in general the mean mite density was 5.8 mite/100 bees (Eshbah, 1990). Allam found in 1999 that the levels of varroa infestation were high during October (autumn), reaching 60%, 75% and 41.8% worker, drone brood

and live bees, respectively, while in winter this level was decreased to 30,60 and 2.4% on worker, drone broods and live bees, respectively, and increased again during May (spring), especially on drone brood reaching 36.2%, 97.3% and 2.6%, respectively. However, the levels of varroa infestation decrease to the minimum level during July (summer) as averaged 23.89%, 37.5% and 3.91% on worker, drone brood and live bees, respectively. El-Shemy *et al.* (1995) mentioned that varroa infestation reached its peak in autumn and spring, but the lowest infestation was during summer, Drone-brood suffered high level of infestation and the same authors found that exposing the bee colonies to sunshine or destroying the drone brood during spring may decrease the infestation level with varroa.

The population dynamic of *V. jacobsoni* in worker and drone broods and honeybee adults was studied and recorded that October had the highest infestation (25-56%) and May had the lowest infestation (3.75%) in sealed worker brood Also, the infestation rates of nurse workers were high during autumn and winter (Serag El-Dien, 1999). While El-Hady (2001) recorded different infestation levels of varroa in three overnorates of Egypt, from April-September, his observations were: at Kafr El-Sheikh (86.66 and 70.00%), El-Qualubia (81.25 % 75.00%), and El-Gharbia (62.50 and 83.33%) in 1988 and 1999, respectively. Also Abd-Alhakam (2002) studied the varroa infestation percentage in worker brood and in adult bees and found that the highest infestation was recorded in winter (15.3% and 14.5%) at the five districts which were Fayoum, Etsa, Ibshawai, Tameia and Sannouris of Fayoum Governorate; while the lowest infestation (3.3 and 3.1%) was recorded in summer for the 1st and 2nd years, respectively, he showed that autumn and spring infestations were 11.2 and 14.1% and 7.4 and 6.9% for the same years, respectively and significant differences were found between all values in the 1st years, but autumn, summer and winter values differed significantly in the 2nd year, and the varroa infestation in adult bees was the highest infestation (13.2 and 16.1%) recorded in winter, while the lowest infestation (2.9 and 33%) was in summer in the 1st and 2nd years, respectively,

finally, autumn and spring infestations averaged 10.2 - 12.9% and 5.1 and 3.7% for the 1st and 2nd years, respectively. Also, Abada (2016) varroa mites have been considered a problem for beekeeping for about 40 years. Mint oil, Eucalyptus oil, lemon juice and to concentration from the extract of propolis alcohol prepared in carton strips saturated with aforementioned compounds with known concentrations hanged in the middle of Carnica bees at Aga county, Dakahlia Governorate for 12 weeks. The population dynamic of the varroa mite on the brood and the adults of honey bee was significantly differed in the inspected months. In addition, the peak of infestation with varroa mite was occurred during September, on brood and on adult bee then gradually decreased until November of both years. In addition, the average of the total count of varroa mite on brood and adult bee was greatly increased.

It was concluded from evaluation results of bayvarol and VarroKiller for controlling varroa mites at Egyptian apiaries that success of both two compounds in this trend with significantly surpassed of first chemical product kindly over the second in decreasing of the parasite enumeration or counts within the experiment's colonies, furthermore of increasing the controlling percentages in this present study than the previous which used same compounds that indicates to success of the added modification in these two mentioned compounds.

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Acaridida mites as a factor for mass production of predator mite, *Amblyseius swirskii* (Acari: Phytoseiidae)

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Abstract:

Development, life table parameters and mass production of the predatory mite, *Amblyseius swirskii* (Athias-Henriot) (Acari: Phytoseiidae) were assessed when reproduced on three different species of Acaridida mites, bulb mite, *Rhizoglyphus robini* (Claparede), acarid mite, *Caloglyphus rhizoglyphoides* (Zachvatkin) and the glycyphagid mite, *Lepidoglyphus destructor* (Schrank) (Acari: Acaridae), at 30±2°c and 65% relative humidity. The potential of Acaridida mites for mass production of this economically important phytoseiid mite is agood and cheap method that reduce the cost of commercial production for *A. swirskii*, and maintain large cultures of *A. swirskii* that can be used in release programs for controlling many phytophagous mite pests on various agricultural crops. *A. swirskii* has agood appetite can eat up to 10-14 immature of acaridida mites. Life cycle of *A. swirskii* females averaged 10.25, 12, 78 and 13.9 days, respectively. The net rate of natural increase (r_m) was 0.186, 0.136 and 0.119 individual/female/day where as the finite rate of increase (e^{r_m}) averaged 1.204, 1.15 and 1.12 individual/female/day, respectively. The highest intrinsic rate of natural increase (r_m) reached 0.186 when predator fed on bulb mite, *R. robini* which considered the suitable prey for the predatory mite, *A. swirskii*. Whereas, lower (r_m) value was 0.119 obtained when predator fed on glycyphagid mite, *L. destructor*.

Introduction

Predator mites of family Phytoseiidae (Acari: Gamasida) are important natural enemies of many phytophagous mites on various agricultural crops in different agro-ecosystems throughout the world (Helle and Sabelis, 1985; Gerson *et al*., 2003 and McMurtry *et al*., 2013). Several species of phytoseiid mites considered the most important biocontrol agents used in augmentative biological control against various pests, (Cock *et al.*, 2010 and Van Lenteren, 2011). The predatory mite, *Amblyseius swirskii* (Athias-Henriot) (Acari: Phytoseiidae) quickly became one of the most successful biocontrol agents in protected cultivation after its introduction into the market in 2005 and is now released in more than 50 countries. It was demonstrated that *A. swirskii* was equally

effective in other crops and countries, resulting in extensive worldwide use of *A. swirskii* in greenhouses and maintain large cultures of *A. swirskii* that can be used in release programs for controlling different pests. *A. swirskii* has excellent pereformance against different agricultural pests such as spider mite, *Tetranychus urticae* (Koch) (Acari: Tetranychidae) ; arthropods; whiteflies (Nomikou *et al*., 2001 and Messelink *et al*., 2008); thrips ; eriophyid mites (El-Laithy, 1998); broad mites (van Maanen *et al*., 2010 and Onzo *et al.*, 2012), but also plant materials like pollen (Momen and El-Saway, 1993) and (Park *et al*., 2011). Plant pollens contain high contents of proteins and essential amino acids and serve as high nutritional quality food for phytoseiid mites (Cook *et al*., 2003 and Riahi *et al.*, 2016, 2017). Therefore, plant pollens play an important role in the persistence and dynamics of many generalist predators as a food supplement or alternative food source, has a considerable impact on the efficiency of the predatory mite in the biological control program , Fadaei *et al*. (2018). The possibility of mass rearing of phytoseiids on alternative and more economical diet such as pollen increases the interest of these predators as a control agent (Castagnoli and Simoni, 1999). Acaridida mites are a factitious host population, may be employed for mass rearing or releasing of phytoseiid predatory mite species in a crop. In our study we mass reared Acarid mites on adiet of (wheat germ, rada, yeast granules) mixed with date palm pollen with asuitable range. Pollen seems to be a suitable medium for rearing phytophagous astigmatic mites under laboratory conditions. Using A. *swirskii for* controlling acarid mites needs to be investigated. Therefore, the present study aimed to mass rearing and production of *A. swirskii* based on Acaridida mites a good and cheap preys that can reduce the cost of diet production for *A. swirskii* and maintain large cultures of *A. swirskii* that can be used in release programs for controlling different pests.

Materials and methods

1. Mass rearing of mites:

The mass rearing of predator mite and the three different preys were investigated at cotton and field crop mites laboratory of Plant Protection Research institute-Sharkia-Egypt.

2. Reproduction of three different Acaridida mites.

Acarid mite, *Caloglyphus rhizoglyphoides* (Zachvatkin), bulb mite, *Rhizoglyphus robini* (Claparede) and the Glycyphagid mite, *Lepidoglyphus destructor* (Schrank) (Acari: Acaridae), reproduced on adiet of (wheat germ ,yeast granules, rada) and mixed with (date palm pollon) with a suitable range and incubated at 30°c and 65±5% relative humidity on big cages filled with a layer of mixture of (Cement: Clay: Charcoal) with percent of (7:2:1) filled on the bottom of cages to depth of 0.5 cm. Water drops were added when needed. A sufficient quantity of Acarid diet putted in the cages as afood source to the three different types of acarid species and each 2-3 days the old acarid diet removed by fine bruch under a stereomicroscope to avoid presence of fungi and repeated every two days through the experiment.

3.Species evaluated as prey in this study: (immature stages of three different Acaridida mites)

3.1. Acarid storage mite, *Caloglyphus rhizoglyphoides* (Zachvatkin)

3.2. Bulb mite, *Rhizoglyphus robini* (Claparede)

3.3. Glycyphagid mite, *Lepidoglyphus destructor* (Schrank)

4.Pollen:

Fresh date palm pollen, (Phoenix *dactylifera* L.) kept in a refrigerator and were mixed with acarid diet (wheat germ, yeast granules and rada) and supplied to the acarid mites when needed. Pollen had better potential to be used as nutrient in artificial diet for mass production of *A. swirskii* (Riahi , 2017 and Fadaei *et al* ., 2018).

5. Culture of predator mite:

A. swirskii was collected from soybean plant leaves at Sharkia Governorate, Egypt. The predator mass reared on immatures of acarid mite, *Tyrophagus putrescentiae* (Schrank), El-Sherief *et al*. (1999) in big cages putted in an incubator under 30±2°C and 65±5% relative humidity. Acarid mite, *T. putrescentiae* reproduced on crushed cereals as food.

6. **For estimating food consumption**:

known numbers of each prey were offered to each predator individual, and devoured preys were replaced with fresh ones daily.

7.Statistical analysis:

Data were analyzed by one-way analysis of variance (ANOVA) and mean comparison using LSD to test the significant differences between mean values and correlation coefficient between mite population and weather factors using SAS statistical software, SAS Institute (2003).

8.Life table parameters:

The experiment was investigated to explain the effect of most suitable prey, *(C. rhizoglyphoides, R. robini* and *L. destructor*) at 30±2°C and 65±5% relative humidity and calculated due to life 48 computer program, Abou-Setta *et al*.,1986.

Results and discussion

The following is an account of the results obtained on biological aspects of the predatory mite, *A. swirskii* under laboratory conditions of 30±2°c and 65±5% R.H as affected by different prey types.

1. Incubation period:

As shown in **Table (1)**, the incubation period of phytoseiid mite *A. swirskii* was greatly affected by different types of prey. The incubation period was long when predator fed on immature stages of Glycyphagid mite, *L. destructor* averaged *2*.55 day for the predator female while it was short when predator fed on bulb mite, *R. robini* averaged 1.53 day and 2.15 days for *C. rhizoglyphoides* prey. Thus, acaridida mites could be suitable prey for mass-rearing of *A. swirskii.*

2. Life cycle:

It could be observed that the duration of life cycle was highly affected by the type of prey employed. This total period average (10.25 ,12.78 and 13.90 days) for female and (9.50, 11.00 and 12.10 days) for male when *A. swirskii* reared on the three tested preys (*R. robni*; C. *rhizoglyphoides* and *L. destructor*), respectively. As shown in Tables (1 and 2).

3. Adult longevity:

As shown in Table (1 and 2), the predator male longevity lasted (29.9, 33.5 and 30.6 days) changed to (33.58, 36.68 and 33.18 days) for female when it fed on three tested preys, respectively.

4. Predator female fecundity: -

Fecundity was significantly affected by introduced prey**.** Therefore, the pre-oviposition, oviposition and post-oviposition periods were obviously affected by prey type, where as immature stages of bulb mite, *R. robini* was the most favorable prey for female fecundity as it gives the highest reproduction rate (66.20 eggs). On the contrary, immature stages of Glycyphagid mite, *L. destructor* resulted in the least number of female deposited eggs as it was (34.80 eggs) (Table,3).

5. Food consumption:

The number of consumed preys was differed according to types of prey and stage of introduced prey, Table (4). To investigate the suitability of various prey. The predatory mite, *A. swirskii* have a high predation capacity when fed on, immature stages of bulb mite, *R. robini*; storage mite, *C. rhizoglyphoides* and glycyphagid mite, *L. destructor,* respectively. Food consumption during its total immature averaged (361, 259.9 and 224.5 prey) for predator female and (79, 63.4 and 51.7 prey) for predator female when fed on immature stages of aforementioned preys, respectively; while, during life span were (298.9; 234.1 and 193.3 prey) for male and (361.0;259.9 and 224.5 prey) for female on the same prey, respectively.

6. Life table parameters:

As shown in Table (5), the calculated life table parameters considered were: net reproductive rate (R_0), doubling time (DT), intrinsic rate of natural increase (r_m), finite rate of increase (λ), gross reproductive rate (GRR) and cohort generation time (T_c). The cohort generation time (T) of Amblyseius *swirskii* was affected by different prey types (Table, 5). Its life table parameters were as follow, cohort generation time as (18.27, 22.43 and 23.24 days); net reproductive rate (R_0) (29.84 , 21.24 and 15.79) per pgeneration; intrinsic rate of natural increase (r_m) as (0.186 , 0.136 and 0.119); finite rate of increase(λ) averaged (1.204 , 1.15 and 1.126) and gross reproductive rate (GRR) (45.26 , 27.07 and 19.36) and doubling time (DT) values (3.726 , 5.096 and 5.824) days for females were reared on different prey types. The highest intrinsic rate of natural increase (r_m) reached 0.186 when predator fed on bulb mite, *R. robini.* This prey was considered as the optimal prey for the predatory mite, *A. swirskii*. Whereas, lower (r_m) value as 0.119 obtained when predator fed on glycyphagid mite, *L. destructor*. While, time for population doubling was 3.726, 5.096 and 5.824, respectively. Gross reproduction rate (GRR) was (45.26 ,27.07 and 19.36) when reared on bulb mite, *R. robini*; storage mite, *C. rhizoglyphoides* and glycyphagid mite, *L. destructor,* respectively.

Table (1): Mean durations (days) of *Amblyseius swirskii* females reared on three different prey types at 30 ± 2°Cand 65% RH and 12L: 12D photoperiod.

Developmental stages	*R. robini*	*C. rhizoglyphoides*	*L. destructor*	L.S.D. at 5%
Egg	1.53^{c} ±0.28	2.15^{b} ±0.36	2.55^{a}±0.31	0.28
Larva	1.35^{c}±0.21	1.65^{b}±0.24	1.88^{a}±0.27	0.22
Larva quiescent	2.10^{b}±0.24	2.18^{ab}±0.29	2.40^{a}±0.41	0.29
Protonymph	0.90^{c}±0.21	1.38^{b}±0.13	1.73^{a}±0.22	0.17
Protonymph quiescent	1.58^{b}±0.24	2.05^{a}±0.20	2.08^{a}±0.26	0.21
Deutonymph	0.95^{a}±0.33	1.00^{a}±0.31	0.68^{b}±0.24	0.27
Deutonymph quiescent	1.85^{b}±0.38	2.38^{a}±0.24	2.60^{a}±0.27	0.27
Immature	8.73^{c}±0.45	10.63^{b}±0.77	11.35^{a}±0.83	0.64
Life cycle	10.25^{c}±0.53	12.78^{b}±0.72	13.90^{a}±0.74	0.61
Generation	12.55^{c}±0.45	16.00^{b}±0.82	17.63^{a}±0.73	0.62
Longevity	33.58^{b}±0.89	36.68^{a}±0.73	33.18^{b}±0.58	0.68
Life span	43.83^{c}±0.95	49.45^{a}±0.86	47.08^{b}±0.91	0.83

Means within rows followed by the same letter were not significantly different at the 5% level.

Table (2): Mean durations (days) of *Amblyseius swirskii* male reared on different prey types at 30 ± 2°C, 75% RH and 12L: 12D photoperiod.

Developmental stages	*R. robini*	*C. rhizoglyphoides*	*L. destructor*	L.S.D. at 5%
Egg	1.38±0.21	1.93±0.24	1.83±0.33	0.24
Larva	0.80±0.33	1.23±0.25	0.70±0.16	0.23
Larva quiescent	1.63±0.32	1.68±0.26	1.98±0.22	0.24
Protonymph	0.48±0.18	0.88±0.24	1.25±0.50	0.31
Protonymph quiescent	2.28±0.25	2.45±0.35	3.38±0.40	0.30
Deutonymph	0.80±0.39	0.85±0.17	1.15±0.24	0.25
Deutonymph quiescent	2.15±0.29	2.00±0.31	1.83±0.35	0.29
Immature	8.13±1.76	9.08±1.59	10.28±1.87	0.70
Life cycle	9.50±1.97	11.00±1.83	12.10±2.20	0.81
Longevity	29.90±1.20	33.50±1.08	30.60±1.78	1.27
Life span	39.40±3.17	44.50±2.91	42.70±3.98	1.49

Means within rows followed by the same letter were not significantly different at the 5% level.

Table (3): Mean Longevity and fecundity of *Amblyseius swirskii* female reared on different prey types.

Developmental stages	*R. robini*	*C. rhizoglyphoides*	*L. destructor*	L.S.D. at 5%
Preoviposition	2.30^{c}±0.35	3.23^{b}±0.49	3.73^{a}±0.22	0.34
Oviposition	27.90^{b}±0.74	29.60^{a}±0.52	25.00^{c}±0.67	0.59
Postoviposition	3.38^{c}±0.41	3.85^{b}±0.17	4.45^{a}±0.35	0.30
Longevity	33.58^{b}±0.89	36.68^{a}±0.73	33.18^{b}±0.58	0.68
Fecundity	66.20^{a}±3.29	46.80^{b}±3.36	34.80^{c}±1.23	2.57
Daily rate	2.37^{a}±0.12	1.58^{b}±0.13	1.39^{c}±0.06	0.09

Means within rows followed by the same letter were not significantly different at the 5% level.

Table (4): Number of preys consumed (Mean ± S.D.) of *Amblyseius swirskii* female and male reared on different diets.

Developmental stages	*R. robini*	*C. rhizoglyphoides*	*L. destructor*	L.S.D. at 5%
Female				
Larva	13.5±1.43	9.4±0.97	8.5±0.85	1.02
Protonymph	29.9±1.10	24.1±1.37	19.1±0.88	1.04
Deutonymph	35.6±1.17	29.9±1.10	24.1±1.20	1.06
Immature stages	79.0±1.76	63.4±1.26	51.7±1.95	1.54
Longevity	282.0±15.85	196.5±17.49	172.8±6.70	12.99
Life span	361.0±15.59	259.9±17.30	224.5±7.44	12.95
Male				
Larva	7.4±0.70	5.6±0.52	4.5±0.71	0.59
Protonymph	24.2±0.79	19.1±0.88	14.1±1.29	0.92
Deutonymph	31.8±3.36	24.5±0.85	18.7±0.95	1.90
Immature stages	63.4±3.24	49.2±1.48	37.3±1.83	2.11
Longevity	235.5±19.78	184.9±5.17	156.0±6.15	11.31
Life span	298.9±21.94	234.1±4.98	193.3±4.88	12.19

Means within rows followed by the same letter were not significantly different at the 5% level.

Table (5): Effect of different prey on life table parameters of the predatory mite, *Amblyseius swirskii* under laboratory conditions.

Parameters	*R. robini*	*C.rhizoglyphoides*	*L. destructor*
Net reproduction rate (Ro)[b]	29.84	21.24	15.79
Mean generation time (T)[a]	18.27	22.43	23.244
Intrinsic rate of increase (r m^{c})	0.186	0.136	0.119
Finite rate of increase (e^{rm}) ƛ	1.204	1.15	1.126
Generation doubling (days)(DT)	3.726	5.096	5.824
Gross reproduction rate (GRR)	45.26	27.07	19.36

[a] Days [b] per generation [c] Individuals/female/day

The purpose of our study was to evaluate biological aspects and life table parameters of the predatory mite, *Amblyseius swirskii* (Athias-Henriot) under laboratory conditions of 30±2°c and 65±5% R.H as affected by different prey types. Previous studies showed that *A. swirskii* reproduced and developed successfully when reared on bulb mite, *R. robini*; storage mite, *C. rhizoglyphoides* and glycyphagid mite, *L. destructor*, respectively. The results obtained in our study were compared with those of some previously published studies in the same field. *Amblyseius swirskii* (Athias-Henriot) is considered a generalist predator attracted great interest as a

biological control agent of mites. The potential of Acaridida mites for mass production of this economically important predator, Riahi *et al*. (2017). Zannou and Hanna (2011) also reported the possible use of acarid mite, *Aleuroglyphus ovatus* (Troupeau) as food for the mass production and pollen of *T. domingensis* as a food supplement for this predator in practical field releases. Commercial production of *A. swirskii* based on storage acaridida mites. The acarid, *Carpoglyphus lactis* L. is the prey used to produce *A. swirskii* commercially, Bolckmans *et al*. (2006) and Riahi *et al*. (2017) they also noticed that Commercial production of *A. swirskii* based on storage mites. Also, Nguyen *et al.* (2013) assessed the development of the predatory mite *A. swirskii* when fed on dried fruit mite (*C. lactis* L.) had shorter immature and preoviposition periods than those fed on the other diets. Our results were in agreement with, Calvo *et al*., 2015 they conculuded that *A. swirskii* can control several major pests including the broad mite, *Polyphagotarsonemus latus*, simultaneously in vegetables and ornamental crops; can develop and reproduce feeding on non-prey food sources such as pollen, which allows populations of the predator to build up on plants before the pests are present and to persist in the crop during periods when prey is scarce or absent; and can be easily reared on factitious prey, which allows economic mass production.

We observed that, when mixing pollen with acarid diet, the fecundity of predators and predation rate was considerably higher. This is probably because the nutritional composition of pollen is more favorable for egg production of predator Our findings agreed with, Alatawi. *et al*. (2018) who investigated the suitability of date palm pollen as an alternate food source for another phytoseiid predator mite. Fadaei *et al*. (2018) studied the biological parameters of *A. Swirskii* on the eggs of *T. urticae* and the others being pollen of (apricot, soybean, sesame, walnut, and date, each mixed with the eggs of *T. urticae*) and the results demonstrated that *A. swirskii* was able to adapt to each of the six tested diets and growth development was considerable with each ; the oviposition and survival times of *A. swirskii* were greatly enhanced by the pollen diets so that a much greater efficiency of this predatory mite in biological control program was achieved.

In our study, the daily fecundity of *A. swirskii* were (2.37; 1.58 and 1.39) eggs/female/day on the three different acarid preys, respectively. Cavalcante *et al*. (2015). The possible use of *A. ovatus* as food for *A. swirskii* and mass production and pollen of *T. domingensis* as a food supplement for this predator in practical field releases. Similar trends were reported by El-Sherif *et al*. (1999) when *A. swirskii* was fed on *Tyrophagous putrescentiae* and Abou-Awad and Elsawi (1992) found that, when *A. swirskii* was maintained at 27 ˚c over several generations on a diet of *Tetranychus urticae*, female predators laid between 1.11 and 1.45 eggs/female/day and also, Momen and Abdel-Khalek (2008), when *A. swirskii* was fed on the eriophyid mite, *Aculops lycopersici* , which is comparable to our results.

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Population denesity of *Aleuroclava psidii* (Hemiptera: Aleyrodidae) on guava in Qaliobiya Governorate, Egypt

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Abstract:

Guava (*Psidium guajava* L) is a new host to the whitefly, *Aleuroclava psidii* (Singh) (Hemiptera: Aleyrodidae) at Qaliobiya Governorate. The high infestation by *A. psidii* causes serious damage and noticeable reduction in quantity and quality of the yield. The present investigation carried out to study the population dynamics of *A. psidii* nymph in relation to the different phonology stages of the defoliated and prune guava trees. The overall means of the first year was 4285 individuals compared with the overall mean count of the second year which was 2449 individual. The whitefly, *A. psidii* have two periods of activities (low and high activity periods) on guava trees. Also, predators and parasitoid will be surveyed and identified. The relationship between the nymph population, three climatic factors (minimum, maximum temperatures and RH %) and plant age were studied.

Introduction

World production statistics for guava are unavailable; however, the guava has major commercial importance in India, Egypt, South Africa, Brazil, Colombia and the Caribbean region. The fruits are eaten fresh or as preserves and processed for use in dairy and baked products. The guava fruit is rich in vitamin C, carbohydrates, proteins, calcium, phosphorus, vitamin A, pantothenic acid, riboflavin, thiamine and niacin and is also a commercial source of pectin and oil (Richard, 2005). In normal guava orchards their ordinary phonological phases are as following, dormancy period in winter, defoliation period on March, shoot growth and flowerage are through April and May and finally get yield on September and October. The guava trees (Psidium *guajava* L) can grow and produce in any season, so they can be harvested out of the period of high competition marketing (summer) (Nava *et al.*, 2014). As most fruit tree species, the guava tree shows different phonological stages through out its vegetative period in response to environmental conditions (Salazar and Burguera, 2006).

The guava has social and economic importance but requires technological advancements to optimize growth (Hojo *et al.*, 2007). Guava producers handle the guava tree to get higher yield, fruit quality and distribute the harvest throughout the year. Among the handling methods, the pruning time stands out as an important

management practice. The implementation of scheduled pruning promotes better circulation of cultural practices in the orchard, extends the harvest season, and adds market flexibility (Ramos *et al.*, 2010). According to Hojo *et al.* (2007), this is an economically viable practice because it can allow the harvest at precise periods of lower market supply.

Guava trees are considered as a new host for the whitefly, *Aleuroclava psidii* (Singh) (Hemiptera: Aleyrodidae) which discovered on *Psidium* sp. (Myrtaceae) in Qaliobiya Governorate Egypt (Abd-Rabou and Evans, 2014). The high infestation by *A. psidii* causes serious damage and noticeable reduction in quantity and quality of the yield. It infests underside surface leaf (Khalaf *et al.*, 2010) and causing many problems because they have piercing mouth parts which allow them to suck plant sap causing weakness of the tree and yellowish of the leaves. Also, the whitefly excretes large amount of honey dew as a result of large amount of plant sap they suck which considered a suitable medium for growth of sooty mould fungi which cover the upper surface of leaves and prevent the photosynthesis and respiration.

The aim of this work was study population dynamics of the whitefly, *A. psidii* on guava in Qaliobiya Governorate in relation to plant phenology during two years of study.

Materials and methods

The examined orchard was about two feddans in Qaliobiya Governorate whose phenological stages illustrated in (Figure,1).

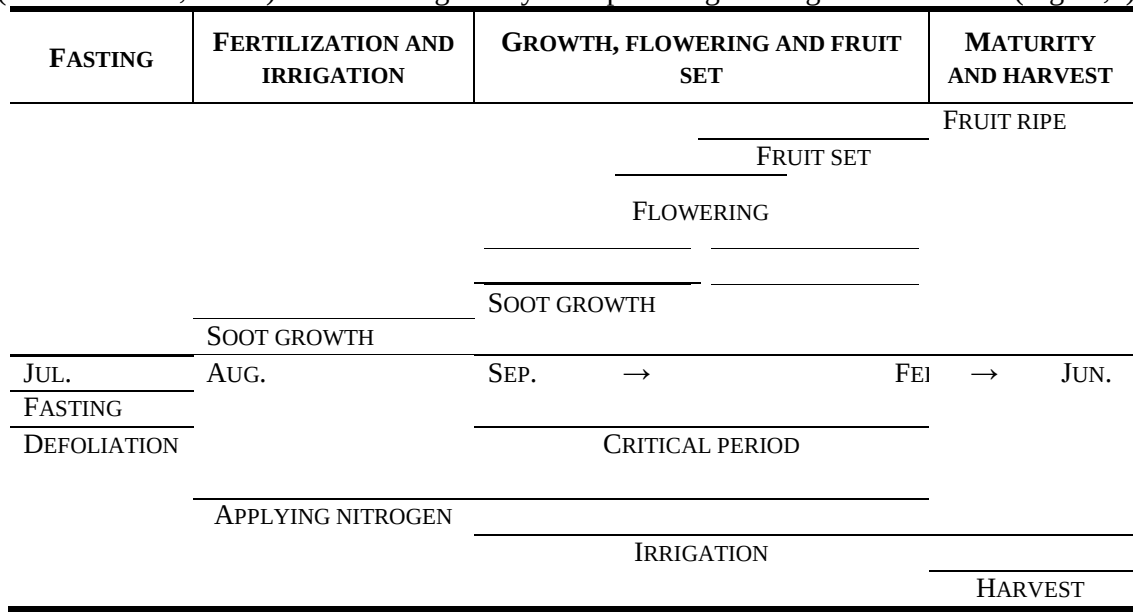

Figure (1): Annual crop cycle of guava and its control by management in Egypt

Samples were taken biweekly of 120 infested leaves (40 leaves x 3 replicates). The leaves were kept in paper bag then transferred to the laboratory to be examined by the aid of stereomicroscope binocular. Alive whitefly, *A. psidii* nymphs only were counted. Weather factors namely maximum, minimum temperatures and mean % relative humidity (RH%) was obtained from the Egypt-Weather Underground *https://www.wunderground.com/global/EG.html*. The effect of tested weather factors on this insect activity was adopted by using the simple correlation, regression coefficient and the partial regression in SAS Institute (1988) Program. The studied pest, the associated predators and parasitoid were collected and identified by Prof. D. Shaaban Abd Rabou, Scale Insect and Mealy bugs Research Department, Plant Protection Research Institute.

Results and discussion

1.Population dynamics of the whitefly, *Aleuroclava psidii* nymphal stage:

Results illustrated in Figures (2 and 3), the number of nymphs of *A. psidii* recorded one peaks per a year. During the two years of study they recorded on mid-April with 1021 and 506.6 nymphs/leaf, respectively.

2.Activity periods of *Aleuroclava psidii* on guava:

Each year of study was divided to two periods of activity, low and high activity periods.

2.1.Low activity period:

Data illustrated in Figures (4 and 5) there was a low activity period per a year of study these periods started from (mid - October till first March) with a peak of 108.67 on first of January and (first of November till first March) with 74 nymphs/leaf recorded on mid December during the two years of study, respectively, through these periods of activity the population increase in stable range because the tree is vigor and full off plant sap (green shoot, flowering and fruit setting periods) however temperatures were highly decreased.

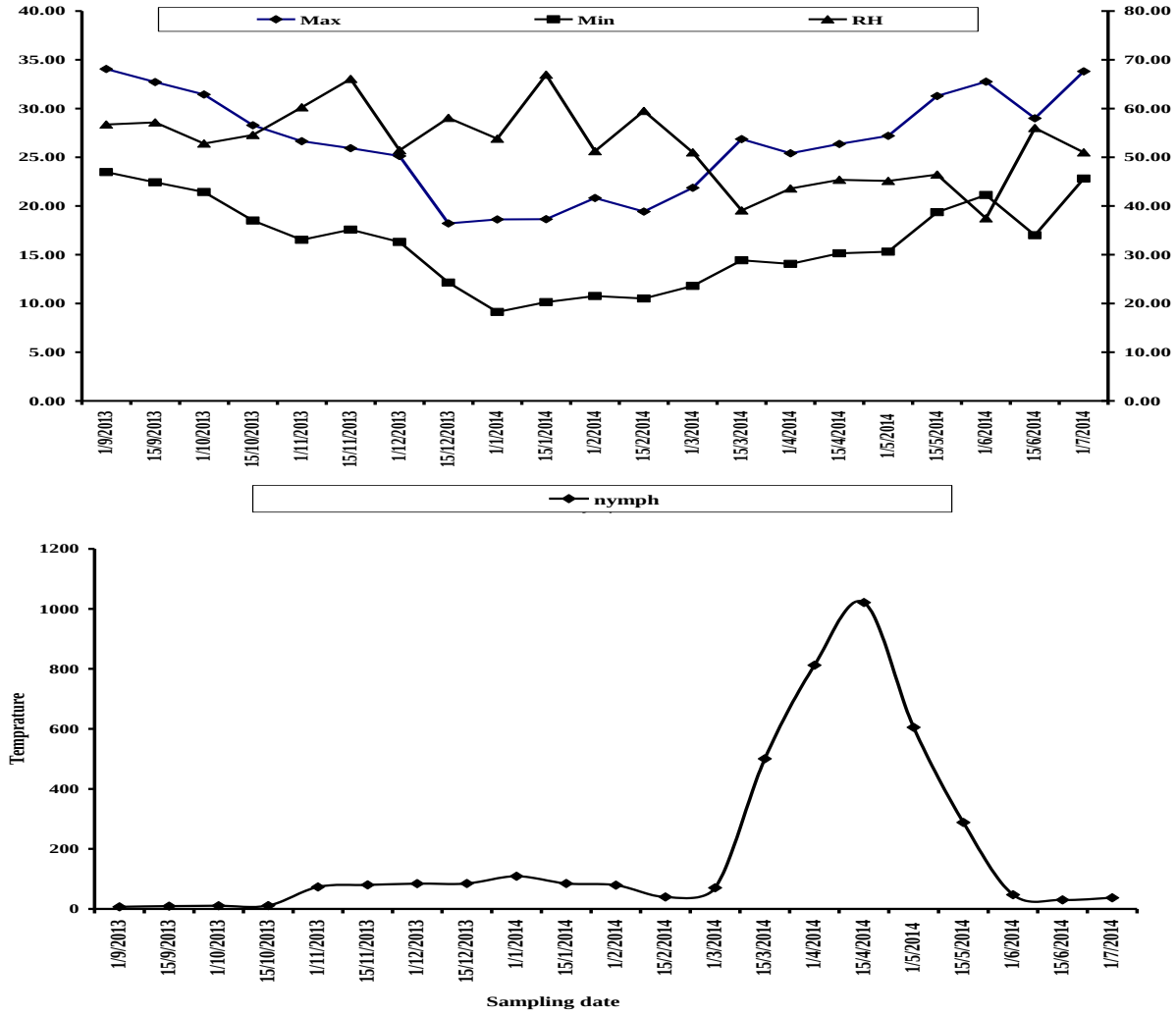

Figure (2): Population dynamics of *Aleuroclava psidii* on guava at Qaliobiya Governorate during 2013-2014 and the maximum, minimum temperatures and % RH.

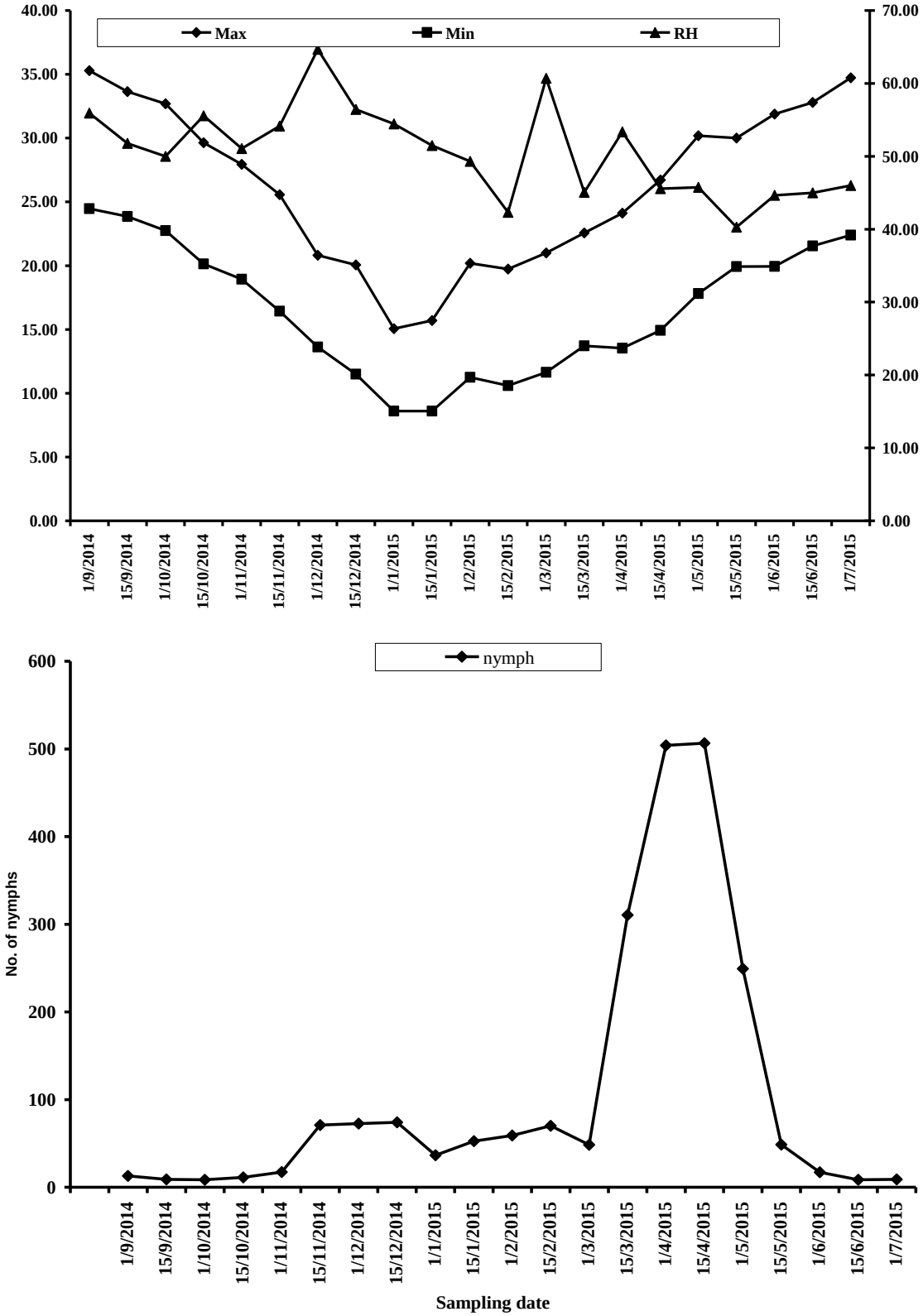

Figure (3): Population dynamics of *Aleuroclava psidii* **on guava at Qaliobiya Governorate during 2014-2015 and the maximum, minimum temperatures and % RH.**

2.2. High activity periods:

Data illustrated in Figures (6 and 7) there was a high activity period per a year of study these periods started from (first of March till first of July) its peak was 1021 and 506.6 nymphs/leaf and recorded on mid April during the two years of study, respectively. The population of nymphal stage were highly increased through these periods due to the risen of temperatures although the decrease of plant sap (fruit maturity and harvest) periods.

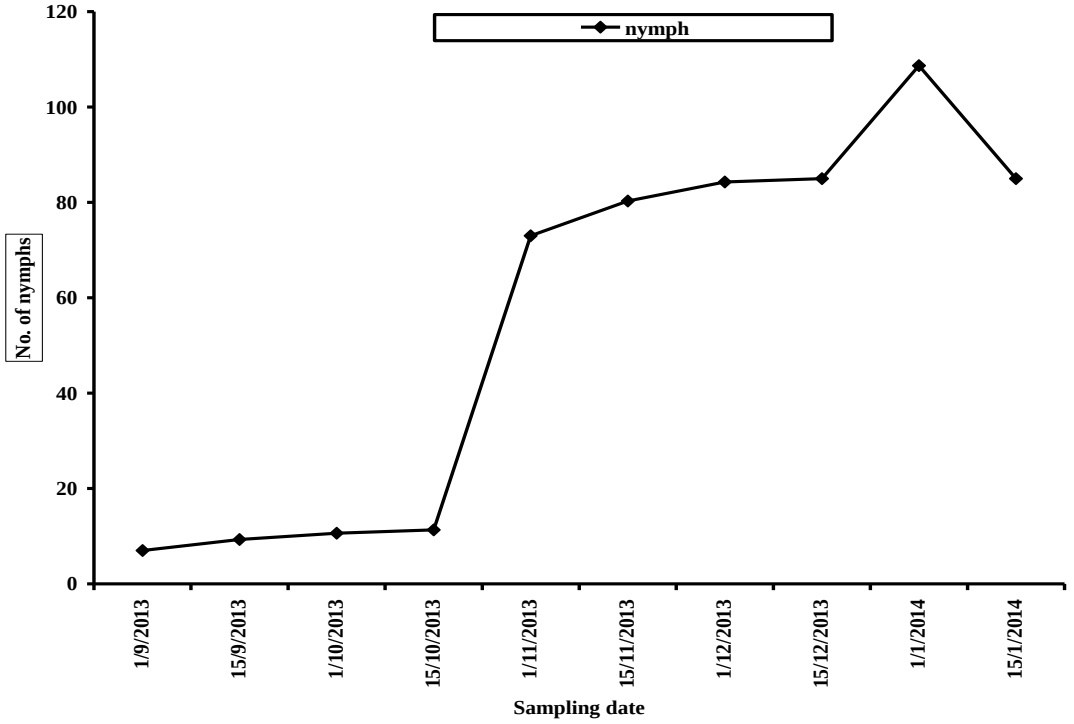

Figure (4): The relationship between *Aleuroclava psidii* nymph stage and maximum, minimum temperatures and % R.H. during the first period (2013-2014)

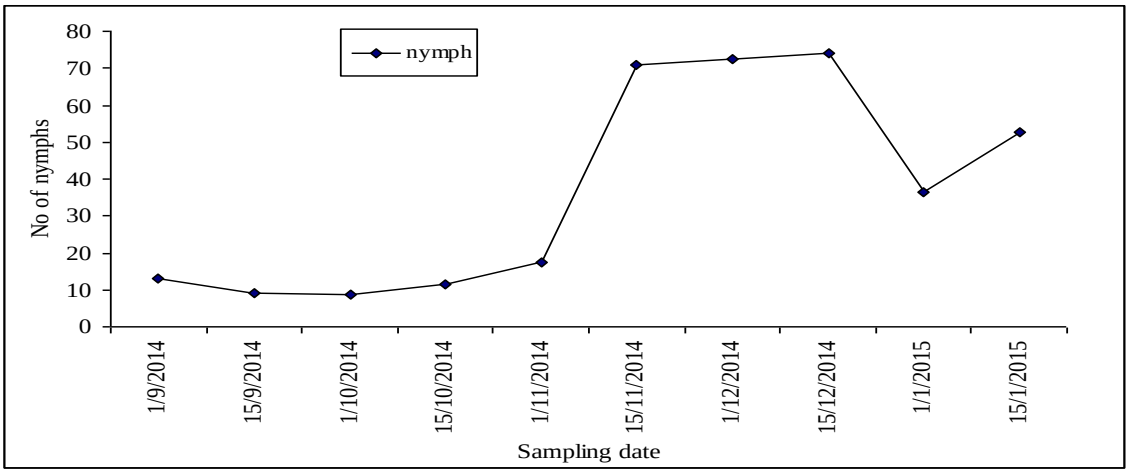

Figure (5): The relationship between *Aleuroclava psidii* nymph stage and maximum, minimum temperatures and % RH during the first period (2014-2015)

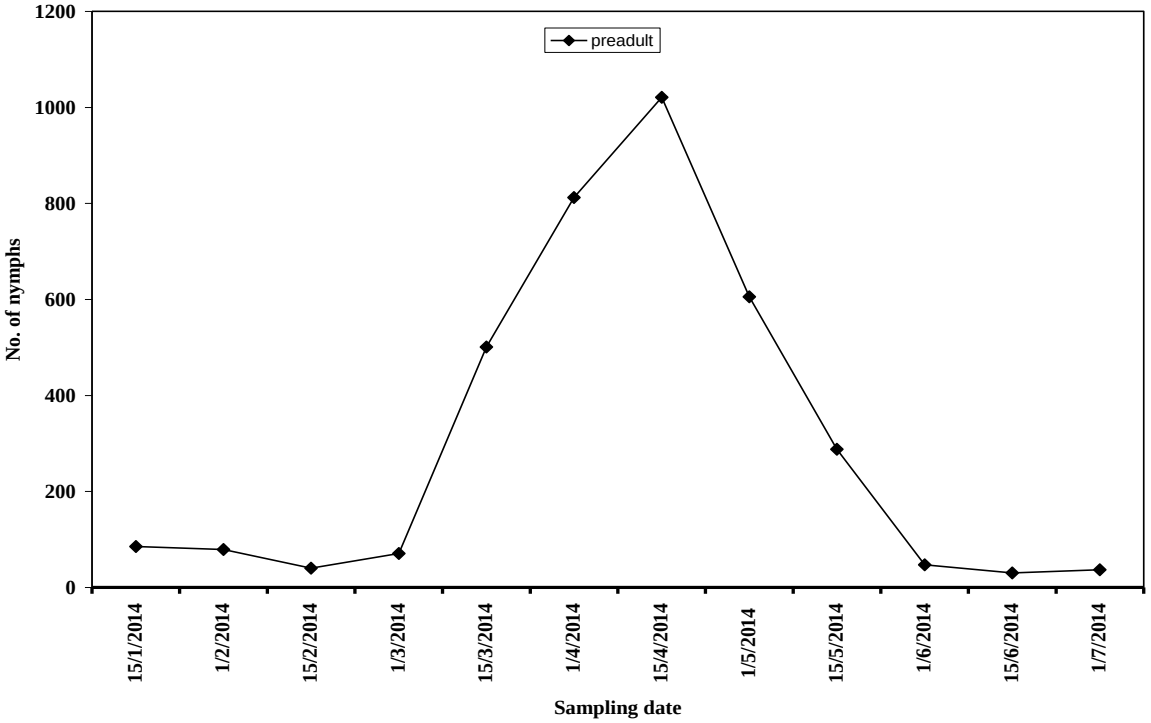

Figure (6): The relationship between *Aleuroclava psidii* nymph stage and maximum, minimum temperatures and % RH during the second period (2013-2014)

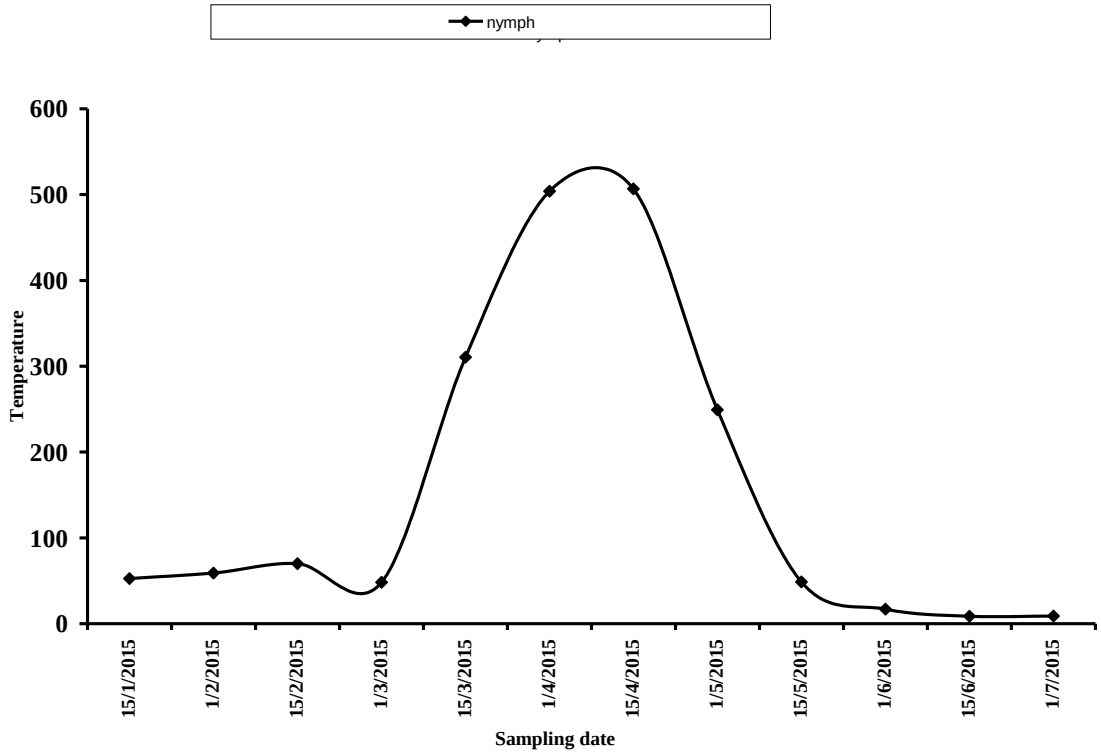

Figure (7): The relationship between *Aleuroclava psidii* nymph stage and maximum, minimum temperatures and % RH during the second period (2014-2015)

3.Effect of main climatic weather factors on nymph population density of *Aleuroclava psidii*:

The effect of abiotic factors on *A. psidii* nymphal stage was studied during two years 2013-2014/ 2014-2015 in Qaliobiya Governorate. Data tabulated in Table (1) mentioned that, each year of study was divided to two periods from 1/9 to 15/1 and from 1/2 to 1/7. During the first period of each year of study, the age plant recorded explained variance (91.35 and 76.53%) respectively. While in the second period of both years of study (E.V = 61.22 and 58.41%) respectively. All of weather factor and age plant recorded high value of the explained variance (97.12 and 91.14 %) in first period where as in the second period was (63.06 and 71. 25%) in the two years of study, respectively.

Table (1): Partial regression of three abiotic factors with their significant level and percentage of explained variance on the nymphal stage of *Aleuroclava psidii* at Qaliobiya Governorate during the two years of study.

Year	Date	Factor	Simple corr. and reg.			Partial regression		
			R	B	P	B	F	EV %
2013-2014	01/9/2013 to 15/1/2014	Max.Temp.	-0.88	-2.89	0.0008	9.90	7.29	78.47
		Min.Temp.	-0.88	-3.63	0.0008	-11.14		
		RH%	0.31	0.48	0.3979	1.53		
		Age-Age^3					21.12	91.35
		All above					16.86	97.12
	15/1/2014 to 1/7/2014	Max.Temp.	-0.03	128.32	0.9289	-5.02	1.49	38.94
		Min.Temp.	-0.13	-171.02	0.7032	-41.71		
		RH%	-0.47	-21.171	0.1400	-13.62		
		Age-Age^3					3.68	61.22
		All above					1.14	63.06
2014-2015	01/9/2014 to 15/1/2015	Max.Temp.	-0.71	16.89	0.0224	9.24	6.60	76.74
		Min.Temp.	-0.73	-23.37	0.0178	8.64		
		RH%	0.55	3.16	0.1043	2.54		
		Age-Age^3					6.52	76.53
		All above					5.14	91.14
	15/1/2015 to 1/7/2015	Max.Temp	-0.24	108.05	0.4831	70.50	1.36	36.84
		Min.Temp.	-0.33	-151.097	0.3260	-107.23		
		RH%	0.13	-4.51	0.6939	-6.35		
		Age-Age^3					3.28	58.41
		All above					1.65	71.25

These results were agreement with that obtained by Muralikrishna (1999) reported a strong positive correlation between different stages of the whitefly and weekly maximum temperature. Narayanaswamy and Ramegowda (1999) found high incidence of the pest on mulberry during April-June in and around Bangalore. The whitefly was present throughout the year in Bangalore, with high populations in summer (March-June) and low ones in winter (October-January). The population was positively correlated with temperature and negatively correlated with humidity. Krishnamoorthy (2000) recorded the population of *Aleurodicus dispersus* Russell was positively correlated with temperature and negatively correlated with humidity. Maximum. Also, Geetha (2000) stated that temperature and rainfall reduced the population of *A. dispersus*, whereas minimum temperature significantly increased the population of *A. dispersus.*

4.Survey of natural enemies of *Aleuroclava psidii*:

Data recorded in Table (2) clearly showed the presence of certain predators

and one parasitoid associated with *A. psidii* as follows:

4.1.Parasitoid:

The parasitoid *Encarsi sophia* (Giraut and Dodd) was the only recorded parasitoid with white fly *A. psidii* This result is in agreement with those obtained by Abd-Rabou and Ahmed (2012) mentioned that *Encarsi* sp. was the most abundant parasitoid associated with most different species of whiteflies. Abd Rabou and Evans (2013) who recorded that *Encarsi sophia* (Giraut and Dodd) was a virtually cosmopolitan parasitoid known to parasitized 36 species of whiteflies.

4.2. Predators:

Data present in Table (2) investigate the presence of five species of mite identified as predators were *Amblyserus swirskii* (A.-H.), Agistemus *exertus*, *Amblyseius enab* (Elbadry), *Euseius scutalis* (A.-H.) and *Tydeus californicus* Banks Gonzales associated with the white fly *A. psidii.* Also, there were other predators, *Chrysoperla carnea* (stephens) and *Rodalia cardinalis* (mulsant). These results are in agreement with those obtained by Abd-Rabou and Ahmed (2012) mentioned that ACARI/Phytoseiidae; *Amblyseius eharai, Amblyseius largoensis* and *Euseius stipulatus* were recorded as a predator on *Dialeurodes citri* (Ashmead) and the ACARI/ Pytoseiidae *Eusius scutalis* recorded as a predator on *Acaudaleyrodes rachipora* (Singh). Abd-Rabou (1999) said that predators play an important role in controlling whiteflies, and C*hrysoperla carnea* (stephens) considered the most abundant predator acting on *Bemisia tabaci* Biotype "B".

Table (2): List of natural enemies associated with *Aleuroclava psidii*:

Family	Scientific name
Predators	
Phytoseiidae	*Amblyseius swirskii* (A.-H.)
	Amblyseius enab (El-Badry)
	Euseius scutalis (A.-H.)
Stigaeidae	*Agistemus exsertus* Gonzales
Tydeidae	*Tydeus californicus* Banks
Parasitoids	
Aphelinidae	*Encarsia sophia* (Girault and Dodd)

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Fecundity, egg fertility and longevity of laboratory reared the pink bollworm, *Pectinophora gossypiella* (Lepidoptera: Gelichidiea) under different adult diet regimes

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Abstract:

Reproduction of most insects depends on nutrients accumulated during the larval stage. Recent studies, however, highlight the fundamental importance of adult nutrition. Feeding at the adult stage allows the intake of carbohydrate, lipids and amino acid rich solutions, which may have an effect on the species reproduction and population growth. Fecundity, egg viability and adults longevity data were collected for adult *Pectinophora gossypiella* (Saunders)(Lepidoptera: Gelichidiea) maintained on one of eight adult diets, these are distilled water, which was used as a control (T1), 20% sugar solution (T2), 20% honey solution (T3), 20% sugar solution + 3 drop of food oil (T4), 20% sugar solution + 10% yeast (T5), 20% sugar solution + 5% yeast (T6), 20% sugar solution + 10% yeast + 3 drop of food oil (T7) and 20% sugar solution + 5% yeast + 3 drop of food oil (T8) at two concentrations. The results indicated that moth performance was poor on honey (T3) or 10% yeast (T5) diets, best on oil diet (T4) and moderately on other diets (T2, T6, T7 and T8). Consistently oil diet (T4) enabling the moths to live moderately (13.59 and 13.87 days for female and male, respectively), produce more eggs (118.92 egg/female) and had high reproductive capacity as the percentage of control (165.98%). Also, they relatively inexpensive; thus, it can be considered good diets for maintaining laboratory colonies of these moths. In conclusion, adult's diet can play an essential role in egg production and in sustaining longevity of females.

Introduction

The cotton bollworm moth, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelichidiea) is considered one of the most important pest infested cotton crop. This pest is very active fliers and larvae mostly remain inside squares, flowers and bolls and cause severe damage (De Melo *et al*., 2012). Adult of lpidopterous insects depends on larval derived nutrients for reproduction (Geister *et al.*, 2008). Nutritional requirements may vary among adults of different species. Among numerous

nutrients (notably, proteins, carbohydrates, lipids, vitamins and mineral elements) discussed by House (1965), it seems that carbohydrate is the most important ingredient in the adult's diet affecting egg production and survival of many lepidopterous adult. In addition, amino acids derived from the adult diet play a role in some species, because amino acids can be incorporated into eggs (Boggs, 1997 and Mevi-Schutz and Erhardt, 2005). Whilst, role of lipids in adult's diet were largely neglected (Beenakkers, 1985). Authors use various types of diets to feed moths in the laboratory (a single diet or a combination of diets, is often used to enhance moth performance. Two of the more commonly used diets for moths are honey solution or a sugar solution) (Adkisson, 1961; Paul *et al*., 1987; Muralimohan *et al*., 2009 and Jothi *et al*., 2016)

The purpose of this study was to select a good adult's diet for use in researches, as well as for use by insect rearing unit of pink bollworm. Insect feeding which results in good egg production and longevity are two important considerations of a good diet. Adults were fed eight diets to determine the effects of water, sugar, honey, food oil and yeast on reproduction maintenance.

Materials and methods

1. Insect: In order to assess the reproductive performance, *P. gossypiella* was obtained from a laboratory colony maintained at the Bollworms Research Department Laboratory, Plant Protection Research Institute, Agriculture Research Center, Dokki, Giza, Egypt. Newly eclosed adults (<24 h old) were confined in the glass chimney cage. The top and bottom of each cage were covered with screening mesh kept in position by rubber bands for stimulating egg-laying response in females. Five pairs of moths were set up for each treatment with three replicates. Eggs laid by female on the piece of paper placed over and under the cage in open Petri dishes through the screening mesh were collected every 48 hours. Moths and any resulting eggs were held at 27 ± 1°C and 75 ± 5% relative humidity (RH). Pairs were provided with the different adult diets inside the glass chimney with a piece of cotton wool previously soaked in each diet. Solution was suspended to be renewed every 48 hours for moths feeding.

2.Diets: Adults were fed eight diets to determine the effects of water, sugar, honey, food oil (as source of lipids) and yeast (as source of protein and amino acids) on reproduction maintenance:

2.1. Distilled water, which was used as a control (T1)
2.2. 20% sugar solution (T2)
2.3. 20% honey solution (T3)
2.4. 20% sugar solution + 3 drop of food oil (T4)
2.5. 20% sugar solution + 10% yeast (T5)
2.6. 20% sugar solution + 5% yeast (T6)
2.7. 20% sugar solution + 10% yeast + 3 drop of food oil (T7)
2.8. 20% sugar solution + 5% yeast + 3 drop of food oil (T8)

The following parameters were analyzed: fecundity, egg viability and adult's longevity. Fecundity was calculated from the mean number of eggs laid during the entire lifecycle of the females, while egg viability was assessed from the mean percentage of hatched larvae in the treatments. The following equation was used for calculating the percent of fecundity and percent of egg viability:

$$\%\text{Control of fecundity or egg viability} = \frac{C - T}{C} \times 100$$

Where; C: The estimated parameter in check
T: The same parameter in treatment

On the other hand, percent of reproduction control (% sterility) was calculated according to the equation of Toppozada *et al*. (1966) as follows:

$$\%\,\text{Sterility} = 100 - \left(\frac{a \times b}{A \times B} \times 100 \right)$$

Where; a: Number of eggs laid/female in treatment

b: %Hatch in treatment

A: Number of eggs laid/female in control

B: %Hatch in control

3. Statistical analyses: Analysis of variance (ANOVA) was conducted on all data using Costat computer program software. Means were compared by Duncan's multiple range test (Duncan, 1955).

Results and discussion

1. Egg production and fecundity percent:

The food source offered had an apperent effect on the butterflies' ability to lay eggs as well as on egg fertility (Table, 1 and Figures, 1 and 2). The number of the average egg ranged between 55.12 to 118.92 egg/female. Adult feeding just water (T1; control) had the lowest number of laying egg (55.12 egg/female). When feeding on honey solution (T3), the number of eggs laying increased poorly by 3.86% to reach 57.75 egg/female. The diet containing sugar (T2) results in significantly more eggs than the non-sugur diet (91.48 egg/female) by 65.97%. This indicate that sugars aid to maintain egg development during adult ageing and the kind of sugar had an effect.

Yeast had a slightly effect on fecundity when offered in sucrose solution at 10% concentration (T5; 72.75 egg/female) compared with females fed with water only. The percentage of increasing in egg production (% fecundity) was 31.98%. But at 10% concentration with oil (T7) it increased fecundity significantly (103.65 egg/female) by 88.04%. Also, it increased fecundity significantly when offered in a sucrose solution at 5% concentration alone (T6; 92.73 egg/female) or with adding oil (T8; 104.0 egg/female). It was higher than control (females fed with water only) by 68.23 and 88.67% for T6 and T8, respectively.

Total lifetime egg production by butterflies fed diets containing mixture of sugar & oil (T4; 118.92 egg/female) is significantly greater than by butterflies fed other diets. The percentage of increasing in egg production (% fecundity) was 115.75%. This indicate that the existence of oil in the feeding diet has a notable effect (T4, T7 and T8).

2. Hatchability of deposited eggs and viability percent:

The average of egg hatchability percent reached 60.78 % in the case of control (T1) pink bollworm (Table, 1). It was found no significant difference in the probability of being fertile in all treatment vs. conrol except T2 and T6 which differed significantly from control and record 80.44 and 78.25 % of hatchability, respectively, but did not differed significantly from other treatments. However, the calculated percentages of egg viability control were higher than the control by 32.28, 22.23, 23.28, 11.17, 28.74, 8.29 and 10.78%, for T2, T3, T4, T5, T6, T7 and T8, respectively.

3.Reproductive capacity:

It was obvious from the results in the Table (1) that the pattern of fecundity and hatchability exhibited by pink bollworm moths due to the different treatments was reflected in the values obtained for reproductive capacity. Generally, in all treatments, the produced females had high reproductive capacity as the percentage of control, since the control reproduction percentages reached 119.54, 26.95, 165.98, 46.73, 116.59, 103.64 & 109.01% after treatment with T2, T3, T4, T5, T6, T7 and T8, respectively. It could be arranged the tested diet according to its effect on reproductive capacity as follows: T4 > T2 > T6 > T8> T7 > T5 > T3 (Table, 1 and Figure ,2).

Table (1): The effect of different adult diets on reproduction potential and longevity of *Pectinophora gossypiella* moth.

Treatment	Eggs/female ± SE	%Control of fecundity (±)	%Hatchability ± SE	%Control of egg viability (±)	%Control of reproduction (±)	Adult longevity (days) ± SD	
						♀	♂
Water (T1)	55.12^{d} ± 22.28	—	60.78^{b} ± 12.29	—	—	11.5^{b} ± 4.76	10.53^{f} ± 4.12
20% sugar (T2)	91.48^{bc} ± 30.29	65.97	80.44^{a} ± 4.34	32.28	119.54	17.83^{a} ± 6.10	21.4^{a} ± 6.28
Honey (T3)	57.25^{d} ± 11.51	3.86	74.29^{ab} ± 17.59	22.23	26.95	11.38^{b} ± 3.33	10.92^{f} ± 4.39
20% sugar & oil (T4)	118.92^{a} ± 17.20	115.75	74.93^{ab} ± 11.83	23.28	165.98	13.59^{b} ± 1.80	13.87^{de} ± 2.05
20% sugar & 10% Yeast (T5)	72.75^{cd} ± 6.36	31.98	67.57^{ab} ± 12.27	11.17	46.73	17.41^{a} ± 6.04	18.0^{b} ± 5.08
20% sugar & 5% Yeast (T6)	92.73^{bc} ± 8.97	68.23	78.25^{a} ± 17.92	28.74	116.59	18.29^{a} ± 3.43	17.5^{bc} ± 3.09
20% sugar & 10% Yeast +Oil (T7)	103.65^{ab} ± 27.37	88.04	65.82^{ab} ± 18.26	8.29	103.64	12.72^{b} ± 5.14	15.55^{cd} ± 2.81
20% sugar & 5% Yeast +Oil (T8)	104.0^{ab} ± 5.44	88.67	67.33^{ab} ± 9.85	10.78	109.01	16.5^{a} ± 3.63	13.1^{e} ± 2.60
LSD (5%)	**19.44**		**15.20**	—	—	**2.12**	**1.99**

Means followed by the same letter at the same column are not significantly different.

$$\%\text{Control of fecundity or egg viability} = \frac{C - T}{C} \times 100$$

$$\%\text{Control o reprction} = 100 - \left(\frac{a \times b}{A \times B} \times 100 \right)$$

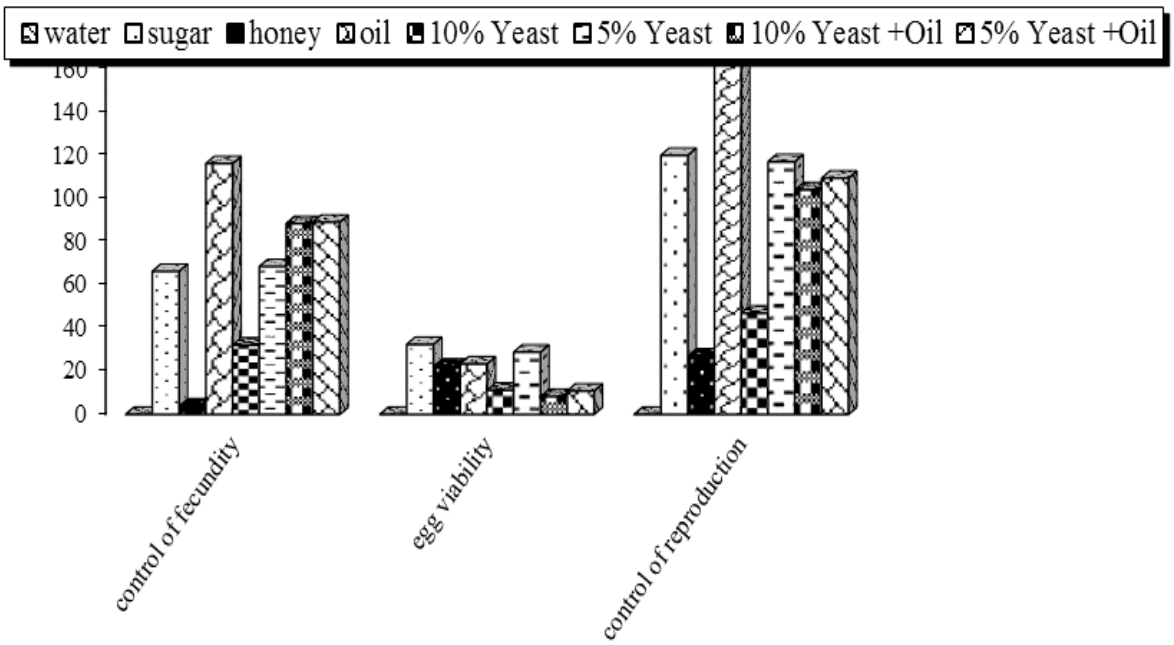

Figure (1): The effect of different adult diets on the fecundity, egg hatchability and longevity of *Pectinophora gossypiella* moth.

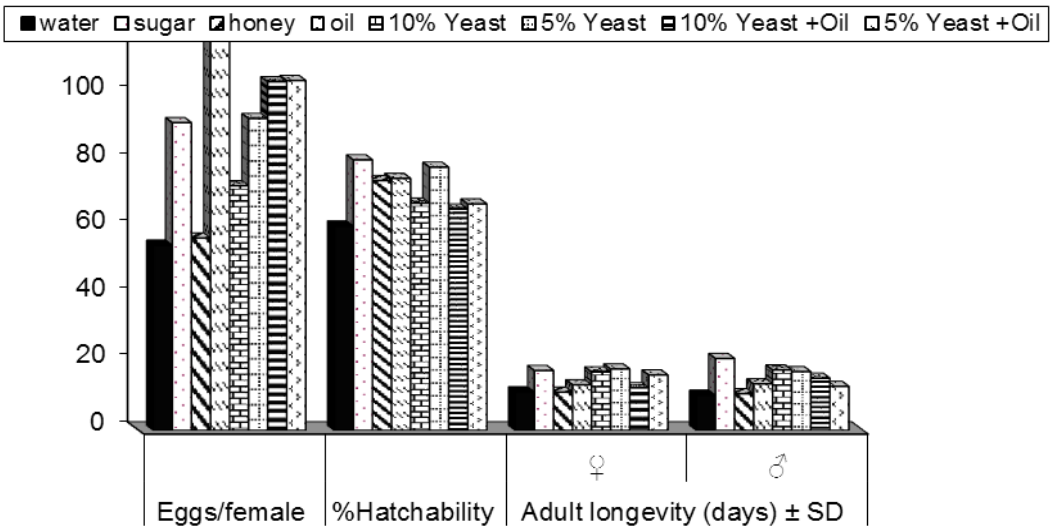

Figure (2): The effect of different adult diets on percent control fecundity, egg viability and reproduction capacity of *Pectinophora gossypiella* moth.

4.Adult longevity:

Adults longevity which feeding on water only was 11.5 & 10.53 days, for femle and male, respectively (Table, 1 and Figure, 1). Sucrose and yeast (5 and 10%) diets were among the diets on which cotton bollworm moth, *P. gossypiella* male and female aduts lived longest (17.83 and 21.4, 17.41 and 18.0 and 18.29 and 17.5 days for sucrose, 5% yeast and 10% yeast, respectively. Conversely, they lived shortest on the honey (11.38 and 10.92 days for female and male, respectively). Oil diets (T4, T7 and T8) was only a moderately good diet for adults (13.59 and 13.87, 12.72 and 15.55 and 16.5 and 13.1 days for female and male, respectively).

Food sources were found to have a significant effect on butterfly fecundity, fertility and longevity of *P. gossypiella* adults. Accumulated information resulted from obove results explain that the existence of oil in the adult diets had the most reproductive capacity. In addition, it had a moderate adult's longevity. It means that reproduction may not only be limited by carbohydrates, but also by deficiencies in other larval-derived substances such as lipids (Behmer and Grebenok, 1998 and Arrese *et al.,* 2001). These results are not in similatry with Bauerfeind *et al.* (2007) who found that lipids, yeast or ethanol added to a sugar solution did not yield a similarly high reproductive output reproduction in the tropical, fruit-feeding butterfly *Bicyclus anynana* (Butler) (Lepidoptera: Nymphalidae) compared to fruit-fed females. Also, Geister et al. (2008) found that in female *B. anynana*, all diet groups (plain sucrose solution, sucrose solution enriched with lipids or yeast) had a substantially lower fecundity and egg hatching success compared to the banana group. Tisdale and Sappington (2001) data indicate that carbohydrates in the adult diet can increase fecundity, fertility and longevity of the beet armyworm, *Spodoptera exigua* (Hübner). Romeis and Wackers (2002) studied the effect of different kind of sugers and found that glucose is the only sugar that has a positive effect on both longevity and fecundity as well as a number of oviposition parameters of *Pieris brassicae*. Also, sugar concentration has been shown to have important effect on most species which have been studied (Leather, 1984). In 1990, Simmons and Lynch collected data about survival and egg production for females of *Spodoptera jrugiperda* (J. E.

Smith), fall armyworm; *Helicoverpa zea* (Boddie), corn earworm *Helicoverpa zea* Boddie and lesser cornstalk borer, *Elasmopalpus lignosellus* Zeller maintained on one of eight adult diets, two honey solution diets, sucrose solution, Gatorade, three beer diets, and water. They found that moth performance was best on honey or sucrose diets. In addition, Jordão *et al*. (2010) found that female fecundity of *Phthorimaea operculella* Zeller was higher in honey-fed females as compared to the water-fed females. In contrast, Euzébio *et al*. (2013) found that the fecundity and longevity of *T. arnobia* (Lepidoptera: Geometridae), adults fed on 15% honey solution did not improve the reproductive capacity and longevity of *Thyrinteina arnobia* (Stoll) females but it favors those of males, which could increase mating probability. This is important because *T. arnobia* males emerge sooner than females, and feeding them could increase their longevity and chances of mating various females.

Therefore, the availability of carbohydrates in the adult diet have a profound impact on the reproductive capacity. While adding yeast (as a source of protein or amino acids) to a soucrose-based diet are generally of low importance and differed according its concentration (also compare Lewis and Wedell, 2007; Molleman *et al.,* 2008 and Bauerfeind and Fischer, 2009), contrasting the findings of Mevi-Schütz and Erhardt (2005) who demonstrated that feeding on amino acid-rich substrates during the adult stage can largely compensate for reduced larval-derived resources in the nectar-feeding map butterfly. As a dietary supplement, yeast has been shown to dramatically increase egg production but to reduce longevity in *Drosophila melanogaster* (Meigen) (Diptera: Drosophilidae) and *Chrysoperla carnea* (Stephens) (Neuroptera: : Chrysopidae) (Good and Tatar, 2001). The different_results might be due to the fact that the amino acid solutions offered in the various studies differed in their composition and concentration. A second possible explanation could be differences in the nutritional requirements of adult Lepidoptera, depending on the nutrients carried over from the larval stage (Boggs, 1997).

The reproductive potential of lepidopterans is influenced by the insect's lifecycle, nutritional status. Although food resources for reproduction of most insects depend on the nutrients accumulated during the larval stage, many lepidopteran species show feeding habits in the adult stage (Chapman, 1998). Romeis and Wackers (2002) mentioned that many adult Lepidoptera are dependent on carbohydrate-rich solutions such as nectar and honeydew. These food sources can contain a range of carbohydrates as well as low levels of other compounds, including free amino acids, proteins and lipids (Nicolson *et al.,* 2007 and Nepi, 2014). Most of studies have examined only the effect of sugars and amino acids in the diet, and all of them used only a limited range of concentrations. While, few studies so far have attempted to determine the importance of lipids in adult's diet on reproduction.

Carbohydrates represent the primary source of energy for adult Lepidoptera (Boggs, 1987). Also, it has been demonstrated and argued that carbohydrates fed by adults may be an additional food supply that helps the vitellogenin synthesis and egg development, thus increasing fecundity (Tisdale and Sappington, 2001). Since insect eggs are primarily composed of protein and lipid (Engelmann, 1999; Ziegler, 2006 and Karl *et al.*, 2007), we anticipate a high demand for these compounds by ovipositing females. The general importance of lipids and proteins for embryonic and larval development in insects is established (Beenakkers *et al*., 1985; Van Handel, 1993 and Diss *et al.*, 1996). Lipids are considered to cover the energetic demands of the developing embryo, while proteins are mainly

structural components, but may additionally serve as energetic resource (Beenakkers *et al*, 1985). For a long time, it was believed that Lepidoptera acquire all their nitrogenous reserves during their larval period, whereas adult feeding was believed to cover energy requirements only (Engelmann, 1970 and Wiggelsworth, 1972). Recently, Levin et al. (2017) found that both essential and nonessential amino acids were allocated to eggs and flight muscles in *Manduca sexta*. Additionally, the role of amino acids in nectar may differ between species (Wheeler and Buck, 1996). Such differences suggest that reproductive resource allocation is a rather complex issue and that any generalizations about the role of adult diet-derived amino acids for butterfly reproduction seem premature. Yeast is known to be an excellent source of protein to insect. The fermenting activity of yeasts results in the production of noticeable concentrations of e.g. ethanol (Leavey, 2004). Ethanol at low concentrations may serve as an energy source (apart from being an olfactory cue; e.g. Omura and Honda (2003), while high concentrations (45.0–7.5%) are toxic (Heberlein *et al.*, 2004).

Lipids are likely to be of key importance for insect reproduction, as they are major constituents of the oocyte dry mass and serve various functions including their role as the main energy source for the developing embryo (Ziegler and Van Antwerpen, 2006). As most insects are neither able to synthesize long-chain polyunsaturated fatty acids (hereafter PUFAs; but Beenakkers *et al*., 1985) nor the tetracyclic steroid nucleus required for the synthesis of sterols (Behmer and Nes, 2003) de novo, they depend on exogenous sources for successful development and reproduction (Al-Izzi and Hopkins, 1982; Beenakkers *et al.*, 1985; Turunen, 1990; Behmer and Grebenok, 1998; Svoboda, 1999 and Mondy and Corio-Costet, 2000).

In conclusion, when interpreting these findings, it should be borne in mind that both larval and adult diets seem to strongly interact with each other to fully meet all nutritional requirements of insects. And conclude that the non-carbohydrate components in adult's diet may play important roles in both reproductive success and survival of pink bollworm. Generally, the performance of the moths on the oil diet was consistently good. It enabling the moths to live moderately and produce more eggs, the oil diet are also relatively inexpensive; thus, they can be considered good diets for maintaining laboratory colonies of these species of moths.

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Toxicity of cinnamon oil and its active ingredient against the carmine spider mite, *Tetranychus cinnabarinus* (Acari: Tetranychidae)

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Abstract:

The carmine spider mite, *Tetranychus cinnabarinus* (Boisduval) (Acari: Tetranychidae) is a worldwide polyphagous agricultural pest and it is an economically important pest that infests greenhouse and field crops. The toxicity of cinnamon oil (*Cinnamomum zeylanicum* Blume) and its active ingredient cinnamaldehyde were studied under laboratory conditions against adult female of carmine spider mite, *T. cinnabarinus*. LC_{50} of each treatment was established and the obtained results revealed that the active ingredient cinnamaldehyde was more effective than the cinnamon oil. LC_{50} was 2521.54 and 4516.61 ppm for cinnamaldehyde and cinnamon oil, respectively, for *T. cinnabarinus*. However, the LC_{90} was 27072.28 and 48576.69 ppm for cinnamaldehyde and cinnamon oil, respectively. It is concluded that cinnamon oil as a promising save control agent for controlling the carmine spider mite, *T. cinnabarinus*.

Introduction

The carmine spider mite, *Tetranychus cinnabarinus* (Boisduval) (Acari: Tetranychidae) is one of the most significant herbivores species of the genus *Tetranychus* which includes nowadays over 140 species (Wang *et al.*, 2004 and Sertkaya *et al., 2010*). This species infests greenhouse and field crops and has been documented to feed on more than 130 plant species of economic importance, including vegetables, fruit- trees and ornamentals (Guo *et al.*, 1998 and Sivira *et al.*, 2011). *T. cinnabarinus* can damage protective leaf surface, palisade layers and cause yellowing, crinkling, crumpling, curling and twisting of leaves (Jeppson *et al.*, 1975).

Commercially available synthetic acaricides are usually expensive and may be needed to be imported for use by farmers. They also tend to have detrimental effects on the environment and can be hazardous to humans. These negative effects have resulted in an increasing interest for natural plant-based pesticides which are assumed to be safer than the synthetic pesticides (Yanar *et al*., 2011). Natural plant extracts play an increasingly prominent role as alternatives to synthetic pesticides due to the increasing concern on health hazards, environmental pollution and negative effects on non target organisms (Sharma *et al*., 2006).

Cinnamon is a common spice used by different cultures around the world for several centuries. It is obtained from the inner bark of trees from the genus *Cinnamomum*, a tropical evergreen plant that has two main varieties; *Cinnamomum*

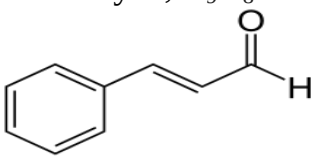
zeylanicum (CZ) and *Cinnamon cassia* (CC) (also known as *Cinnamomum aromaticum*/Chinese cinnamon) (Mazyad and Soliman, 2001). Almost every part of the cinnamon tree including the bark, leaves, flowers, fruits and roots, has some medicinal or culinary use. The volatile oils obtained from the bark, leaf and root barks vary significantly in chemical composition, which suggests that they might vary in their pharmacological effects as well (Shen *et al*., 2002). The present work was aimed to evaluate the toxicity of cinnamon oil and its active ingredient on *T. cinnabarinus*.

Materials and methods

1.Rearing the carmine spider mite, *Tetranychus cinnabarinus***:**

The carmine spider mite, *T. cinnabarinus* was collected from unsprayed castor bean plants and reared at 25± 2° C and 60± 5%RH. cinnamon oil and its active ingredient cinnamaldehyde were bought from Essential oil Extracts Center, National Research Center.

-Cinnamaldehyde, C_9H_8O.



Cinnamaldehyde formula (Vogt, 2010)

2.Preparing the stock solution of the tested materials:

Convenient stock concentrations of each material were prepared on basis of the tested material, (cinnamon oil or cinnamaldehyde powder), weight and the volume of the distilled water (w/v) in the presence of tween 80(0.1%) as emulsifier. The stock concentrations were kept in glass stoppered bottles and stored under refrigeration. Such stock solutions were prepared periodically. Four diluted concentrations for each plant extract were used to draw the LD-P lines. Three replicates were used for each concentration.

3.Toxicity test:

The toxicity of cinnamon oil and cinnamaldehyde powder was evaluated against adult females of *T. cinnabarinus*. Thirty newly emerged adult females were transferred to the lower surface of castor leave discs (2.5 cm diameter) placed separately on moist cotton wool in petri dishes. Each petri dish contains three replicates, ten individuals in each replicate. Each acaricide had four concentrations, 1000, 5000, 7500 and 10000 ppm, which were sprayed on the individuals. Mortality was recorded for 7 days after treatment. The mortality percentage was estimated and corrected according to the Abbott's formula, 1925. LC_{50} values were determined using probit analysis statistical method of Finney (1971).

Equation: Sun, 1950 (to determine LC_{50} index)

Toxicity index for LC_{50}=

$$\frac{LC_{50} \text{ of the most effective compound}}{LC_{50} \text{ of the least effective compound}} \times 100$$

Results and discussion

1.Efficiency of cinnamon oil and cinnamaldehyde on adult female of carmine spider mite *Tetranychus cinnabarinus*:

The data in Table (1) indicated that, the active ingredient, cinnamaldehyde, caused high mortality proportion on the carmine spider mite, *T. cinnabarinus* than the cinnamon oil. This is because cinnamon oil contains cinnamaldehyde (80– 90%) and other materials as eugenol, eugenol acetate, cinnamyl acetate, cinnamyl alcohol, methyl eugenol, benzaldehyde, benzyl benzoate, linalool, monoterpene, hydrocarbon, caryophyllene, safrole and others, such as pinene, phellandrene, cymene and cineol (Heath, 1978). While the active ingredient cinnamaldehyde is concentrate active ingredient powder. These results were in agreement with Tasnin and Khalequzzaman (2016).

However, Table (2) and Figure (1) demonstrated that the cinnamaldehyde was

more effective than the cinnamon oil, with LC_{50}: 2521.54 ppm and 4516.61ppm, respectively. LC_{90} value was 27072.28 ppm and 48576.69 ppm for cinnamaldehyde and cinnamon oil. The toxicity index was 100% for cinnamaldehyde while it was 55.83% for cinnamon oil. The slope values indicated that cinnamaldehyde and cinnamon oil had the same value which was 1.24. Also, LC_{90}/ LC_{50} values were 10.736 and 10.755 for cinnamaldehyde and cinnamon oil, respectively. The obtained results were in agreement with Mohammed and Hany (2013).

Table (1): Corrected mortality percent of the carmine spider mite ,*Tetranychus cinnabarinus* treated with cinnamon oil and cinnamaldehyde derivatives under laboratory conditions 25±2 ˚C and 60±5% RH.

No.	Treatments	Conc. (ppm)	Mortality after treatments %				Total Mortality %
			One day	Three days	Five days	Seven days	
1	Cinnamic oil	1000	13.33	3.33	3.33	3.33	23.32
		5000	10	16.67	13.33	3.33	43.33
		7500	10	20	16.67	13.33	60
		10000	20	20	16.67	16.67	73.34
2	Active ingredient	1000	6.67	3.33	10	13.33	33.33
		5000	16.67	26.67	10	3.33	56.67
		7500	16.67	10	26.67	16.67	71.01
		10000	20	40	13.33	10	83.33

Table (2): Efficiency of cinnamaldehyde and cinnamon oil against the carmine spider mite, *Tetranychus cinnabarinus*:

Treatments	Conc.	Corrected mortality%	LC_{50}	LC_{90}	Slope± S.D.	Toxicity index LC_{50}	LC_{90}/ LC_{50}	R	P
Cinnamic oil	1000	23.32	4516.61	48576.69	1.24± 0.178	55.83	10.755	0.952	0.061
	5000	43.33							
	7500	60							
	10000	73.34							
cinnamaldehyde	1000	33.33	2521.54	27072.28	1.24± 0.172	100	10.736	0.954	0.077
	5000	56.67							
	7500	71.01							
	10000	83.33							

R: Regression **P: Propability**

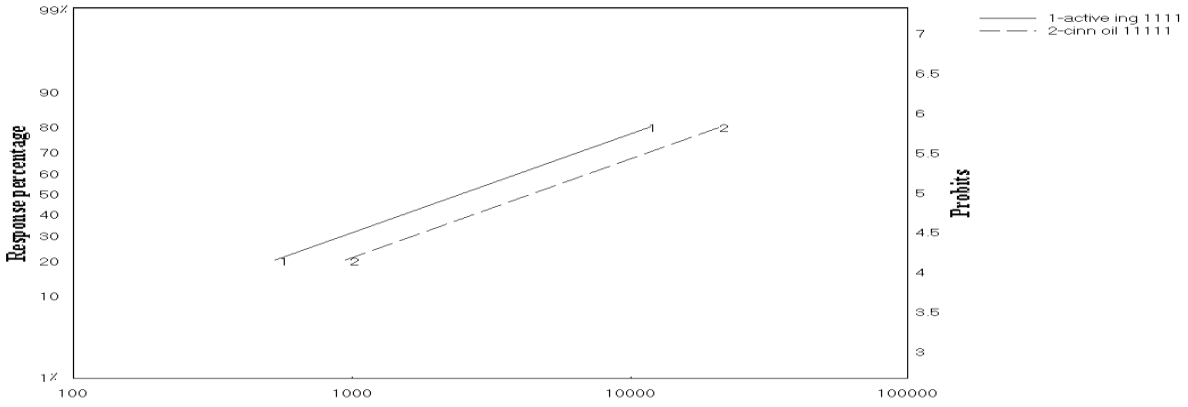


Figure (1): LD-P lines for cinnamic oil and cinnamldehyde against adult female of the carmine spider mite, *Tetranychus cinnabarinus*

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Relationship between enzyme activity and resistance to insecticides in the tested field strains of *Aphis gossypii* (Hemipetra: Aphididae)

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Abstract:

The cotton aphid, *Aphis gossypii* Glover (Hemiptera: Aphididae) is phloem feeders, often found on the abaxial leaf surface and excrete the excess material obtained from the phloem as honeydew and in high numbers can cause leaf curling and its honeydew can create a shine on the leaves. Resistance to several insecticides belonging to different groups in the six field strains of the cotton aphid, *A. gossypii* collected from Behera, Dakahlia, Menofia, Skarkia, Gharbia and Beni-Suif Governorates in 2010 cotton season was investigated using slide-dipping method. The insecticides used in this study belong to organophosphates, carbamates, pyrethorids and neonicotinoids. The results indicated that the field strains exhibited high levels of resistance to the organophosphates fenitrothion, prothiofos, pirimiphos methyl and malathion (RR=9.6-49-fold), the carbamates pirimicarb and carbosulfan (RR= 14.8-53.4-fold), pyrethroids lambda-cyhalothrin, alpha-cypermethrin, fenpropathrin, and es-fenvalerate (RR=11.9-44.7-fold) and the neonicotinoids imidacloprid, acetamiprid and thiamethoxam (RR = 2.1-8.2-fold), except for thiamethoxam in Menofia and Dakahlia (11.5 and 14.0-fold, respectively). Enzyme activities of esterases and acetylcholinesterase (AChE) were studied in six field strains of *A. gossypii*. The results indicated that field strains exhibited higher levels of *α* - and *β* - esterase activities and lower AChE activity than those achieved in the susceptible strain. These results indicated that esterases may appear to play insecticide resistance belonging to different groups, while AChE may also appear to play a role in organophosphates and carbamates. However, positive correlation between esterase activity and insecticide resistance or negative correlation between AChE and organophosphate or carbamate resistance but not significant was observed at 1% or 5% accuracy level. Therefore, esterase and AChE activities may not relate to insecticides resistance.

Introduction

The cotton aphid, *Aphis gossypii* Glover (Hemipetra: Aphididae) is an economically important pest in cotton fields in Egypt as well as many other countries. One of the commonly practiced approaches utilized by growers to protect cotton plants from aphids is the use of chemical insecticides. As such applications are frequent, the role of most of the abundant natural enemies is eliminated particularly after the aphid develop resistance to these insecticides (Godfrey *et al.*,2001), thus making subsequent treatments inefficient and leading to an increase in aphid population levels (Godfrey and Fuson, 2009). In Egypt, several organophosphorus and carbamate insecticides had been used against cotton aphids since 1970 and until 2000. The carbamate carbosulfan and neonicotinoids had been also used against cotton aphids since and until now. Resistance to organophosphorus, carbamate and pyrethroid insecticides had been reported by several authors in many countries (Li *et al*., 2003; Ahmad *et al*., 2003; Herron and Wilson, 2004; Jhansi and Subbaratnam, 2005 a, b and Singab, 2007a, b). Resistance in cotton aphids to neonicotinoids had been reported by Wang *et al*. (2001, 2002); Yu *et al*. (2004); Singab (2007b) and Barakat *et al*. (2013). One of the cotton aphids, *A. gossypii* and resistance to organophosphorus, carbamate and pyrethroid insecticides was found to associate with high esterase and oxidase activities (Xie *et al*., 2002 and Ezz el Din, 2003). Insensitivity of acetylcholinesterase (AChE) was also found for OP and carbamate resistance (Sun *et al*., 2002; Xie *et al*., 2002; Benting and Nauen, 2004; Andrew *et al*., 2004 and Toda *et al*., 2004). As for neonicotinoid resistance, the activities of carboxyl esterase and glutathione-s transferases were main metabolic mechanism of resistance (Pan *et al*., 2003).

The present work presents focuses on survey of the resistance to the insecticides commonly used in Egypt for the control of the cotton aphis, *A. gossypii* field populations collected from six Governorates in 2010 cotton growing season to determine the levels of resistance of certain tested insecticides. Biochemical determinations were also studied. Enzyme activities of esterases and acetylcholinestrase were also investegated in an attempt to clarify the correlation between resistance development and the activity of these enzymes.

Materials and methods

1. Monitoring of resistance to insecticides in the field strains of *Aphis gossypii* during 2010 cotton growing season:

1.1. The laboratory strain of the cotton aphid, *Aphis gossypii* :

The susceptible strain of *A. gossypii* was obtained from a cotton field population at Fayoum Governorate then reared entirely unexposed to any insecticides at the Central Agricultural Pesticides Laboratory for ten generations under constant conditions of 27± 2º C, 55 ± 5 % RH. This strain was used for all bioassay investigations and regarded as a reference strain in studies on monitoring resistance and biochemical determinations.

1.2. The field strains of the cotton aphid, *Aphis gossypii* :

Field strains of *A. gossypii* were collected from selected cotton fields at Behera, Dakahlia, Menofia, Skarkia, Gharbia and Beni-Suif Governorates in 2010 befor the commencement of spray season early (May).

Bioassay of the tested insecticides against the cotton aphid, *Aphis gossypii*: Slide-dipping technique (Dittrich, 1962) was used to obtain concentration mortality lines of the tested insecticides against the adult stage of *A. gossypii*. Five different concentrations of each tested insecticide were prepared by dilution in water. By

means of a fine brush, ten adult aphids were affixed to a piece double face scotch tap then stuck tightly to glass a slide on the dorsal part. Slides were then dipped in the prepared insecticide aqueous solutions for ten seconds, three replicates were used for each concentration, mortality counts were recorded 2 hours after treatment and the percentages of mortality were corrected according to Abbott's formula (1925) and mortality data were subjected to statistical analysis as described by Busvine (1957). The rates of resistance were expressed as resistance ratios (RR) at LC_{50} value of the field strains as compared with the LC_{50} value of the laboratory strain.

Resistance ratio (RR) = LC_{50} of the field strains / LC_{50} of the laboratory strain

1.4. Insecticide used:

1.4.1. Organophosphates: chlorpyrifos methyl (Reldan, 50 % EC), chlorpyrifos ethyl (Dursban, 5% EC), pirimiphos methyl (Actellic 50 % EC), profenofos (Selecron, 50% EC), malathion (Malason, 57% EC), prothiofos (Tokuthion, 5% EC), fenitrothion (Sumithion, 57% EC)

1.4.2. Carbamates: (carbosulfan (Marshal, 50% WG), methomyl (Lannate, 90% SC) and pirimicarb (Aphox**,** 50% WG)

1.4.3. Pyrethroid: deltamethrin (Decis, 2.5% EC), fenpropathrin (Fenithrin, 30 % EC), esfenvalerate (Sumi-alfa, 5% EC), alpha-cypermethrin (Alfa-cyper, 10% EC), lambda-cyhalothrin (Karate, 2.5% EC).

1.4.4. Neonicotinoids: imidacloprid (Confidor, 20% SL), Thiamethoxam (Actara, 25% WG), acetamiprid (Mospilan 20% WP).

2. Enzyme assay:

2.1. Preparation of haemogenate samples for biochemical analysis:

Adult indiriduals of *A. gosypii* were homogenized in distilled water at 500 rpm using a Teflon homogenizer surrounded with a jacket of crushed ice for 3 minutes. Homogenates were collected (on ice according to Liu *et al.*, 2010) in cold tubes previously coated with crystals of phenylthiourea to prevent melanization, then centrifuged at 6000 rpm for 10 min at 5°C. using a beckman gs-6r centrifuge. After centrifugation, the supernatant fluid was divided into small aliquots of 0.5 ml each and stored at -20 °C. until needed. Three replicates were made for every biochemical determination.

2.2. Determination of acetylcholinesterase activity:

The activity of acetylcholinesterase (AChE) was measured according to the method described by Simpson *et al.* (1964) using acetylcholine bromide (AChBr) as a substrate at a level of 6×10^{-3} *M* Test tubes (T) contains 0.2 ml of adult tissues homogenate, 0.5 ml 0.067 M phosphate buffer and 0.5 ml substrate (3 mM AChBr) were prepared. The total substrate tubes (TS) contained 0.7 ml phosphate buffer (0,067 mM) and 0.5 ml substrate. A control tube (C) contains 0.2 ml of adult homogenate and 1 ml of phosphate buffer was prepared. All test tubes were incubated for exactly 30 minutes at 37°C. After incubation period, 1 ml of alkaline hydroxylamine (equal to a volume of 2 *M* hydroxylamine chloride and 3.5 *M* NaOH mixed thoroughly shortly before use was added to all tubes. Tubes were shaken well and allowed to stand for 2 minutes then 0.5 ml of HCl (1 part of conc. HCl mixed with 2 parts of distilled water) was added. The mixture was shaken vigorously then allowed to stand for 2 minutes 0.5 ml of ferric chloride solution (0.92 *M* FeCl3 in 0.1 *M* HCl) was added to all test tubes and mixed well. The resulting mixture was centrifuged and the supernatant was measured spectrophotometrically at 515 nm. The activity of the homogenate was calculated by applying the following equation:

(TS+C) – T / Weight/ml homogenate/30 = µg substrate hydrolyzed/min/g body weight. Where:(T) = test, (TS) = substrate, (C) = control

2.3. Determination of non-specific esterases activities:

Alpha-and beta-esterases (α-E, β-E, respectively) were determined according to the method of Van Asperen (1962) using α-naphthyl acetate and β-naphthyl acetate as substrates. Naphthol produced as a result of substrate hydrolysis was measured by addition of diazoblue sodium lauryl sulphate solution which produces a strong blue colour in the case of α-naphthol or a strong red colour that of β-naphthol. The resulting colour was measured spectrophotometrically using a Milton Roy Spectronic (model 1201) spectrophotometer. The reaction mixture consisted of 5 ml substrate solution ($3x10^{-4}M$ α-orβ-naphthyl acetate, 1% acetone and 0.04 *M* phosphate buffer pH7) added to 20 µl of adult homogenate. The mixture was incubated for exactly 15 minutes at 27 °C. then 1 ml of diazoblue color reagent (prepared by mixing 2 parts of 1% diazoblue B and 5 parts of 5% sodium lauryl sulphate) was added. The developed color was measured at 600 and 555 nm for α- and β-naphthol, respectively. Enzyme activity was expressed as µg α- or β-naphthol released / min. / adult.

2.3.1. Preparation of the standard curves of α- and β-naphthol

Stock solutions were prepared by dissolving 20 mg α- or β-naphthol in 100 ml of 0.04 M phosphate buffer (pH 7). Ten milliliters of the stock solution were diluted up to 100 ml by the phosphate buffer. Aliquots containing of 2.5, 5, 10, 20 and 40 µg of α-naphthol or 2.5, 5, 7.5, 10 and 20 µg β-naphthol were pippetted into test tubes and completed to 5 ml by phosphate buffer. One milliliter of diazoblue reagent was added and the developed color was measured as mentioned earlier. The standard curves of both α-E and β-E were blatted by O.D. (Optical Density) against concentration according by Bradford (1976).

3.Determination of total proteins:

Total proteins were determined according to the method described by **Bradford (1976).**

3.1. Preparation of protein reagent:

Coomassie Brilliant Blue G-250 (100 mg) was dissolved in 50 ml 95% ethanol. To this solution, 100 ml of 85% (w/v) phosphoric acid were added. The resulting solution was diluted to a final volume of 1 liter.

3.2. Protein assay:

- Sample solutions of 50 µl were pipetted into a test tubes and the volume adjusted to 0.1 ml with phosphate buffer (pH 6.6).
- 5 ml of protein reagent was added to every test tube and the contents were the roughly mixed (inversion or overtaxing).
- Absorbance at 595 nm was measured after 2 min. then before 1 hr against blank prepared from 0.1 ml phosphate buffer (pH 6.6) and 5 ml protein reagent. The weight of protein was plotted against the corresponding absorbance thus resulting in standard curve used to determine the protein in the unknown samples.

3.3. Preparation of standard curve of protein:

For the preparation of the standard curve of protein serial concentrations of Bovine serum albumin solutions containing 10 to 100 µg of protein were pipetted into test tubes and the volume was adjusted to 0.1 ml with phosphate buffer (pH 6.6). Five ml of protein reagent were added and the resulting colour was measured spectrophotometrically at 595 nm as mentioned before. The optical densities were plotted against concentrations to construct. The standard curve of protein was then plotted by O.D. (Optical Density) against concentration.

Results and discussion

1. **Monitoring of resistance of tested insecticides in the field strains of *Aphis gossypii* in 2010 cotton growing season**

The levels of resistance to organophosphorus, carbamate, and pyrethroid and neonicotinoid groups of

insecticides against the 6 tested field strains of *A. gossypii* collected from six governorates are shown in Table (1). Most of the field strains exhibited high levels of resistance to the organophosphorus fenitrothion, prothiofos, pirimiphos methyl and malathion (RR=9.6-49-fold), the carbamates pirimicarb and carbosulfan (RR= 14.8-53.4-fold) and the pyrethroids lambda-cyhalothrin, alpha-cypermethrin, fenpropathrin, and es-fenvalerate (RR=11.9-44.7-fold). On the contrary for malathion in Gharbia and Behera (RR=6.6 and 7.4-fold), carbosulfan in Behera and Dakahlia (RR=1.6 and 3.6-fold), es-fenvalerate in Behera and Dakahlia (RR=4.4 and 5.6-fold), showed low to moderate levels of resistance to the organophosphorus chlorpyrifos methyl, chlorpyrifos ethyl and profenofos (RR= 1.7-7.7-fold), the carbamate methomyl (RR = 2.2-5.3-fold), the pyrethroid deltamethrin (RR = 2.5-9.0-fold) and the neonicotinoids imidacloprid, acetamiprid and thiamethoxam (RR = 2.1-8.2-fold), except for chlorpyrifos ethyl in Sharkia and Menofia (RR=11.1 and 13.5-fold, respectively), thiamethoxam in Menofia and Dakahlia (11.5 and 14.0-fold, respectively).

Table (1): Resistance ratioes of insecticides in six field strains of *Aphis gossypii* collected from different Governorates in 2010 cotton growing season

Group	Insecticide	LC_{50}ppm S-strain	Resistance ration (RR*)					
			Behera	Dakahlia	Menofia	Gharbia	Sharkia	Beni-Suef
Organophos-phorus	Chlorpyrifos methyl (Reldan)	63.8	7	4.2	1.7	3.6	5	6.5
	Chlorpyrifos ethyl (Dursban)	26.32	5.3	6.3	13.5	5	11.5	2
	Pirimiphos methyl (Actellic)	70.5	24.8	15.4	36.2	19.2	31.5	9.6
	Profenofos (Selecron)	208.6	2.5	7.7	4.3	4.3	7.2	2.6
	Malathion (Malason)	149.3	7.4	10.7	23.1	6.6	20.8	17.3
	Prothiofos (Tokuthion)	154.49	16	12.3	24.5	19	31.4	14.2
	Fenitrothion (Sumithion)	111.67	40.2	17.9	49	32.1	56.3	25.3
Carbamates	Carbosulfan (Marshal)	17.66	1.6	3.6	13.5	14.8	44.1	53.4
	Methomyl (Lannate)	41.25	2.2	5.3	4.1	2.8	5.1	---
	Pirimicarb (Aphox)	189.04	39.9	17.1	50.4	45.6	43.2	17.5
Pyrethroids	Deltamethrin (Decis)	2.22	2.5	3.9	9	4.2	8.4	7.3
	Lambda-cyhalothrin (Karate)	5.89	11.9	44.7	15.4	16.3	36.1	32.6
	Es-fenvalerate (Sumi-alpha)	4.04	4.4	5.6	15.4	9.2	27.1	23.5
	Fenpropathrin (Fenethrin)	12.99	13.9	22.9	21.8	11.2	18.6	27.9
	Alpha-cypermethrin (Alpha-cyper)	8.94	16.7	19.8	12.7	14.4	22.9	26
Neonicotinoids	Imidacloprid (Confidor)	7.35	2.9	2.8	3.7	3.1	4.1	2.1
	Acetamiprid Mospilan	5.61	4.8	3.4	6.3	2.2	5.3	4.2
	Thiamethoxam (Actara)	8.84	6.5	14	11.5	7	8.2	8.1

*RR (Resistance ratio) = LC_{50} of the field strain / LC_{50} of the laboratory strain

2.Determination of acetylcholinestrase and esterase activities in the field strains of *Aphis gossypii*:

The activities of acetylcholinesterase (AChE), *α*-esterase (*α* EST) and β-esterase (β EST) were determined in six field strains of *A. gossypii* collected from six governorates. Data are presented in Table (2).

Table (2): Total protein and specific activity of acetylcholinesterase (AChE), α-esterase and β-esterase in the susceptible strain (s-strain) and 6 field strains of *Aphis gossypii* collected from different Governorates in 2010 cotton growing season.

Strain	Total protein mg/ g b.w.	Specific activity µg /min/g b.w.			Ratio of F/S*			
		AChE	*α*- esterase	*β*- estruses	Total Protein	AChE	*α*- esterase	*β*- esterase
susceptible strain	**19.46**	**1174.6**	**1126.72**	**923.87**	**1**	**1**	**1**	**1**
Beni-Suf Strain	**23.07**	**1061.3**	**1594.01**	**1257.58**	**1.19**	**0.9**	**1.41**	**1.36**
Menofia Strain	**22.99**	**888.29**	**1883.27**	**1199.42**	**1.18**	**0.75**	**1.67**	**1.3**
Dakahlia Strain	**25.19**	**992.87**	**1636.78**	**1200.25**	**1.29**	**0.84**	**1.45**	**1.3**
Behera Strain	**20.84**	**1112.4**	**1468.91**	**1122.75**	**1.07**	**0.94**	**1.3**	**1.22**
Sharkia Strain	**23.76**	**961.47**	**2079.37**	**1368.56**	**1.22**	**0.81**	**1.85**	**1.48**
Gharbia Strain	**22.12**	**992.68**	**1656.06**	**1111.42**	**1.13**	**0.85**	**1.47**	**1.2**

* F/S = Activity of enzyme or total protein in the field strain / Activity of enzyme or total protein in the susceptible strain

2.1. Actylcholinesterase (AChE):

As with AChE, the results refer that the activity of AChE in the field strains was low when compared to the susceptible strain. The activity of AChE in the S-strain was 1174.62µg/min/g b.w., while in the field strains ranged 888.29-1112.4 µg/min/g b.w. The lowest level of activity recorded in Menofia strain (0.75 times) followed by Sharkia strain (0.81 times), Dakahlia strain (0.84 times), Gharbia strain (0.85 times), Beni-Suef strain (0.90 times) and Behera strain (0.94 times). Reduced activity of AChE was also reported by Singab (1996) on OP or carbamate- resistant strain of *Spodoptera littoralis* and Rofail *et al*. (1995) on resistant strain of *Pectinophora gossypii*. Several authors contributed to the reduced sensitivity of AChE in the OP or carbamate - resistant strains of *A. gossypii* and its responsibility for resistance to insecticides (Sun *et al*. 1987 and 1994; Suzuki and Hama 1994; Xie *et al*. 2002; Andrews *et al*. 2004 and Benting and Nauen 2004).

2.2. *α*- and *β*- esterases:

For of *α*- EST, data in Table (2) show that all field strains showed a high activity than the susceptible strain (S-strain). The activities of *α*- EST in the different considered field strains of *A. gossypii* collected from different Governorates. For *α*-esterases, (Table 2) all field strains showed a higher activity than the susceptible strain (S-starin). The activity of *α*-esterases in the S-starin was 1126.72 µg/min/g b.w. compared to activities of 1468.91-2079.37 µg/min/g b.w. in field strains. The highest level of activity was recorded in Sharkia strain (1.85 times), followed by Menofia strain (1.67 times) Then Gharbia strain (1.47 times), Dakahlia strain (1.45 times), Beni-Suef strain (1.41 times) and finally Behera strain (1.30 times).

For *β*-EST the same trend of activity was obtained Table (2), all field strains exhibited higher activity than that obtained in S-strain, where the activity of *β*-esterases in S-strain was 923.87 µg / min/g b.w. compared to 1111.42-1368.56µg/min/g b.w. in the field strains. The highest level of resistance was records in Shrike strain (1.48

times) followed by Beni-Suef strain (1.36 times) then Menofia strain (1.30 times), Dakahlia strain (1.30 times), Behera strain (1.22 times) and finally Gharbia strain (1.20 times).

These results indicate that the field strains of *A. gossypii* exhibited relatively higher levels of EST activities than in the S-strain. Thus, they seem to play an important role in determining insecticides resistance in the field strains of considered insect pest. Several authors reported that *A. gossypii* resistance to organophosphorus, carbamate, pyrethroid or neonicotinoid insecticides was associated with high EST activity (Saito, 1990, Sun *et al*. 1994, Xie *et al*. 2002, Ezzel-Din 2003, Pan *et al*. 2003 and Jhansi and Subbaratnam, 2004)

3.The relationship between enzyme activity and resistance to insecticide in the tested field strains of *Aphis gossypii*:

The relationship between enzyme activity and insecticide resistance was studied statistically in six field strain in ***A. gossypii*** collected from six governorates in 2010 cotton growing season. Data obtained are presented in Table (3).

3.1. The relationship between Actylcholinesterase activity and insecticide resistance:

Table (3) shows a negative correlation between AChE activity and the levels of resistance for all tested OP and carbamate insecticides except the OP chlorpyrifos methyl and the carbamate carbosulfan that showed a positive correlation. However, these correlations were not significant at either 1% or 5% accuracy levels (r coefficients = -0.200 and -0.745, respectively, at n=6). Such correlations refer that decrease in AChE activity is not statistically associated with increase in insecticide resistance. In other words, AChE activity is not significantly related to resistance level.

3.2. The relationship between *α*-esterase activity and insecticide resistance:

Results in Table (3) shows a positive correlation between α-esterase activity and the levels of resistance for all tested insecticides belonging to organophosphorus, carbamates, pyrethroids and neonicotinoids insecticides, except the organophosphorus, chlorpyrifos methyl that exhibited a negative correlation coefficient. All calculated correlation coefficient were not significant at either 1% or 5% accuracy levels (r = +0.144 and +0.795, n=6). This mesns that increase in α-esterase activity is not statistically associated with increase in insecticide resistance. In other words, α-esterase activity is not related to insecticide resistance. However, the calculated r values nearly approached the tabular coverponding values, especially for the organophosphorus: chlorpyrifos ethyl (r = +0.795), malathion (r = +0.773), fenitrothion (r = +0.713), pirimiphos methyl (r = +0.666); the carbamate methomyl (r = +0.701); the pyrethroids es-fenvalerate (r = +0.778), deltamethrin (r = +0.765) and the neonicotinoid imidacloprid (r = +0.781). Thus, α-esterase seems to be clear to play a role in the resistance to these compounds.

3.3. The relationship between *β*-esterase activity and insecticide resistance:

Table (3) shows that there is a positive correlation between β-esterase activity and the level of resistance for all tested insecticides belonging to organophosphorus, carbamates, pyrethroids and neonicotinoids except the organophosphorus chlorpyrifos ethyl, pirimiphos methyl, fenitrothion; the carbamate pirimicarb and the neonicotinoid thiamethoxam. All correlation coefficient was significant at either 1% or 5% accuracylevels (r = +0.010 and +0.773, n=6). Such correlation refers that increase in β-esterase activity is not related to with increase in insecticide resistance.

It is concluded that the field populations of *A. gossypii* from different Governorates seem to possess a sort of resistance to most of the tested insecticides representing organophosphorus, carbamates

and pyrethroids. These populations expressed a high esterase activity and less AChE activity than those expressed by the S-strain. However, no statistically significant correlations could be drawn between insecticide resistance and enzyme activities at either 1% or 5% levels of accuracy. This result contradicts with the findingd of Xie *et al*. (2002) who showed that the resistance of *A. gossypii* populations to organophosphate insecticides involves the *α*-esterase activity. The same authors added that the insensitivity of AChE to the carbamate methomyl might be responsible for methomyl resistance.

Contributions to the role of esterase activity and insensitivity of AChE in resistance to organophosphorus and carbamates insecticides as well as esterase activity in resistance to pyrethroids and neonicotinoids insecticides in several pests are given the work of Ghoneim *et al.* (1994) who reported that correlation between esterase activity and resistance to insecticides in *S.littoralis* populations in Egypt was recognized for the pyrethroids deltamethrin, alpha-cypermethrin, fenpropathrin and the organophosphorus cyanophos. Similar results were obtained by Saleh *et al*. (1986) with fenitrothion on a cyanophos-resistant strain of *S. littoralis.* Rofail *et al*. (1995) referred to a correlation between resistance ratio to cyanophos and the high activity of *α*-esterase or low activity of AChE in a cyanophos-resistant strain of *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae).

Table (3): The relationship between insecticide resistance and enzyme activity:

Group	Insecticide	N	Correlation Coefficient (r)		
			AChE	α-esterase	β-esterase
Organophosphorus	Chlorpyrifos methyl (Reldan)	6	0.927	-0.510	0.157
	Chlorpyrifos ethyl (Dursban)	6	-0.745	0.795	-0.095
	Pirimiphos methyl (Actellic)	6	-0.435	0.666	-0.263
	Profenofos (Selecron)	6	-0.576	0.481	0.723
	Malathion (Malason)	6	-0.551	0.773	0.214
	Prothiofos (Tokuthion)	6	-0.425	0.275	0.178
	Fenitrothion (Sumithion)	6	-0.200	0.713	-0.090
Carbamates	Carbosulfan (Marshal)	6	0.110	0.401	0.558
	Methomyl (Lannate)	5	-0.214	0.701	0.762
	Pirimicarb (Aphox)	6	-0.234	0.439	-0.447
Pyrethroids	Deltamethrin (Decis)	6	-----	0.765	0.154
	Lambda-cyhalothrin (Karate)	6	------	0.233	0.773
	Es-fenvalerate (Sumi-alpha)	6	-----	0.778	0.431
	Fenpropathrin (Fenethrin)	6	------	0.105	0.310
	Alpha-cypermethrin (Fastac)	6	-----	0.051	0.301
Neonicotinoids	Imidacloprid (Confidor)	6	------	0.781	0.010
	Acetamiprid (Mospilan)	6	-----	0.387	-0.371
	Thiamethoxam (Acara)	6	------	0.144	0.071
Tabular r	N = 6	5% = 0.811			
		1% = 0.917			
	N = 5	5% = 0.878			
		1% = 0.959			

The statistical analyses for the relationships between resistance ratio and enzyme activity revealed no significant correlations between resistances to any tested insecticides and the activity of any of the considered enzymes at either 1% or 5% level of the accuracy (Table, 3). This indicating that a decrease in AChE activity or increase in esterase activity is not associated with increase in resistance.

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Monitoring of resistance to pyrethroid and neonicotinoid insecticides of *Aphis gossypii* (Hemiptera: Aphididae)

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Abstract:

Resistance to several insecticides belonging to tow groups in the four field strains of the cotton aphid, *Aphis gossypii* Glover (Hemiptera: Aphididae) collected from Behera, Dakahlia, Menofia, Skarkia and Beni-Suif Governorates during 2008-2010 at cotton seasons was investigated using slide-dipping method. The insecticides used in this study belong to pyrethorids (Es-fenvalerate, deltamethrin, lambda-cyhalothrin, fenpropathrin, alpha-cypermethrin) and neonicotinoids (imidacloprid, acetamiprid, thiamethoxam). The results indicated that the pyrethroid, deltamethrin recorded low levels of resistance during 2008-2010 cotton growing seasons (Resistance ratio (RR) rang between 2.5-10.3-fold), but the other pyrethroids exhibited high levels of resistance in most of the field strains during 2008-2010 cotton growing seasons, lambda-cyhalothrin (RR rang between 9 - 44.7-fold), es-fenvalerate (RR rang between 2.9- 23.5-fold), fenpropathrin (RR rang between 5.6- 27.3-fold), alpha-cypermethrin (RR rang between 12.6 - 26-fold). All tested neonicotinoids were still effective insecticides against most of field strains, where resistance levels were low or moderate during 2008-2010 cotton growing seasons (RR rang between 1.7-11.9-fold), except for thiamethoxam which showed high resistance in Dakahlia (RR 20.5-fold) in 2009 cotton growing season.

Introduction

The cotton aphid, *Aphis gossypii* Glover (Hemipetra: aphididae) is one of the most important piercing sucking pests in cotton fields in Egypt. The grower is usually used the chemical pesticides in controlling the cotton aphid pest. As such applications are frequent, the role of most of the abundant natural enemies is eliminated particularly after the aphis develop resistance to these insecticides (Godfrey *et al.*, 2009), thus making subsequent treatments inefficient and leading to an increase in aphid population levels (Godfrey and Fuson, 2001).

In Egypt, several insecticides of different chemical groups are used against cotton pests. Pyrethroid resistance in *A. gossypii* has previously been documented in many parts of the world, such as Pakistan (Ahmed *et al.*, 2003) and Australia (Herron and Wilson, 2004). The neonicotinoid imidacloprid has been used on cotton for control cotton aphid in Egypt since 1997,

while the neonicotinoid acetamiprid, thiamethoxam and diotefuran have been used for controlling aphid pests on vegetable since 2002, 2003 and 2004, respectively. Resistance in cotton aphids to neonicotinoids have been reported by Wang *et al.* (2001 and 2002) and Yu *et al.* (2004). Resistance to these compounds was also obtained on *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) (Karunker *et al.*, 2008); *Nilaparvata lugens* (Stål) (Hemiptera: Delphacidae) (Wen *et al.*, 2009)*; A. gossypii* (Tabacian *et al*., 2011 and Jam *et al.*, 2014); *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) , *Earias insulana* (Boisduval) (Lepidoptera : Noctuidae) , *A. gossypii* and *B. tabaci* (Nour El-Hoda *et al*., 2012) and *A. gossypii* and *B. tabaci* (Ghelani, 2014) .

The present work presents a survey of the resistance to the insecticides commonly used in Egypt for the control of the cotton aphid, *A. gossypii* field populations collected from certain Governorates, namely Behera, Dakahlia, Menofia and Beni-Suef during 2008 - 2010 cotton growing seasons to determine the levels of resistance of certain tested insecticides that showed the least levels of resistance accompanied by the high toxic action. It is hoped that such approach might help to developing a safer programme for aphid control.

Materials and methods

1. Monitoring of resistance to insecticides in the field strains of the cotton aphid, *Aphis gossypii* during cotton growing seasons (2008-2010):

1.1. The laboratory strain of the cotton aphid, *Aphis gossypii*:

Susceptible strain of *A. gossypii* was obtained from a cotton field population at Fayoum Governorate, then, reared entirely unexposed to any insecticides at the Central Agricultural Pesticides Laboratory for ten generations under constant conditions of 27± 2º C and 55 ± 5 % R.H. This strain was used for all bioassay investigations and regarded as a reference strain in studies on monitoring resistance and biochemical determinations.

1.2.Field strains of the cotton aphid, *Aphis gossypii:*

Field strains of *A. gossypii* were collected from selected cotton fields at Behara, Dakahlia, Menofia and Beni-Suef Governorates during the early cotton growing seasons of 2008-2010 (3-seasons). Aphid strains were collected insmediately befor the commencement of spray season early (May).

1.3. Bioassay of the tested insecticides against the cotton aphid, *Aphis gossypii*:

Slide-dipping technique (Dittrich, 1962) was used to obtain concentration mortality lines of the tested insecticides against the adult stage of *A. gossypii*. Five different concentrations of each tested insecticide were prepared by dilution in water. By means of a fine brush, ten adult aphids were affixed to a piece double face scotch tap then stuck tightly to glass a slide on the dorsal part. Slides were then dipped in the prepared insecticide aqueous solutions for ten seconds. Three replicates were used for each concentration. Mortality counts were recorded 2 hours after treatment and the percentages of mortality wewe corrected according to Abbott,s formula (1925) and mortality data were subjected to statistical analysis as described by Busvine (1957). The rates of resistance were expressed as resistance ratios (RR) at LC_{50} value of the field strains as compared with the LC_{50} value of the laboratory.

Resistance ratio (RR) = LC_{50} of the field strains / LC_{50} of the laboratory strain

1.4. Insecticides used:

1.4.1. Pyrethroid insecticides: deltamethrin (Decis, 2.5% EC), fenpropathrin (Fenithrin, 30 % EC), esfenvalerate (Sumi-alfa, 5% EC), alpha-cypermethrin (Alfa-cyper,10% EC), lambda-cyhalothrin (Karate, 2.5% EC).

1.4.2. Neonicotinoid insecticides: imidacloprid (Imidor, 20% EC, imidacloprid (Confidor, 20% SL),

Thiamethoxam (Actara, 25% WG), acetamiprid (Mospilan 20% WP).

Results and discussion

1. Monitoring resistance to insecticides in the field strains of the cotton aphid, *Aphis gossypii* during three seasons:

1.1. Pyrethroid insecticides:

Table (1) showed the levels of resistance to certain pyrethroid insecticides in four field strains of *A. gossypii* collected from Behera, Dakahlia, Menofia and Beni-Suef Governorates during 2008-2010 cotton growing seasons. From data Deltamethrin was the highest effective pyrethroid and recorded the least levels of resistance for most tested field strains. (Resistance ratios ranged 2.5-10.3-fold). As for Es-fenvalerate, Behera strain, resistance levels were low in all seasons (resistance ratios ranged between 2.9 and 4.4-fold), but Dakahlia strain showed a high resistance level in both 2008 and 2009 (11.3 and 11.8-fold). In Menofia and Beni-Suef strains resistance to es-fenvalerate trended to increase the cotton growing seasons of 2008-2010. (6.1, 7.8 and 15.4-fold) and (14.9, 11.3 and 23.5-fold), respectively. As for lambda-cyhalothrin, expect for Beni-Suef strain that showed a low level of resistance in 2008 (4.0-fold), very high resistance levels were observed in the other tested four field strains during 2008-2010 cotton growing seasons resistance ratios ranged 9.7-44.7-fold). The highest level of resistance was observed in Dakahlia strain (44.7-fold) followed by that of Beni-Suef strain (32.6-fold), then Menofia strain (15.4-fold) and finally Behera strain (12.8-fold). As a matter of fact, Behera strain exhibited relatively low levels of resistance to fenpropathrin in 2008 and 2009 (5.6 and 4.3-fold, respectively), and a similir trend of resistance occurred in the cases of lambda-cyhalothrin, fenpropathrin and alpha-cypermethrin during all considered the cotton growing seasons. On the other hand, high levels of resistance were recorded for both fenpropathrin and alpha-cypermethrin resistance ratios ranged (13.9-27.9-fold) and (12.6-26.0-fold), respectively.

Table (1): Resistance to pyrethroid insecticides on the cotton aphid, *Aphis gossypii* collected from certain Governorates during 2008, 2009 and 2010 cotton growing seasons.

Insecticide	Season	Behera			Dakahlia			Menofia			Beni-Suef		
		Slope	LC_{50} ppm	RR*	Slope	LC_{50} ppm	RR*	Slope	LC_{50} ppm	RR*	Slope	LC_{50} ppm	RR*
Deltamethrin Decis 2.5% EC	Lab. strain	1.53	2.22	-----	1.53	2.22	-----	1.53	2.22	-----	1.53	2.22	-----
	2008	1.56	11.59	5.2	1.01	16.44	7.4	1.53	17.73	8	1.58	19.57	8.8
	2009	1.09	15.51	7	1.41	14.76	6.7	1.09	14.55	6.6	2.61	22.9	10.3
	2010	1.7	5.65	2.5	1.68	8.57	3.9	1.17	20	9	2.48	16.1	7.3
Lambda-cyhalothrin Karate 20 %EC	Lab. strain	1.71	5.89	-----	1.71	5.89	-----	1.71	5.89	-----	1.71	5.89	-----
	2008	1.8	65.03	11	1.51	83.1	14.1	2.14	57	9.7	1.42	23.3	4
	2009	2.11	75.55	12.8	1.85	131.18	22.3	1.39	122.02	20.7	1.52	91.21	15.5
	2010	1.68	69.81	11.9	1.56	263	44.7	1.55	90.78	15.4	1.73	192	32.6
Esfenvalerate Sumi-alpha 5%EC	Lab. strain	1.73	4.04	-----	1.73	4.04	-----	1.73	4.04	-----	1.73	4.04	-----
	2008	1.46	11.82	2.9	2.11	45.62	11.3	1.6	24.63	6.1	0.9	60.15	14.9
	2009	2.28	9.27	2.3	2.36	47.78	11.8	1.98	31.46	7.8	2.01	45.78	11.3
	2010	1.34	17.68	4.4	1.43	22.75	5.6	1.25	62.3	15.4	1.07	94.97	23.5
Fenpropathrin Fenethrin, 30 % EC	Lab. strain	1.19	12.99	-----	1.19	12.99	-----	1.19	12.99	-----	1.19	12.99	-----
	2008	1.56	72.11	5.6	1.19	194.9	15	1.7	141.99	10.9	1.38	337.11	26
	2009	1.92	55.5	4.3	2.1	315.57	24.3	1.14	229.36	17.7	1.95	310.1	23.8
	2010	1.16	180.55	13.9	1.77	297.32	22.9	1.69	283.75	21.8	1.9	362.07	27.9
Alpha-cypermethrin Alpha-cyper, 10 % EC	Lab. strain	1.96	8.94	-----	1.96	8.94	-----	1.96	8.94	-----	1.96	8.94	-----
	2008	1.57	150.66	16.9	2.54	131.34	14.7	1.79	112.23	12.6	1.66	128.05	14.3
	2009	1.44	181.55	20.3	2.39	166.44	18.6	1.6	127.17	14.2	1.33	214.34	24
	2010	1.96	148.96	16.7	1.89	176.9	19.8	1.57	113.89	12.7	1.16	232.3	26

RR* (Resistance ratio) = LC_{50} of the field strain / LC_{50} of the laboratory strain

In conclusion, the results emphasize that the pyrethroid deltamethrin reflected a low to moderate of resistance, while the other pyrethroids (es-fenvalerate, fenpropathrin, alpha-cypermethrin and lambda-cyhalothrin) exhibited high levels of resistance in most of the considered field strains for 2008-2010 cotton growing seasons. Such conclusions are agreeing with the results of Singab (2007) who monitored of resistance to pyrethroids in field strains of *A. gossypii* in 2005-2007 cotton growing seasons in Gharbia and Fayoum Governorates and reported that field strains exhibited low levels of resistance to deltamethrin, and high level of resistance to fenpropathrin. Similar observations given by Ahmed *et al.* (2003) who reporting that field populations of *A. gossypii* collected from cotton field from 1997 to 2000 in Pakistan showed very high levels of resistance to the pyrethroids cypermethrin, alpha-cypermethrin, fenpropathrin and lambda-cyhalothrin, while the levels of resistance to deltamethrin were relatively lower than the levels of resistance to other pyrethroids. In contrast, Gubran *et al.* (1992) mentioned that the field strains of *A. gossypii* collected from cotton fields in Sudan during 1988-1990 was highly resistance to both fenvalerate and deltamethrin. The same pattern of high resistance to fenvalerate and deltamethrien was also reported from China by Subbaratinam and Redhika (2005).

1.2. Neonicotinoid insecticides:

Table (2) showed the levels of resistance to the tested neonicotinoid insecticides in 4 field strains of *A. gossypii* collected from Behera, Dakahlia, Menofia and Beni-Suef Governorates in 2008-2010 cotton growing seasons. Imidacloprid (represented by Confidor) was effective against the 4 considered field strains but recorded the least levels of resistance compared to the other tested neonicotinoid insecticides (resistance ratios ranged 1.7-4.7-fold). As for, Beni-Suef strain low resistance levels were recorded compared to the other strains in 2008-2010 (2.0, 2.3 and 2.1-fold), respectively. In Menofia strain resistance increased with the progrems of seasons, although it was still low level in 2008-2010 (1.9. 3.1 and 3.7-fold, respectively), In Behera and Dakahlia strains, resistance fluctuated between a low level in 2008 (2.5 and 1.7-fold) and a moderate level in 2009 (4.7 and 4.1-fold) and a low level in 2010 (2.9 and 2.8-fold), respectively.

For the other formulation of imidacloprid (Imidor), resistance in 2008 season was high for Behera strain (9.3-fold) while for Menofia, Dakahlia and Beni-Suef strains it showed moderate levels of resistance (4.7, 5.6 and 6.2-fold, respectively). In 2009, resistance level to Imidor increased for Menofia and Dakahlia strains (6.7 and 7.3-fold, respectively) while for Behera and Beni-Suef strains they declined (7.9 and 3.5-fold, respectively). In 2010, the all considered field strains exhibited a noticeable decline in resistance levels, 2.9, 3.4, 5.0 and 5.9-fold for Menofia, Dakahlia, Behera and Beni-Suef.

The same trend of resistance to imidacloprid was also observed with acetamiprid during 2008-2010 cotton growing seasons. Relatively higher resistance levels were obtained with Confidor, (resistance ratios 1.7-6.3-fold). However, Menofia strain showed comparatively higher levels of resistance but these levels still remained as moderate (2.8, 5.8 and 6.3-fold) for 2008, 2009 and 2010, respectively. The other tested field strains showed low level of resistance in 2008, (resistance ratios were 1.7, 2.3 and 2.8-fold for Beni-Suef, Dakahlia and Behera strains, respectively), but increased slightly in 2009 (3.0, 3.7 and 3.3-fold, respectively) and increased in 2010 for Beni-Suef and Behera strains (4.2 and 4.8-fold, respectively). In 2010, no significant changes in resistance were observed for Dakahlia strain, (3.7-fold).

For thiamethoxam, low levels of resistance were recorded in Menofia, Behera and Beni-Suef strains in 2008 season (2.2, 2.8 and 3.7-fold, respectively), while in Dakahlia strain showed resistance moderate level was (6.0-fold). In 2009, resistance level increased and resistance ratios recorded 11.9, 5.7, 4.6 and 20.5-fold for Menofia, Behera, Beni-Suef and Dakahlia strains, respectively. In 2010, further increase in resistance was observed in Beni-Suef (8.1-fold) and Behera (6.5-fold) while no change in resistance took place in Menofia strain (11.5-fold) and Dakahlia strain showed a decline in resistance level that remained still relatively high (14.0-fold).

The above results suggested that all tested neonicotinoids were except thiamethoxam effective against *A. gossypii*, with low to moderate resistance level except. Thiamethoxam, on the other hand, showed high resistance in both Dakahlia and Menofia strain. Similar results were reported by Nauen *et al*. (2003) and Denholm *et al*. (2002) who mentioned that neonicotinoids are active against numerous sucking and biting insects including aphids, whiteflies, thrips, leaf miners, beetles and some lepidopterous species. Denhlom *et al*. (2002) found that neonicotinoids showed good activity against the insect pests resistant to other classes of insecticides concluding organophosphates, carbamates, pyrethroids and chlorinated hydrocarbons. Singab (2007) further indicated that low to moderate levels of resistance to the neonicotinoids imidacloprid, acetamiprid, thiamethoxam and dinotefuran were observed on filed strains of *A. gossypii* in 2005-2007 cotton growing seasons. Godfrey *et al*. (2009) added that the repeated applications of any neonicotinoid against *A. gossypii* can develop in resistance to all neonicotinoids.

Table (2): Resistance to neonicotinoid insecticides in *Aphis gossypii* collected from certain Governorates during 2008, 2009 and 2010 cotton growing seasons.

Insecticide	Season	Behera			Dakahlia			Menofia			Beni-Suef		
		Slope	LC_{50} ppm	RR*	Slope	LC_{50} ppm	RR*	Slope	LC_{50} ppm	RR*	Slope	LC_{50} ppm	RR*
Imidacloprid Confidor, 20 % SL	Lab. strain	2.17	7.35	------	2.17	7.35	------	2.17	7.35	------	2.17	7.35	------
	2008	1.47	18.68	2.5	2.04	12.49	1.7	1.74	13.83	1.9	1.72	14.72	2
	2009	2.2	34.73	4.7	1.46	30.42	4.1	1.86	22.54	3.1	1.57	17.21	2.3
	2010	1.44	21.29	2.9	2.53	20.8	2.8	1.3 9	27.46	3.7	2.02	15.25	2.1
Imidacloprid Imidor, 20 % EC	Lab. strain	1.62	3.63	------	1.62	3.63	------	1.62	3.63	------	1.62	3.63	------
	2008	1.54	33.57	9.3	1.9	16.54	5.6	1.88	17.15	4.7	1.75	22.36	6.2
	2009	1.72	28.71	7.9	2.64	26.41	7.9	1.66	24.17	6.7	2.01	12.62	3.5
	2010	2.22	18.06	5	1.66	12.45	3.4	1.73	10.51	2.9	1.75	21.31	5.9
Aceamiprid Mospilan, 20 % SP	Lab. strain	2.23	5.61	------	2.23	5.61	------	2.23	5.61	------	2.23	5.61	------
	2008	2.23	15.5	2.8	1.78	13.06	2.3	1.83	15.47	2.8	1.93	9.69	1.7
	2009	1.46	18.53	3.3	1.92	20.71	3.7	2.01	32.4	5.8	1.8	17.04	3
	2010	1	26.91	4.8	2.33	18.97	3.4	1.49	35.26	6.3	1.19	23.26	4.2
Thiamethoxam Actara, 25 % WG	Lab. strain	1.91	8.84	------	1.91	8.84	------	1.91	8.84	------	1.91	8.84	------
	2008	1.37	24.36	2.8	1.21	53.12	6	1.64	19.15	2.2	1.66	32.97	3.7
	2009	1.85	50.78	5.7	1.19	181.19	20.5	2.1	105.32	11.9	1.07	40.74	4.6
	2010	1.02	57.64	6.5	1.2	123.9	14	1.15	101.34	11.5	0.88	71.33	8.1

* RR (Resistance ratio) = LC_{50} of the field strain / LC_{50} of the laboratory strain

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Response of squash varieties to *Tetranychus urticae* (Acari: Tetranychidae) and *Bemisia tabaci* (Hemiptera: Aleyrodidae) infestation in relation with its leaf chemical compositions

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Abstract:

Immature fruit of squash (*Cucurbita pepo* L.) is a popular vegetable in Egypt. It can be produced almost as year– round crop. Field studies were carried out to evaluate four squash varieties i.e. Arkan, Dafn, Sama 740 and Andro 174 for their liability to the two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) and the whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) infestation during 2015 and 2016 seasons at Beni Suief Governorate, Egypt. Andro 174 variety was the most susceptible during the both seasons, while Sama 740 and Arkam varieties were the most tolerant during the investigated period. Metrological phenome as temperature and humidity played a key role in the *T. urticae* and *B. tabaci* infestations on the tested squash varieties. On the other hand, the sensitivity of squash varieties to the pest injury relies mainly on the phytochemical contents which varied from variety to another, which affect on pest density levels on squash leaves. A positive relationship was found between pest infestations and squash leaf contents *i. e*., nitrogen, total proteins, total carbohydrates and reducing sugar. In addition, the effect of potassium content, total phenols and tannins was negative effect on the *T. urticae* and *B. tabaci* populations, in where these target pests increased as the leaf content of these components decreased. It is concluded that the obtained results should be taken into account in planning of integrated pest management programs in squash plants.

Introduction

Squash (*Cucurbita pepo* L.) fruits are used for local consumption and for export. They contain some nutritional compounds for human feeding such as moderate quantity of mineral salts, it is eaten cocked as an immature fruit which is rich with fibers and vitamins or consumed for the mature seed which is a good source of fats and protein (Abdein, 2016). It has a highly economic value, and a nutritive food source especially vitamins and is one of the most popular vegetables grown in Egypt (Shehata *et al*., 2009). This crop was infested by two-spotted spider mite, aphids and whitefly (El-Dars *et al*., 2013). The last pests cause a numerous damage in both quantity and quality for crop directly by

plant juice loosen or indirectly by plant disease transmitting (Abdel-Salam *et al*., 1982; Geoghiou, 1990; Masaki *et al.*, 1991 and Ibrahim, 2005). Also, more than 200 host plant species were infested by these pests (Abdallah *et al*., 2014). A number of vegetable crops such as tomato, squash, eggplant, cucumber was also subject to *Tetranychus urticae* Koch (Acari: Tetranychidae) infestations during summer plantation causing numerous injuries and yield losses (Kherebe *et al.*, 1984; Heikal and Ali, 2000 and Faris *et al.*, 2004). The whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) caused crop losses by transmitting up to 150 virus species and by inducing plant disorders as likely as squash silver leaf (Polston *et al.*, 2014). Moreover, whitefly secreted honeydew on leaf surface, which lead to the growth of sooty mold fungi, then reduced the efficiency of leaves during photosynthesis processes (Burger *et al.*, 1988; Jimenez *et al*., 1995; Bleicher *et al*., 2000; Byrne *et al.*, 2003 and Lourenção *et al*., 2011).

Recently, the preference and non preference of pests to had gained a significant importance in pest control research programs. However, some issues were carried out with regard to the influence of climatic factors and leaf components on the pest population dynamics, damages and losses on vegetable crops by many authors (Rai *et al*., 1991; Kumar and Sharma, 1993; Kappoor *et al*., 1997; El-Kawass, 2000 and Abou-Zaid, 2003). Leaf chemical contents, varied from variety to another, might be affected on the population level of herbivores (El-Bassiony *et al.*, 2007; Aiad *et al*., 2014 and Azouz *et al*., 2014).

So that, the present work was aimed to evaluate the susceptibility of four squash varieties to *T. urticae* and *B. tabaci* infestations and its correlation with certain leaf phytochemical components. The population dynamics of the mite was also studied throughout the two successive seasons, 2015 and 2016.

Materials and methods

1. Population fluctuation of *Tetranychus urticae* and *Bemisia tabaci* on four squash varieties:

The population fluctuation of two spotted spider mite, *T. urticae* movable stages and whitefly *B. tabaci* nymphs on the four squash varieties (Arkam, Dafn, Sama 740 and Andro 174 varieties) were recorded per leaf, while other species of mite and insect pests have been neglected due to their occurrence by few numbers. An area of 700 m^2 was divided into 12 plots cultivated at Beni-Ady, Nasr District, Beni Suief Governorate, Egypt, during the summer seasons 2015 and 2016. The squash seeds were planted at 15th March throughout both seasons. Each tested cultivar was represented by three replicates (58 m^2) which were arranged in a randomized complete block design. The experimental area was kept free from any pesticide treatments. To estimate the infestation of *T. urticae* movable stages and nymphs of *B. tabaci* individuals, samples of 30 leaves from each variety were randomly picked at weekly intervals started after three weeks plant age until the end of this experiment. Each sample was kept in a tightly closed paper bag and transferred to the laboratory in the same day to count and recorded the numbers of pest individuals/inch^2 using a binocular stereomicroscope. The daily mean of minimum, maximum temperatures and RH %, were obtained from the meteorological records of Central Laboratory for Agriculture Climate, Agriculture Research Center at Dokki, Egypt.

2. Determination of phytochemical leaf components of four tested squash varieties cultivated under open field conditions:

Leaf samples of the squash varieties (Arkam, Dafn, Sama 740 and Andro 174) were collected during the vegetation growth period, then it was cleaned and washed with

distilled water and left to dry at room temperature. After that leaves were grinded into fine powder. Determination of nitrogen, reduced sugars and total tannins contents were determined and calculated according method described by Sadasivam and Manickam (1991a, b and c). Furthermore, potassium and total phenols contents were conducted by method of Chapman and Pratt (1961) and Heinonen (1999), respectively. Finally, total of carbohydrates and proteins were estimated and conducted according to method of Crompton *et al.*, (1967) and Bradford (1976), respectively.

3. **Statistical analyses:** Statistical analyses were performed using SAS program computer including F-test and calculated LSD (Least significant difference) to find the differences between seasonal mean numbers of tested pests on four investigated squash varieties (SAS Institute, 2003).

Results and discussion

1) Response of different squash varieties to infestation of *Tetranychus urticae* and *Bemisia tabaci*:

a. The two-spotted spider mite, *Tetranychus urticae*:

Data presented in Table (1) indicated that the tested squash varieties were significantly differed in their *T. urticae* infestations according to the mean numbers of movable mite stages through 2015 and 2016 seasons. Andro 174 variety was a high significant response to *T. urticae* infestation recording of 139.42 and 122.36 movable stages / leaf for two successive seasons, respectively which in turn showed significant differences with the other varieties, Arkam, Dafn and Sama 740. While, Sama 740 variety was the most tolerant variety recorded 62.64 and 56.27 movable stages / leaf for two successive seasons, there were significant differences between the tested varieties with the LSD value were 31.14 and 30.20 during the both two seasons, respectively.

In the present studies the two-spotted spider mite, *T. urticae* was observed the mortality pest infested squash plant and various vegetable crops as well as in okra plant (Allam *et al*., 2014). Our results also were in confirmed with the findings of Puttaswamy and Channabasavanna (1980) who reported that *Tetranychus ludeni* Zacher (Acari: Tetranychidae) started building up during April, and attained its peak during May-June. Similar results were reported by Kumar and Sharma (1993) and Gulati (2004). All of them studied the seasonal occurrence of mites on okra, during summer season.

b. The whitefly, *Bemisia tabaci*:

The obtained results in Table (2) indicated that the tested squash varieties significantly differed in their susceptibility to *B. tabaci* infestation according to the mean population of nymphs through 2015 and 2016. One peak of *B. tabaci* nymphs / variety was observed throughout the two tested seasons on all investigated squash cultivars. Andro 174 variety was the most highly significant response to *B. tabaci* infestation recorded 90.67 and 103.70 nymphs / inch^2 for two successive seasons which in turn, showed significant differences with the other cultivars, Arkam, Dafn, Sama 740. On the other hand, Arkam and Sama 740 varieties were the most tolerant that gave the lowest significant difference in *B. tabaci* being the mean numbers of 32.09 and 30.48 nymphs / inch^2 during both tested seasons, respectively.

A slight infestation of *B. tabaci* nymphs / inch^2 was occurred on the first season, 2015 when compared than another investigated season, 2016. These results are in agreement with published literature were supported by Sattar *et al*., 2005 in this study Whitefly nymphs and adults infested numerous cucurbit plants as well as watermelon, Indian squash and melon.

Table (1): Response of different squash varieties to *Tetranychus urticae* infestation under field conditions during 2015 and 2016 seasons.

Varities Inspections date	Mean numbers of *T. urticae* movable stage / inch^2							
	Season 2015				Season 2016			
	Arkam	Dafn	Sama 740	Andro 174	Arkam	Dafn	Sama 740	Andro 174
April, 15th	12.67	12.67	6.67	10.67	7.33	12	5.33	13
22nd	14	18	8.67	27.33	10	21	9.33	25.67
29th	34	38.33	19	49	14	33.33	15.67	45
May, 6th	45	52.33	33.33	71.67	24.33	46.67	26.33	65.67
13th	69.67	74	41.67	111.67	36.67	69	36.67	83.33
20th	92.33	101.67	62.33	145	57.33	93.33	49	108.33
27th	118.67	131.67	85	193.33	76.33	108.67	61.67	148.33
June, 4th	125	138.33	100.67	215	105	123.33	75	175
11th	133.33	160	115	236.67	121.67	150	100	210
18th	148.33	195	131.67	273.33	133.33	185	116.67	233.33
25th	135.33	180	85	200	157	208.33	123.33	238.33
Mean± SE	84.39±15.48 ^{BC}	100.18±19.68 ^{B}	62.64 ±13.21^{C}	139.42 ±17.3^{A}	67.55 ±16.37^{BC}	95.52±20.03 ^{AB}	56.27±12.87 ^{C}	122.36±25.07 ^{A}
LSD	31.14				30.2			

Values singed by the same letter of the same season are not significantly different at alpha = 0.05 % level.

Table (2): Response of different squash varieties to *Bemisia tabaci* infestation under field conditions during 2015 and 2016 seasons.

Inspections date	Mean numbers of *B. tabaci* nymphs / inch^2							
	Season 2015				Season 2016			
	Arkam	Dafn	Sama 740	Andro 174	Arkam	Dafn	Sama 740	Andro 174
April, 15th	4	6	2.67	8.67	8	10.67	4	10
22nd	6.67	10	6	15	11.33	16.33	6	24.67
29th	16.67	24.67	10	24.67	15.33	27.33	8.67	43
May, 6th	25	41.67	34	48.33	24	39.33	16.67	71.67
13th	34	58.33	41.67	70	33.67	51.67	25.67	91.33
20th	46	80.67	53.33	93.33	41.67	65	35	113.33
27th	48.33	103.33	65.67	120.67	55.33	86	48.67	130
June, 4th	65	138.33	76.67	151.67	57.33	117.33	51.67	163.33
11th	58.33	120	66.67	183.33	60	135	62.33	191.67
18th	35	81.67	43.33	166.67	42.33	148.33	50	156.67
25th	14	41.67	35	115	21.67	95	26.67	145
Mean± SE	32.09 ±6.25C	64.21 ±13.37 B	39.55 ±7.64 C	90.67 ±18.7 A	33.7 ±5.72 C	72.00 ±14.45 B	30.48 ± 6.18 C	103.70 ±18.21 A
LSD	19.85				19.84			

Values singed by the same letter of the same season are not significantly different at alpha = 0.05 % level.

2. Interaction between certain weather factors and *Tetranychus urticae* and *Bemisia tabaci* populations during during 2015 and 2016 seasons:

a.The two-spotted spider mite, *Tetranychus urticae* populations:

The simple correlation values (r) in Table (3) illustrated that there was highly significant positive effect of temperature (maximum, minimum and mean temperatures) on the population of *T. urticae* infested the four squash varieties during 2015 and 2016 seasons. On the other hand, average RH % had significantly positive correlation coefficient factor (r) during the first season but insignificant negative relation was observed through 2nd season. Similarly, results were obtained by Gulati (2004); Ismail *et al*. (2007) and Haque *et al*. (2011) in which these issues were reported that temperature was found an important regulatory factor for *T. urticae* building up for numerous vegetable crops with positive correlation.

The amount of variability explained variance (E.V. %) could be attributed to the combined effect of the tested weather factors on the *T. urticae* population on the four squash varieties were recorded more than 80% during the two successive seasons, 2015 and 2016. E.V. % was 93.33, 95.66, 90.61 and 92.40 % on Arkam, Dafn, Sama-740 and Andro-174 varieties throughout the 1st season, respectively. Moreover, it was 86.32, 85.81, 88.56 and 84.62 % for the previously mentioned varieties during 2nd season, respectively. These results agree with that obtained by Allam *et al.* (2014), who illustrated that the simultaneous impact of certain environmental variable factors and other factors on the census of the mite pest and its predators revealed that, temperature, relative humidity and plant age were the most vital factors effected on the population densities of this species. Also, Ghallab *et al.* (2001) revealed that the population of tetranychid mites including *T. urticae* correlated with temperatures.

Table (3): Simple correlation between mean numbers of *Tetranychus urticae* movable stage on different squash varieties and certain climatic factors during 2015 and 2016 seasons.

Varieties		Simple correlation values								Explained variance%
		Max. Temp.		Min. Temp.		Mean Temp.		Mean RH%		
		r	p	r	P	r	P	r	p	
2015	Arkam	0.785	0.004	0.918	0.001	0.874	0.004	0.671	0.024	93.330
	Dafn	0.748	0.008	0.891	0.002	0.843	0.011	0.738	0.010	95.660
	Sama 740	0.721	0.012	0.869	0.005	0.817	0.021	0.719	0.013	90.610
	Andro 174	0.769	0.006	0.901	0.001	0.858	0.007	0.686	0.020	92.400
2016	Arkam	0.831	0.002	0.905	0.001	0.897	0.002	-0.43	0.189	86.320
	Dafn	0.822	0.002	0.903	0.001	0.893	0.002	-0.45	0.171	85.810
	Sama 740	0.833	0.002	0.924	0.001	0.910	0.001	-0.46	0.158	88.560
	Andro 174	0.828	0.002	0.907	0.001	0.899	0.002	-0.51	0.110	84.620

b.The whitefly, *Bemisia tabaci* populations:

Data tabulated in Table (4) revealed that the simple correlation coefficient (r) was highly significant positive relationship between three tested temperature and the population of *B. tabaci* nymphs infested the four squash varieties during both two seasons. On the other hand, a significant positively effective during the 1st season. However, a non significant negative through the 2nd season with average RH%. the combined effective of the investigated weather factors on the *B. tabaci* activity during experimental time. The combined effect of explained variance of the four tested factors on *B. tabaci* population were (56.69, 62.07, 74.50 and 87.32 %) during the 1st season and were 61.10, 80.95, 68.77 and 82.66 % throughout 2nd season on Arkam, Dafn, Sama-740 and Andro-174 varieties, respectively.

Table (4): Simple correlation between mean numbers of *Bemisia tabaci* nymphs on different squash varieties and tested climatic factors during 2015 and 2016 seasons.

Varieties		Simple correlation values								Explained variance%
		Max. Temp.		Min. Temp.		Mean Temp.		Mean RH%		
		r	P	r	p	r	p	r	P	
2015	Arkam	0.647	0.031	0.709	0.015	0.689	0.019	0.218	0.520	56.690
	Dafn	0.684	0.020	0.772	0.005	0.743	0.009	0.348	0.294	62.070
	Sama 740	0.746	0.008	0.837	0.001	0.805	0.003	0.342	0.304	74.500
	Andro 174	0.732	0.010	0.879	0.002	0.826	0.002	0.678	0.022	87.320
2016	Arkam	0.551	0.079	0.570	0.067	0.586	0.058	-0.731	0.011	61.100
	Dafn	0.821	0.002	0.875	0.001	0.881	0.000	-0.649	0.031	80.950
	Sama 740	0.692	0.018	0.741	0.009	0.745	0.009	-0.699	0.017	68.770
	Andro 174	0.812	0.002	0.870	0.001	0.874	0.001	-0.703	0.016	82.660

In general, this work ultimate that both temperature and relative humidity were familiar factors affecting the development rate of *T. urticae* and *B. tabaci*, followed by other factors such as initial population and growth condition of plants. Many authors studied the different relationship between Tetranychidae, Phytoseiidae, Tenuipalpidae, Tarsonemidae, Stigmaeidae and the tested sucking and leaf miner pests with various meteorological factors was extensively reported by, El-Saidy *et al*. (2012) on *Phaseolus* and eggplant and Allam *et al*. (2014) on okra plant. Also, different pests [*Liriomyza trifolii* (Burgess) (Diptera : Agromyzidae), *B. tabaci*, *Myzus persicae* (Sulzer) (Hemiptera: Aphididae) and *Thrips tabaci* (Lindeman) (Thysanoptera: Thripidae)] were correlated with some weather factors (Shalaby, 2004)

Finally, thermelogical factors such as minimum, maximum and mean temperatures and average relative humidity were important factors which effect on the development rate of both *T. urticae* and *B. tabaci* on squash.

3. **Effect of phytochemical components of squash leaf of the tested varieties on the infestation of of *Tetranychus urticae* and *Bemisia tabaci*:**

One of the most important factors which may explain the susceptibility or the tolerance of squash varieties to the infestation of *T. urticae* and *B. tabaci* was the phytochemical components in their leaves. So data tabulated in Table (5) showed the mean infestation rates of *T. urticae* and *B. tabaci* movable stage and nymphs / inch^2 , respectively, on four different squash varieties namly; Arkam, Dafn, Sama-740 and Andro-174 and the corresponding amount of their leaf contents, Nitrogen, total proteins, total carbohydrates, reducing sugar, tannins and total phenols at the plant growth stages during 2016 season and their relation with *T. urticae* and *B. tabaci* infestation.

Regarding Andro-174 variety, it was observed that the higher contents of all tested leaf contents than other tested varieties except on reduce sugar (3.77) and potassium contents as well as the nitrogen of 695.33, total proteins of 4.17, total carbohydrates of 23.57, total phenols of 2.15 and tannins of 775.67 and also, it had the highest general mean of the population density of *T. urticae* (122.36 mite /inch^2) and *B. tabaci* (103.70 nymphs/inch^2), while, the potassium content and reducing sugar were recorded the highest amount in Dafn leaves cultivar (175.00 and 9.83), respectively and the lowest content were recorded in Sama 740 leaves (110.67 and 4.98) for these two chemical components, respectively (Table, 5).

Table (5): Measurement amount of phytochemical components in leaves of four squash varieties during season 2016.

Cultivars	Mean numbers/ inch^2		phytochemical components						
	T. urticae	*B. tabaci*	Nitrogen content	Potassium content	Total protein	Total carbohydrates	Reducing sugars	Total phenols	Tannins
Arkam	67.55 bc	33.70 c	612.00 b	152.67 a	3.18 b	15.53 b	7.45 b	1.72 bc	696.33 a
Dafn	95.52 ab	72.00 b	284.67 c	157.00 a	1.95 c	16.99 b	9.83 a	1.60 c	608.00 b
Sama 740	56.27 c	30.48 c	254.00 c	110.67 c	1.67 c	18.28 b	4.98 c	1.95 ab	747.67 a
Andro 174	122.36 a	103.70 a	695.33 a	133.00 b	4.17 a	23.57 a	3.77 c	2.15 a	775.67 a
LSD	30.2	19.84	57.18	15.73	6.48	2.84	1.72	0.28	86.1

Concerning the relation between the population levels of *T. urticae* and *B. tabaci* and the previously mentioned components, data was arranged in Table (6) showed that the calculated correlation coefficient values were significantly positive in case of nitrogen content for all the tested varieties expect with Dafn variety, the relation was insignificant during 2016 season. In case of potassium content, it was positive on the infestation of mite pest for Dafn and Andro 174 varieties and was a negative effect on the other two tested varieties, Arkam and Sama 740. In addition, for the repellent compounds, total phenol and tannins, there had a negative effect on the *T. urticae* occurrence on the four investigated varieties except for total phenol with Sama 740 cultivar was a positive correlation coefficient.

Similar by Mead *et al*. (2010) recorded the same results when tested different maize varieties against *T. urticae*. Moreover, Ahmed (1994) reported that host plants resistance to mite infestation may be attributed to low protein and amino acid contents in leaves, which provided less nutritive diet for the spider mite *T. urticae.* Hoffland *et al*. (2000) stated that the protein concentration in tomato leaves was positively correlated with nitrogen content. Moreover, Zaher *et al.* (1980) recorded insignificantly positive correlation between *T. urticae* infestation on soybean and leaf nitrogen content. Contarawise, Magouz *et al*. (2006) and El-Sanady *et al*. (2008) reported a negative correlation between the population density of movable mite stages and nitrogen contents on soybean plant. The obtained data agreement with Badegana and Payne (2000) stated that there was a positively significant correlation between the intrinsic rate increase (r_m), the finite rate of increase (λ) and nitrogen content in the host plant leaves. Similar results were obtained by Taha *et al.* (2014) when tested different cotton cultivars, they found that the cotton genotype, Giza 90 was the most susceptible to *T. urticae* infestation during 2010 and 2011 seasons. On contrary, Wilson (1993) reported that *T. urticae* populations were unaffected by cotton varieties in Australia.

However, the calculated correlation coefficient (r) values showed the relationship between whitefly (nymphs) abundance and these leaf phytochemical components which resulted that nitrogen, total carbohydrates, and reducing sugar affected positively on the population of *B. tabaci* nymphs, in which, the population increased by increasing the content of these tested components in the count of *B. tabaci* nymphs on the four tested leaves. Moreover, total protein was positively affected on this pest in Dafn and Sama 740

while in Arkam and Andro 174 was negatively affected on this pest. Potassium content, total phenols and tannins had negative effect on the *B. tabaci* nymphs on populations, in where, nymphs of the target pest increased when decreased of the content of these components in the plant leaves.

Table (6): Correlation coefficient (r) and its probability (p) between phytochemical contents of squash varieties and abundance of *Tetranychus urticae* and *Bemisia tabaci* during **season 2016.**

Pests	Varieties	Nitrogen content		Potassium content		Total protein		Total carbohydrates		Reducing sugars		Total phenols		Tannins	
		r	p	R	p	r	p	r	p	r	P	r	p	r	p
T. urticae	Arkam	0.63	0.56	-0.54	0.64	0.77	0.44	0.25	0.84	0.99	0.04	-0.76	0.45	-1.00	0.03
	Dafn	0.96	0.18	0.78	0.43	0.48	0.68	-0.38	0.75	0.03	0.98	-0.27	0.82	-0.10	0.94
	Sama 740	0.97	0.16	-0.60	0.59	0.87	0.33	0.87	0.33	0.99	0.10	0.87	0.33	-0.68	0.53
	Andro 174	0.82	0.39	0.96	0.18	-0.88	0.32	0.31	0.80	0.79	0.42	-0.96	0.17	-0.92	0.25
B. tabaci	Arkam	0.97	0.16	-0.94	0.23	-0.61	0.59	0.78	0.43	0.76	0.45	-0.22	0.86	-0.78	0.43
	Dafn	0.31	0.80	-0.08	0.95	1.00	0.06	0.55	0.63	0.84	0.36	-0.95	0.20	-0.01	0.99
	Sama 740	-0.46	0.70	-0.95	0.20	0.59	0.60	0.66	0.54	0.28	0.82	-0.08	0.95	-0.68	0.53
	Andro 174	1.00	0.02	-0.64	0.56	-1.00	0.05	0.78	0.43	0.33	0.79	-0.65	0.55	-0.56	0.62

We can conclude that the most susceptible variety to the infestation with *T. urticae* and *B. tabaci* was Andro 174 variety during the experimental time. Also, from previously data can be concluded that the different squash varieties tolerant to mite and insect infestation could play an important role contributing to integrated pest management strategies in integrated crop management programs. So, we recommended that squash variety, Sama 740 variety was used in planting because it highly tolerance to these pests.

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• Negotiation research spans many disciplines (Abd-Rabou, 1996).

• This result was later contradicted (Simmons and Abd-Rabou, 2009).

• This effect has been widely studied (Abd-Rabou ,1998; Simmons *et al.*, 2002; Evans and Abd-Rabou, 2005and Abd-Rabou *et al.*, 2005).

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Journal article

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