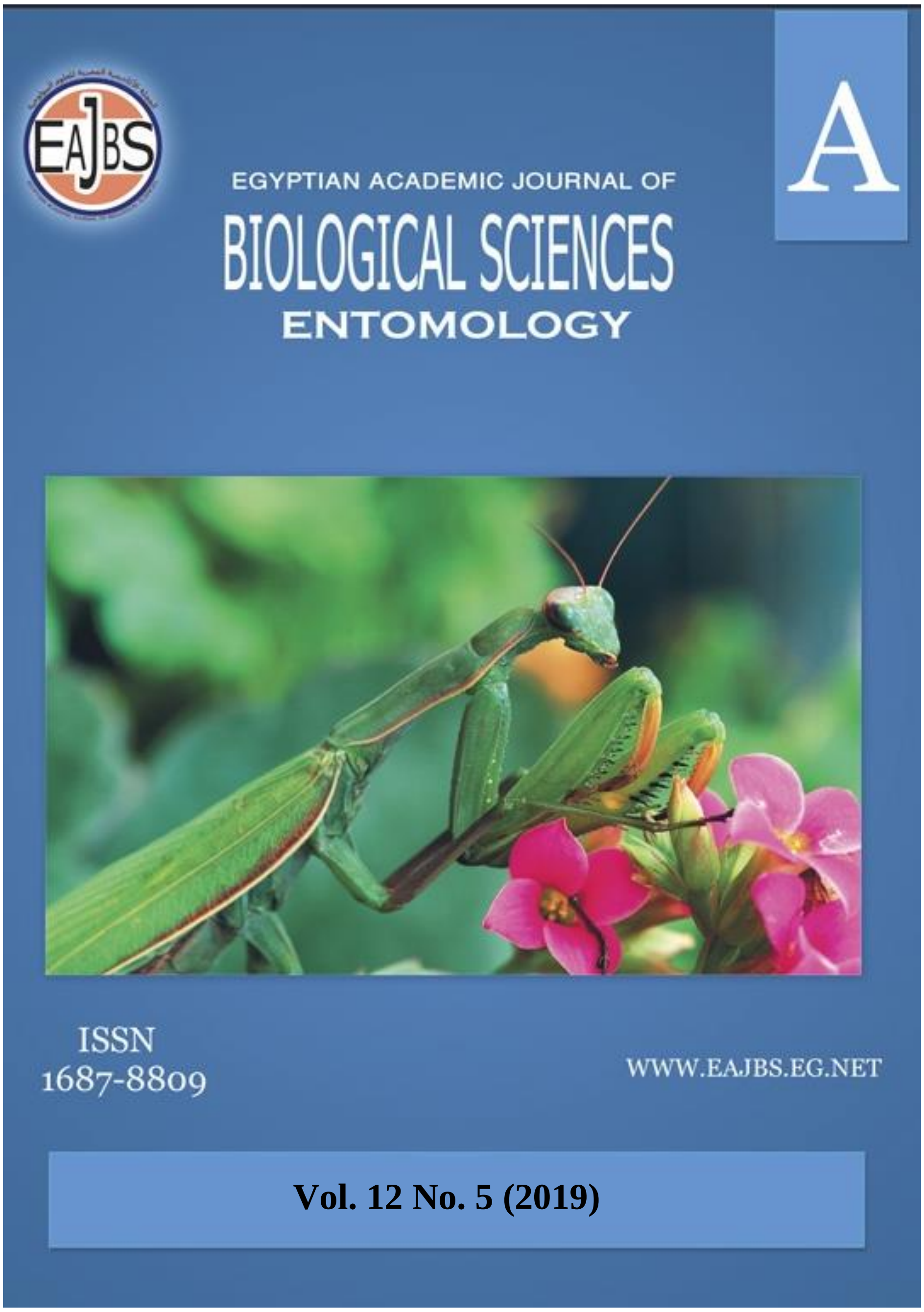

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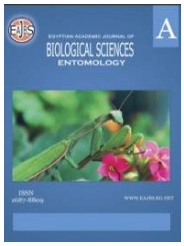

Apple Tree Borers at Menoufia, Egypt with Special Reference to the Phytochemical Changes and Their Relation to the Infestation with *Synanthedon myopaeformis* Borkh. (Lepidoptera: Sesiidae).

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ABSTRACT

The first part of the work aimed to study the survey of apple trees borers that attack apple orchards in two different geographical regions, at Abo-Mashour and Al-Khatatba locations (Menoufia governorate). Five species were recorded in the study showed, these borers were *Synantheden myopaeformis* Borkh., *Zeuzera pyrina* L., *Hypothenemus eruditus* Westwood., *Scolytus amygdali* Guer. and *Chlorophorus varius* Mull (non recorded at Al-Khatatba) . Highest percentages of infestation (26.08 & 21.33 %) were recorded for *Sy. myopaeformis* followed by *Z. pyrina* (17.83 &13.01%) at Abo-Mashour and Al-Khatatba, respectively. An annual increase of infested trees with these borers, especially *Sy. myopaeformis* (10.59 & 9.59) and *Z. pyrina* (9.22 & 6.62) give serious indicators to quick devastation and the death of infested trees. The weather factors detected a significant correlation with infestation by different borers except *Ch. varius.* Also significant differences for both *Z. pyrina* and *S. amygdale* were detected in the two regions under study, while the infestation showed insignificant differences of both *Sy. myopaeformis* and *H. eruditus* The second part of the study aimed to investigate the role of phytochemical components within apple trees and their relation to the infestation with apple clearwing moth *Sy myopaeformis*. The analysis by GC-MS chromatograph showed differences in both Chemical composition and the percentages of compounds in the tested wood samples from apple trees under study. In the uninfested young trees (resistant trees), the levels of 9-Octadecenoic acid (Oleic acid), 9-Hexadecanoic acid and Ethyl iso-allocholate were found at higher rates than the uninfested old trees, as they were 31.42%, 14.83% and 5.37% respectively. The infested old trees showed high levels of these chemical compounds compared to uninfested ones as the percentages of 9-Octadecenoic acid (Oleic acid), 9-Hexadecanoic acid and Ethyl iso-allocholate increased by 5.8 fold, 3.1 fold and 3.1 fold, respectively, while the percentages in uninfested old trees were 7.42%, 5.39% and 3.34% respectively.

INTRODUCTION

Apple trees (*Malus domestica* Borkh.) are cultivated worldwide and are considered the most widely consumed fruits in the world. Apple trees are deciduous and grow in most countries of the moderate regions and in some tropical areas (Ferree and Warrington 2003). Apple trees, in Egypt and in most world countries are attacked by various insect pests. Aphids, Codling moth, Leopard Moth, Clearwing Moth, dogwood moth, scale insects, leafminers, leafrollers, jewel beetles and bark beetles are the main insect pests attacking fruit trees, including apple orchards (Blommers 1994, Abdel-Azim 1997, Pfammatter & Vuignier, 1998, Anonymous 1999, Brown et al. 2008, Karaca et al. 2010, Simon et al. 2010, Hegazi et al. 2010, Hegazi et al. 2014, Batt & Abd El-Raheem 2017).

In Egypt and several other countries, the xylophagous clearwing moth *Sy. myopaeformis* Borkh. (Lepidoptera: Sesiidae) is a serious pest in the apple orchards (Tertyshny 1995, Al-Antary et al. 2004, Ateyyat 2005, Ateyyat 2006, Aurelian 2011, Batt and Abd El-Raheem 2017). The first and second instar larvae of the apple clearwing moth feed superficially within the bark whereas the older instar larvae feed on the vascular tissues between the bark and cambium. This leads to destructive tunnels inside the trunk of apple trees resulting in economic losses of the crop as a result of the deterioration in the growth of the tree and finally death of the whole tree. (Bergh and Leskey 2003, Kain & straub2001, Aurelian 2011). Thus, several studies were carried out by many authors (Abd El-Kader & Zaklama 1971, Awadallah et al. 1978, Tadros 1993, Tadros 1994 a, 1994 b, Girgis et al. 1995, Abdel-Azim, 1997, Shehata et al.1999, Tadros et al. 2003, Batt & Abd El-Raheem 2017) which aimed to study the Ecology, Biology, monitoring and control of this dangerous pest.

In all, Variation in phytochemicals or metabolic diversity in plants possibly explains variation in response to a diversity of natural enemies, including specialist and generalist insect herbivores (Becerra 1997, Dyer et al. 2004, Lankau 2007, Kursar et al. 2009). These studies have provided the information needed to find novel technologies and resources for assessing and understanding pest management issues according to the relation between the insects and the host plants.

According to the aforementioned views, the main objectives of our study were to (1) survey wood borers attacking apple orchards in Menoufia governorate, (2) annual percentages and progress of infestation for different apple tree borers, (3) changes of chemical components and their relation of infestation with apple clearwing moth.

MATERIALS AND METHODS

Survey of Apple Tree Borers in Two Geographical Regions of Menoufia Governorate:

The present study was carried out on apple orchards during 2017–2018 with 15-20 years-old apple trees. Infested apple orchard at two geographical regions at Menoufia governorate (South of the Nile Delta in northern Egypt), the first, at Abo-Mashour village (Berkat Al-Saba district, 30.68390° N, 31.06222° E) and the second Al-Khatatba location (Al-Sadat district, 30.33938° N, 30.70440° E), were chosen to survey the stem tree borers species infesting apple trees. The borer species were recognized by different infestation symptoms of each species.

In the last week of December 2017, the infested apple trees with each borer species were counted and marked by colored paint. The percentage of infestation for each borer species was calculated. A monthly examination was done to determine the new numbers of infested apple trees and then marked. The progress of infestation was estimated by a monthly cumulative number of infested trees. The annual percentage of infestation by borer species at the end of December 2018 was determined as follows:-

$$\text{Infestation \%} = \frac{\text{No. of infested trees / borer species}}{\text{Total number of examined trees}} \times 100$$

Increase (progress) of infestation % =

$$\frac{\text{Infested number secondly of trees} - \text{infested number firstly of trees}}{\text{The examined number of trees}} \times 100$$

Analysis of Chemical Components of Infested and Uninfested Apple Trees:

The study was carried out in apple orchard, Abo-Mashour (30.68390° N, 31.06222° E), with 15-20-year-old apple trees but has several areas with trees less than four years old of the same species instead of the old damaged ones. The orchard was neglected, heavily attacked by insect borer *Sy. myopaeformis* and no pesticides were applied for more than 3 years.

Apple Trees Were Divided Into 3 Groups:

A- non-infested young trees (resistant trees), b- non-infested old trees and c- infested old trees.

The trunk samples including bark, phloem, cambium and xylem were taken from 30 trees (10 from each of the previous groups) 10-50 cm above the ground. The samples of each group were mixed well together and 30g were taken from each mixture to be analyzed.

Sample Preparation:

1. Extraction:

The dried samples were grounded to a fine powder using a pestle and mortar. The sample powder was put into a methanol solution for two days before filtering the solution. The solution was filtered to separate the solids away using a filter paper. The methanol solution that remains after the filtration process was evaporated using rotary evaporator till dried. The solution in methanol was 3:1 and injected 1µL in GC-MS.

2. Gas Chromatography–Mass Spectrometry (GC-MS) Analysis:

The chemical composition of the collected samples was performed using Trace GC 1310-ISQ mass spectrometer (Thermo Scientific, Austin, TX, USA) with a direct capillary column TG–5MS (30 m × 0.25 mm × 0.25 µm film thickness). The column oven temperature was initially held at 60°C and then increased by 5 °C /min to 150 °C withhold 2 min then increased to 300 with 10 C/min and hold for 5 min. The injector temperature was kept at 250 °C. Helium was used as a carrier gas at a constant flow rate of 1 ml/min. The solvent delay was 2 min and diluted samples of 1 µl were injected automatically using Autosampler AS3000 coupled with GC in the split mode. All mass spectra were recorded in the electron impact ionization (EI), mass spectra were collected at 70 electron volts ionization voltages over the range of m/z 50 – 650 in full scan mode. The ion source and transfer line temperatures were set at 200 and 250 °C respectively. The components were identified by comparison of their retention times and mass spectra with those of (NIST and WILEY) mass spectral database, Davies (1990) and Wiley NIST (2008).

Statistical Analysis:

The data obtained from apple trees attacked with different borer species in infested orchards at Abo-Mashour (Berkat Al-Saba district) and Al-Khatatba (Al-Sadat district) locations Menoufia governorate, during 2018 were estimated by (SAS program, 2001).

RESULTS AND DISCUSSION

Survey of Apple Tree Borers in Two Geographical Regions of Menoufia Governorate:

Cultivated apple trees in infested orchards with fruit tree borers at Abo-Mashour (Berkat Al-Saba district) and Al-Khatatba location (Al-Sadat district) Menoufia governorate, indicated that five borers species infested the apple trees in the Abo-Mashour region. These borers are *Synanthedon myopaeformis* Borkh. (Lepidoptera: Sesiidae), *Zeuzera pyrina* L., (Lepidoptera: Cossidae), *Hypothenemus eruditus* Westwood, *Scolytus amygdali* Guer. (Coleoptera: Curculionidae: Scolytina) and *Chlorophorus vairus* Mull. (Coleoptera: Cerambycidae), while four species only (the same of previous species except for

Chlorophorus vairus) recorded at Al-Khataba location.

The previous studies point that all borers that have been found in the study have been established as pests on fruit trees in Egypt, for instance, Willcocks 1924, Batt 2002, 2008, Hegazi et al. 2010, 2014, Tadros 1994 a, 1994 b, Girgis 198, Abd El-Moaty et al. 2013.

Monthly Changes of Infestation:

At the two geographical regions in our study, under the different effects for each of weather factors, the new infestations of various borers attacking the apple trees were recorded in the Table (1) and Table (2).

1. At Abo-Mashour Location:

As shown in Table (1), the number of new infestations during the year of study showed that the highest monthly infestations were recorded during August (8 infestations) with both *Z. pyrina* & *Sy. myopaeformis* ; during July (5 infestations) with both *H. eruditus* & *S. amygdali* and during August (3infestations) with *Ch.vairus.*

Table (1). Monthly numbers of new infestations for borers of attacking apple trees in infested orchards at Abo-Mashour (Berkat Al-Saba district) location Menoufia governorate, during 2018.

Months	Species of apple tree borers										Weather factors		
	Z.pyrina		*Sy. myopaeformis*		*H. eruditus*		*S. amygdali*		*Ch. varius*		*Minimum Temp .°C*	*Maximum Temp.°C*	*Rh%*
	No.	Cu.	No.	Cu.	No.	Cu.	No.	Cu.	No.	Cu.			
Dec.2017	44	44	79	79	45	45	8	8	14	14	----------	----------	----------
Jan.	1	45	3	82	1	46	1	9	0	14	10.3	17.96	51.1
Feb.	3	48	3	85	2	48	2	11	0	14	10.7	19.4	55.6
Mar.	3	51	4	89	2	50	0	11	2	16	13.5	23.7	57.2
Apr.	6	57	5	94	2	52	2	13	1	17	14.6	26.6	49.3
May	4	61	5	99	4	56	3	16	2	19	19.06	32.15	50.2
Jun.	5	66	6	105	3	59	4	20	0	19	21.33	32.53	52
Jul.	7	73	7	112	5	64	5	25	2	21	23.4	34.43	55.4
Aug.	8	81	8	120	4	68	4	29	3	24	26	36.6	54.7
Sep.	5	86	5	125	2	70	3	32	0	24	24.95	35.7	50.2
Oct.	3	89	4	129	1	71	1	33	1	25	21.3	30.95	59.8
Nov.	1	90	2	131	0	71	0	33	0	25	15.95	25.23	71.6
Dec.2018	1	91	2	133	1	72	1	34	0	25	11.4	20.4	64.9
A	91		133		72		34		25		----------	----------	----------
B	510												

A = Total number of infested trees B = Number of examined trees
N = number of infested trees Cu. =Cumulative number of infested trees

2. At Al-Khataba Location:

The highest numbers of new infestations for apple tree borers (Table2) were recorded during August with *Z. pyrina* (5 infestations) & *H. eruditus* (4 infestations) and during July with *Sy. myopaeformis* (7 infestations) & *S. amygdale* (3 infestations).

Table (2). Monthly numbers of new infestations for borers of attacking apple trees in infested orchards at Al-Khatatba ((Al-Sadat district)) location Menoufia governorate, during 2018.

Months	Species of apple tree borers								Weather factors		
	Z.pyrina		*Sy. myopaeformis*		*H. eruditus*		*S. amygdali*		*Min. Temp .°C*	*Max. Temp.°C*	*Rh%*
	No.	Cu.	No.	Cu.	No.	Cu.	No.	Cu.			
Dec.2017	28	28	51	51	39	39	3	3	------------------		
Jan.	1	29	3	54	1	40	0	3	8.65	18.8	62
Feb.	1	30	2	56	0	40	0	3	9.23	20.8	61.3
Mar.	3	33	3	59	3	43	0	3	11.13	24	60.98
Apr.	4	37	4	63	2	45	1	4	14	28.5	55.98
May	3	40	3	66	3	48	2	6	17.13	32.5	51.12
Jun.	4	44	5	71	3	51	2	8	19.8	34.7	50.5
Jul.	4	48	7	78	2	53	3	11	21	35.3	50.3
Aug.	5	53	6	84	4	57	2	13	21.5	35.9	62.8
Sep.	0	53	3	87	1	58	1	14	19.83	34.15	57.9
Oct.	2	55	2	89	0	58	2	16	17.15	31.43	65.1
Nov.	1	56	2	91	0	58	1	17	13.48	25.9	68.88
Dec.2018	1	57	2	93	0	58	0	17	10.4	20.6	65.34
A	57		93		58		17		------------------		
B	438										

A = Total number of infested trees B = Number of examined trees
N = number of infested trees Cu. =Cumulative number of infested trees

Annual percentages and progress of infestation for different apple tree borers:

The annual cumulative numbers of infestation during the study period for each apple tree borer at Abo-Mashour and Al-Khataba locations indicated that the infestation percentages of different borers were represented in Fig. (1) and Fig. (2) respectively.

1. At Abo -Mashour Location:

The percentages of infestation were 17.83, 26.08, 14.12, 6.67 and 4.90% for *Z. pyrina*, *Sy. mopeaformis*, *H. eruditus*, *S. amygdali and Ch. varies* respectively.

The data also detected that the increase of infestation recorded during the one year study was as follows 9.22, 10.59, 5.29, 5.10 and 2.16 % for each of *Z.pyrina*, *Sy. mopeaformis*, *H. eruditus* , *S. amygdali*, and *Ch. varies* respectively, Fig(1).

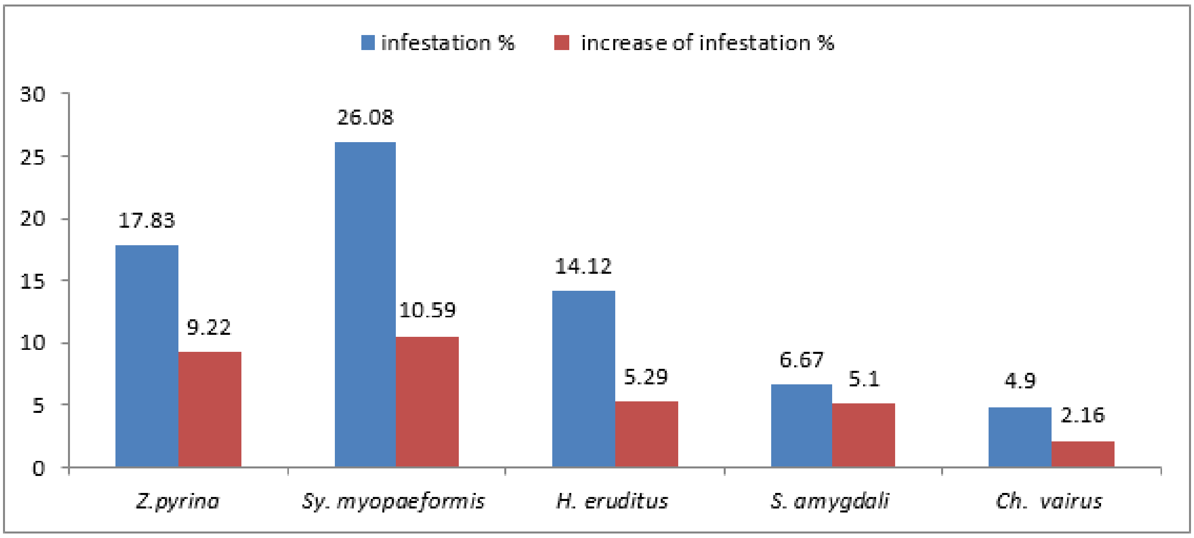

Fig (1) Annual percentages and progress of infestation for different borers of apple trees at Abo-Mashour location during 2018

2. At Al-Khatataba Location:

As shown in Fig(2) the annual percentages of infestation recorded 13.01, 21.23, 13.24 and 3.88 for each of *Z. pyrina*, *Sy. mopeaformis*, *H. eruditus* , *S. amygdali* respectively, in this respect the progress of infestation indicated that the annual increase of infestation recorded 6.62, 9.59, 4.34 and 3.20% for each of *Z. pyrina*, *Sy. mopeaformis*, *H. eruditus* and *S. amygdali* respectively.

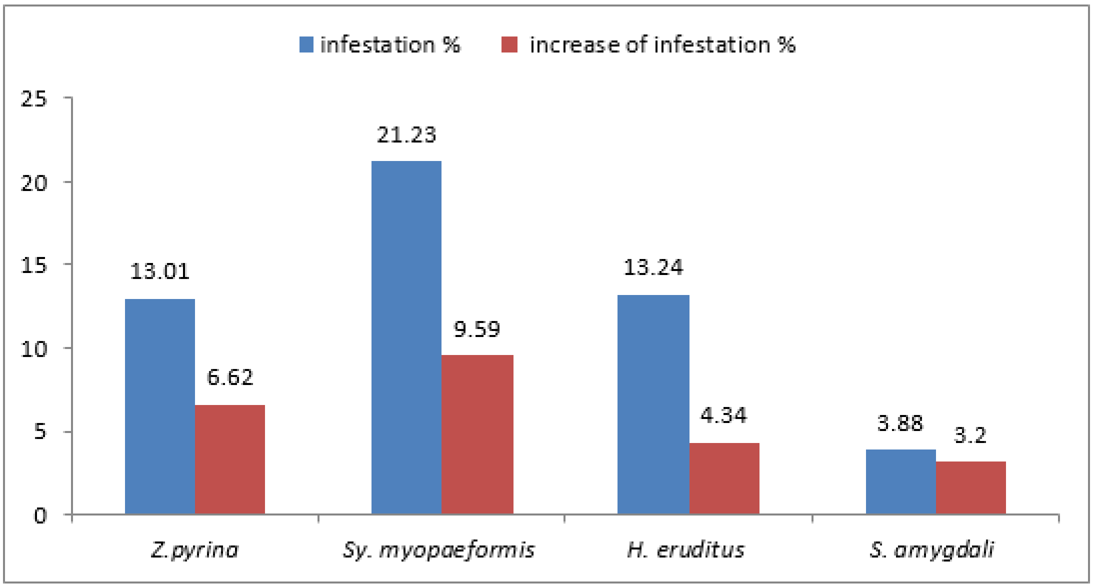

Fig (2) Annual percentages and progress of infestation for different borers of apple trees at Al-Khatatba location during 2018

Comparative Study between the Infestation by Apple Tree Borers at Abo-Mashour and Al-Khatatba Locations:

The obtained data in Table (3) indicated that the infestation by *Z. pyrina* and *S. amygdali* was significant while the differences between the infestation of both *Sy. Myopaeformis* and *H. eruditus* were insignificant. (T= 1.37and 1.12, respectively).

Table (3): Comparative study for infestation by apple tree borers at Abo-Mashour and Al-Khatatba locations

Species of apple tree borers	Abo-Mashour	Al-Khatatba	T- Test
	Mean ± SE	Mean ± SE	
Z. pyrina	3.92 ± 0.65	2.42 ± 0.45	1.82
Sy. myopaeformis	4.5 ± 0.52	3.5 ± 0.46	1.37
H. eruditus	2.25 ± 0.41	1.58 ± 0.40	1.12
S.amygdali	2.17 ±0.45	1.17 ±0.28	1.79

Probable Effect of Weather Factors:

Many factors may play an important role in affecting the state of trees and the monthly abundance of different borer species for apple trees. The temperature and relative humidity are some of the weather factors affecting the infestation. The correlations between these factors and infestation by apple tree borers showed significant differences in two geographical regions (Abo-Mashour and Al-Khatatba), Table (4).

Table (4). The correlations between weather factors (Min. Temp. °C, Max. Temp. °C and RH %) and the infestations by apple tree borers at Abo-Mashour and Al-Khatatba locations

Abo-Mashour						
Species of apple tree borers	Min. Temp. °C		Max. Temp. °C		RH%	
	r	b	r	b	r	b
Z. pyrina	0.740**	0.306	0.784**	0.279	-0.540*	-0.190
Sy. myopaeformis	0.794**	0.263	0.823**	0.234	-0.555*	-0.156
H. eruditus	0.577	0.151	0.644*	0.144	-0.539*	-0.120
S.amygdali	0.697*	0.201	0.722**	0.179	-0.541*	-0.133
Ch. varius	0.457 Ns	0.087	0.510*	0.084	-0.216Ns	-0.035
Al-Khatatba						
Species of apple tree borers	Min. Temp. °C		Max. Temp. °C		RH%	
	r	b	r	b	r	b
Z. pyrina	0.529*	0.181	0.569*	0.122	-0.504*	-0.131
Sy. myopaeformis	0.689*	0.245	0.658*	0.175	-0.610*	-0.164
H. eruditus	0.512*	0.156	0.552*	0.126	-0.568*	-0.132
S.amygdali	0.889**	0.194	0.892**	0.132	-0.542*	-0.10

* = Significant ** = highly Significant Ns = non-significant

Chemical Components Of Apple Trees:

Analysis of methanol extract of trunk wood of infested and uninfested apple trees detected the chemical components of each young, old infested and uninfested apple trees, as in the following results:

1. GC-MS Chromatogram of the Methanol Extract of Resistant Young Apple Trunk Wood:

GC-MS chromatogram of the methanol extract of apple trunk wood depicted 20 peaks indicating the presence of 20 compounds. The chemical components identified in the methanol wood extract from resistant young apple trees with the retention time ranging from 2.17 to 33.33 minutes were presented in (Table 5). Twenty compounds were detected as results of the GC-MS analysis of the wood composition. These are l-Gala-l-ido-octose (0.03%), 2,2-Dideutero octadecanal (0.10%), 2-pentanone,4-hydroxy-4-methyl- (2.43%), 5-Cyclopropylcarbonyloxypentadecane (0.03%), N-2,4-Dnp-L-arginine (0.02%), Benzenemethanol, à-(1-aminoethyl)- (0.03%),[1,1'-Bicyclopropyl]-2-octanoic acid, 2'-hexyl-, methyl ester (0.01%), Dodecanoic acid, 3-hydroxy- (0.10%), 2-Aminoethanethiol hydrogen sulfate (ester) (0.24%), Z-8-Methyl-9-tetradecenoic acid (0.05%), 9-Hexadecenoic acid (14.83%),9-Octadecenoic acid (Z)- (Oleic acid) (31.42%), Oxiranecarboxamide,2-ethyl-3-propyl-(6.58%), Z-(13,14-Epoxy)tetradec-11-en-1-o l acetate (9.96%), 7-Methyl-Z-tetradecen-1-ol acetate (2.35%),1-Heptatriacotanol (11.87%), Ethyl iso-allocholate (5.37%), 2-Hydroxy-3-[(9E)-9-octad ecenoyloxy]propyl(9E)-9-octadecenoate (6.04%), Tetraneurin - A- diol (5.31%) and Alanine, 3-(benzyloxy)-, L- (3.23%).

2. GC-MS Chromatogram of the Methanol Extract of Uninfested Old Apple Trees Trunk Wood:

The methanol extract of trunk wood from uninfested old apple trees with the retention time ranging from 3.37 to 31.00 minutes revealed the presence of 12 compounds summarized in (Table 6). The major identified chemical components were, 2-Pentanone,4-hydroxy-4-

methyl- (9.46%), Benzene, 1,3-bis(1,1-dimethylethyl) (0.37%), 2,4-Bis(1,1-Dimethylethyl)Phenol (1.81%), 13,16-Octadecadiynoic acid, methyl ester (1.33%), Tetradecanoic acid (14.99%), 9-Hexadecenoic acid (5.39%), 9-Octadecenoic acid (Z)- (Oleic acid) (7.42%),7-Methyl-Z-tetradecen-1-ol acetate (3.44%), Ethyl iso-allocholate (3.34%), 1-Heptatriacotanol (5.20%), 1,2-benzenedicarboxylic acid, diisooctyl ester (46.73%) and Alanine, 3-(benzyloxy)-, L-(0.52%).

3. GC-MS Chromatogram of the Methanol Extract of Infested Old Apple Trees Trunk Wood:

The chemical compounds present in the methanol extracts of trunk wood from infested old apple trees were identified by GC-MS analysis resulting in the presence of 16 chemical compounds with the retention time ranging from 2.08 to 33.28 minutes as shown in (Table 7). The identified compounds were, 12-Methyl-E,E-2,13-octadecadien-1–ol (0.85%),12,15-Octadecadiynoic acid, methyl ester (0.22%), 9,12-Octadecadienoyl chloride,(Z,Z)- (0.08%), Dodecanoic acid, 3-hydroxy (1.95%), 2-Aminoethanethiol hydrogen sulfate (ester) (0.24%), Dodecanoic acid, 3-hydroxy- (1.21%), Phenol, 2,4-bis(1,1-dimethylethyl) (5.97%), 9-Hexadecenoic acid (16.93%), 9-Octadecenoic acid (Z)- (Oleic acid) (42.87%), Z-(13,14-Epoxy) tetradec-11-en-1-o l acetate (2.59%), 7-Methyl-Z-tetradecen-1-ol acetate (0.24%),1-Heptatriacotanol (7.33%), Hexadecadienoic acid, methyl ester (4.80%), Ethyl iso-allocholate (10.19%), Tetraneurin - A- diol (4.01%) and Alanine, 3-(benzyloxy)-, L- (0.50%).

Table (5). Major chemical components identified from trunk wood of uninfested young apple trees

RT 1	Compound Name	Area %	Molecular Formula	Molecular Weight
2.17	1-Gala-1-ido-octose	0.03	C8H16O8	240
2.84	2,2-Dideutero octadecanal	0.10	C18H34D2O	270
3.37	2-pentanone,4-hydroxy-4-methyl-	2.43	C6H12O2	116
5.50	5-Cyclopropylcarbonyloxypentadecane	0.03	C19H36O2	296
5.61	N-2,4-Dnp-L-arginine	0.02	C12H16N6O6	340
5.82	Benzenemethanol, à-(1-aminoethyl)-	0.03	C9H13NO	151
11.92	[1,1'-Bicyclopropyl]-2-octanoic acid, 2'-hexyl-, methyl ester	0.01	C21H38O2	322
12.16	Dodecanoic acid, 3-hydroxy-	0.10	C12H24O3	216
14.33	2-Aminoethanethiol hydrogen sulfate (ester)	0.24	C2H7NO3S2	157
16.59	Z-8-Methyl-9-tetradecenoic acid	0.05	C15H28O2	240
26.31	9-Hexadecenoic acid	14.83	C16H30O2	254
26.64	9-Octadecenoic acid (Z)- (Oleic acid)	31.42	C18H34O2	282
27.06	Oxiranecarboxamide,2-ethyl-3-propyl-	6.58	C8H15NO2	157
27.55	Z-(13,14-Epoxy)tetradec-11-en-1-o l acetate	9.96	C16H28O3	268
28.33	7-Methyl-Z-tetradecen-1-ol acetate	2.35	C17H32O2	268
30.21	1-Heptatriacotanol	11.87	C37H76O	536
30.68	Ethyl iso-allocholate	5.37	C26H44O5	436
31.15	2-Hydroxy-3-[(9E)-9-octad ecenoyloxy]propyl(9E)-9-octadecenoate #	6.04	C39H72O5	620
32.16	Tetraneurin - A- diol	5.31	C15H20O5	280
33.33	Alanine, 3-(benzyloxy)-, L-	3.23	C10H13NO3	195

Table (6). Major chemical components identified from trunk wood of uninfested old apple trees

RT 1	Compound Name	Area %	Molecular Formula	Molecular Weight
3.37	2-Pentanone,4-hydroxy-4-methyl-	9.46	C6H12O2	116
10.18	Benzene, 1,3-bis(1,1-dimethylethyl)	0.37	C14H22	190
17.98	2,4-Bis(1,1-Dimethylethyl)Phenol	1.81	C14H22O	206
21.0 8	13,16-Octadecadiynoic acid, methyl ester	1.33	C19H36O2	296
22.04	Tetradecanoic acid	14.99	C14H28O2	228
26.29	9-Hexadecenoic acid	5.39	C16H30O2	254
26.74	9-Octadecenoic acid (Z)- (Oleic acid)	7.42	C18H34O2	282
28.42	7-Methyl-Z-tetradecen-1-ol acetate	3.44	C17H32O2	268
29.94	Ethyl iso-allocholate	3.34	C26H44O5	436
30.21	1-Heptatriacotanol	5.20	C37H76O	536
30.81	1,2-benzenedicarboxylic acid, diisooctyl ester	46.73	C24H38O4	390
31.00	Alanine, 3-(benzyloxy)-, L-	0.52	C26H44O5	195

Table (7). Major chemical components identified from trunk wood of infested old apple trees

RT 1	Compound Name	Area %	Molecular Formula	Molecular Weight
2.08	12-Methyl-E,E-2,13-octadecadien-1 –ol	0.85	C19H36O	280
3.43	12,15-Octadecadiynoic acid, methyl ester	0.22	C19H30O2	290
7.48	9,12-Octadecadienoyl chloride,(Z,Z)-	0.08	C18H31ClO	298
12.98	Dodecanoic acid, 3-hydroxy	1.95	C12H24O3	216
14.87	2-Aminoethanethiol hydrogen sulfate (ester)	0.24	C2H7NO3S2	157
15.44	Dodecanoic acid, 3-hydroxy-	1.21	C12H24O3	216
17.98	Phenol, 2,4-bis(1,1-dimethylethyl)	5.97	C14H22O	206
26.24	9-Hexadecenoic acid	16.93	C16H30O2	254
26.53	9-Octadecenoic acid (Z)- (Oleic acid)	42.87	C18H34O2	282
27.51	Z-(13,14-Epoxy)tetradec-11-en-1-o l acetate	2.59	C16H28O3	268
28.46	7-Methyl-Z-tetradecen-1-ol acetate	0.24	C17H32O2	268
30.47	1-Heptatriacotanol	7.33	C37H76O	536
30.53	Hexadecadienoic acid, methyl ester	4.80	C19H36O	280
30.74	Ethyl iso-allocholate	10.19	C26H44O5	436
32.19	Tetraneurin - A- diol	4.01	C15H20O5	280
33..28	Alanine, 3-(benzyloxy)-, L-	0.50	C26H44O5	195

According to the available Knowledge, this study is the first in Egypt interested in the interaction between *Sy. myopaeformis* and apple trees. Previous ecological studies on *Sy. myopaeformis* Borkh (Batt & Abd El-Raheem, 2017), detected that the young apple trees (less than 4 years old) were not infested by the apple clearwing moth, however, the old trees (15-20 years old) were heavily attacked. These observations are consistent with (Brunner 1915, Kinawy 1981, Johnson 1993).

The differences in the principle chemical compositions of infested and uninfested apple trees wood considering, the tree age, led us to predict that these variations can be the key reason for being attacked by the apple clearwing moth or not. This prediction is supported by the view of (Schultz 1988) who mentioned that Plant chemistry changes with plants maturity, Nykänen & Koricheva (2004) who pointed out that changes in woody plants chemicals occur as a result of insects injury, also the damage in the early season caused more changes in plant chemicals than late-season damage, thus, the time of injury is an important factor in determining the response of the plant to the feeding by insects. Similar observation on fig trees was obtained by Kinawy (1981) who reported that the chemical composition varied according to the age of fig trees as the total phenols were found to be less in old fig trees than the young ones.

The analysis results showed differences in both Chemical composition and in the percentages of compounds in the different wood samples for the infested old trees, uninfested old trees and the resistant young trees. We confined our emphasis to the chemical components presented at high concentration and which have previous references as a bioactive components against insects (Table 8). 9-Octadecenoic acid (Oleic acid), 9-Hexadecanic acid, Ethyl iso-allocholate, 1,2-Benzenedicarboxylic acid, diisooctyl ester and Tetradecanoic acid were the most important chemical components identified from infested and uninfested old trees, and uninfested young trees.

The infested old trees showed high levels of these chemical compounds compared to uninfested ones as the percentages of 9-Octadecenoic acid (Oleic acid), 9-Hexadecanoic acid and Ethyl iso-allocholate increased by 5.8 fold, 3.1 fold and 3.1 fold respectively, (Table 8). In comparison with the infested old trees, the levels of these chemical compounds in the uninfested old trees were found in lower concentrations (maybe natural levels) as they were 7.42% for 9-Octadecenoic acid (Oleic acid), 5.39% for9-Hexadecanoic acid and 3.34% for Ethyl iso-allocholate. The presence of these chemical components at their natural rates in uninfested old trees may not be sufficient to protect trees from injury and this is what drives the trees to produce two new and exclusive chemical components in high level, Tetradecanoic acid (14.99%) and 1,2-Benzenedicarboxylic acid, diisooctyl ester (46.73%) to make the apple trees unfavorable for the apple clearwing moth feeding and thus the apple trees are not attacked. These changes in apple trees phytochemicals may explain the role of these chemical compounds in the self-defence mechanism against the apple clearwing moth attack, as these bioactive plant defense compounds may cause toxicity or repel the attacking insects, Wink (2006) and Fürstenberg-Hägg *et al.* (2013).

Our interpretation is that the increased production of such chemical components may be due to the feeding of the apple clearwing moth larvae, the results indicated by Suckling et al. (2012) prove our interpretation as he found that the apple seedlings infested with the herbivore *Epiphyas postvittana* larvae produced larger amounts of chemical components than uninfested ones. Additionally, the obtained results are consistent with the view of Lämke & Unsicker (2018) who stated that feeding by insects represents stress for the attacked trees, and therefore induce the trees to increase the concentration of phytochemicals, which has a role in self-defence. On the same approach, Inbar *et al.* (1999), Bernays & chapman (1994) and Traw & Dawson (2002) mentioned that herbivore feeding can induce the plant to increase its chemical defences or decrease its nutritional quality which leads to reduced performance of herbivores. Moreover, Marquis et al. (2001) and Poorter *et al.* (2004) assumed that morphological and phytochemical plant traits are the main reason for the intensity of herbivore damage to its host plants.

Regarding the chemical composition content of the uninfested young trees (resistant), the levels of 9-Octadecenoic acid (Oleic acid), 9-Hexadecanoic acid and Ethyl iso-allocholate were found at higher rates than the uninfested old trees (Table 8), as they were 31.42%, 14.83% and 5.37% respectively. This is evidence that the young trees naturally contain a high level of such chemical components that protect them from the apple clearwing moth attacking.

The results also showed that young apple trees, containing many chemical compounds at relatively high portion such as 2-Pentanone,4-hydroxy-4-methyl-(2.43%), Oxiranecarboxamide,2-ethyl-3-propyl- (6.58%),Z-(13,14-Epoxy)tetradec-11-en-1-ol acetate (9.96%), 7-Methyl-Z-tetradecen-1-ol acetate (2.35%), 1-Heptatriacotanol (11.87%), 2-Hydroxy-3-[(9e)-9-octadecenoyloxy]propyl(9e)-9-octadecenoate (6.04%), Tetraneurin - a-diol (5.31%) and Alanine, 3-(benzyloxy) - , l- (3.23%). We expect that such compounds may have a role in preventing apple trees from infestation by the apple clearwing moth, (Table 5).

In accordance with the previous findings, this part of the research has helped to illustrate some of the principal characteristics of constitutive defenses of apple trees against the apple clearwing moth. Yet, the full information on the mechanisms behind the evolution of apple trees defense is still limited, and further studies are needed to reach new facts in the development of apple trees defense against the apple clearwing moth, which could be used to develop new approaches in the future for apple orchards protection and improvement of apple crop production.

Table (8). The proportions and biological activity of the most important chemical components identified in methanol extract from wood of old trees (infested and uninfested) and resistant young trees.

Compound name	Old tree			Young tree	Biological activity (previous studies)
	Infested	Uninfested	Increasing ratio	resistance	
9-Hexadecenoic acid	16.93%	5.39%	3.1	14.83%	**Pesticide and larvicide** [Abdul Rahuman et al.(2000), Rajalakshmi & Mohan (2016), Abubakar & Majinda (2016), Kumar et al.(2010), Kala & Ammani (2017), Sharma et al.(2018) and Ahmed et al.(2018)]
9-Octadecenoic acid (Z)-	42.87%	7.42%	5.8	31.42%	Pesticide and insectfuge [Rajalakshmi & Mohan (2016), Chandrasekaran et al.(2011), Salem et al.(2016), Sharma et al.(2018)]
Ethyl iso-allocholate	10.19%	3.34%	3.1	5.37%	Pesticide [Saravanan et al.(2014)]
Tetradecanoic acid	0.00%	14.99%	-	0.00%	larvicidal and repellent activity [Gomathy & Rathinam (2017), Sharma et al.(2018) and Duke & Duke's, (1992)]
1,2-benzenedicarboxylic acid, diisooctyl ester	0.00%	46.73%	-	0.00%	Pesticide [Khalil et al.(2014)]

REFERENCES

Abdel-Azim MM (1997) Survey and control of some fruit tree borers by pheromones in Egypt. MSc, faculty of Science, Cairo University Egypt, 233 pp.

Abd El-Kader S and Zaklama S (1961) The Chemical and Mechanical Control of inner Stages of *Zeuzera pyrina* L. The First Arabic Conference of Horticulture 16th, April, 1961, Cairo, Egypt (1):20-23.

Abd-El-Kader S and Zaklama S (1971) The chemical control of the apple clearwing moth, *Synanthedon myopaeformis* Borkh. (Lepidoptera: Aegeriidae). Agri Res Rev 49 (1):71-76.

Abd El-Moaty RM, Hashim SM, Tadros AW (2013) Evaluation of some alternative control methods of wasp beetle, *Chlorophorus varius* mull. (Coleoptera: Cerambycidae) in mango orchards in Egypt. J Plant Prot and Pathol, Mansoura Uni 4 (2): 189 – 198.

Abdul Rahuman A, Gopalakrishnan G, Ghouse BS, Arumugam S, Himalayan B (2000) Effect of Feronia Limonia on mosquito larvae. Fitoterapia, 71:553-5. DOI: 10.1016/S0367-326X(00)00164-7

Abubakar MN and Majinda RRT (2016) GC-MS Analysis and Preliminary Antimicrobial Activity of Albizia adianthifolia (Schumach) and Pterocarpus angolensis (DC). Medicines 28,3(1). https://doi.org/10.3390/medicines3010003

Ahmed BE, Badawi H, Mostafa S and Higazy AM (2018) Human Anticancers and Antidiabetic Activities of the Cyanobacterium *Fischerella* sp. BS1-EG Isolated from River Nile, Egypt. Inter J Current Microbiol and Appl Sci 7(1): 3473-3485. https://doi.org/10.20546/ijcmas.2018.701.409

Al-Antary T, Ateyyat M , Al-Rafae A (2004) Clearwing borer in apple orchards in Ash-Shoubak. Al Mohandes Al-Ziraie 78: 49 – 51.

Anonymous (1999a) Integrated Pest Management for Apples and Pears. Second Edition. University of California, Agriculture and Natural Resources Publication: 3340, California, USA.

Ateyyat MA (2005) 'Efficacy of Some Insecticides Against the Small Red Belted Clearwing Borer, *Synanthedon myopaeformis* (Borkh.) (Lepidoptera: Sesiidae), in Apple Orchards in Jordan', Communi in Agril App Biol Sci 70, 759_765.

Ateyyat MA (2006) 'Effect of Three Apple Rootsocks on the Population of the Small Red-Belted Clearwing Borer, *Synanthedon myopaeformis*'. J Insect Sci 6, 40.

Aurelian VM (2011). Semiochemical-based mass trapping of the apple clearwing moth (*Synanthedon myopaeformis* (Borkhausen)) (Lepidoptera: Sesiidae). MSc thesis Edmonton, Alberta, Department of Biological Sciences, 222pp.

Awadallah AM, El-Nahal AKM, Ismail II, Zaklama SF, Tadros AW (1978). Seasonal fluctuation in population of the clearwing moth, *Synanthedon myopaeformis* Borkh. (Lepidoptera: Sesiidae) under field conditions. Agricul Res Rev 56(1):71-81.

Baldwin IT (2010) Plant volatiles. Current Biol 20, 392–397. https://doi.org/10.1016/j.cub.2010.02.052

Batt MA (2002) Studies on some coleopterous borers infesting fruit and wood trees. M.Sc. thesis, Faculty of Agriculture, Menoufia University, Egypt, 188 pp.

Batt MA (2008).Studies on certain factors affecting the infestation of trees with some wood borers. Ph.D. Thesis, Faculty of Agriculture, Menoufia University, Egypt, 176pp.

Batt MA and Abd El-Raheem AM (2017) Ecological Studies on the Apple Clearwing Moth *Synanthedon myopaeformis* Borkh. (Lepidoptera: Sesiidae) in Apple Orchards at Menoufia Governorate, Egypt. J Plant Protec and Pathol, Mansoura Uni 8 (3), 101–105.

Becerra JX (1997). Insects on plants: Macroevolutionary chemical trends in host use. Science, 276(5310):253–256.

Bergh JC, Leskey TC (2003) Biology, ecology and management of dogwood borer in eastern apple orchards. Canad entomol 135:615- 635. https://doi.org/10.4039/n02-089

Bernays EA and Chapman RF (1994) Host-plant selection by phytophagous insects. Chapman and Hall, Inc., New York, USA. https://doi.org/10.1093/ee/24.6.1754

Blommers LHM (1994) Integrated pest management in European apple orchards. Ann Rev Entomol 39 (1): 213-241.https://www.annualreviews.org/doi/abs/10.1146/ annurev.en. 39.010194.001241

Brown MW, Mathews CR, Krawczy kG (2008) Analyzing the results of biodiversity experiments: enhancing parasitism of tufted apple budmoth, in: Proc. 7th IOBC International Conference on Integrated Fruit Production (Book of Abstracts), Avignon, October 28–30, 6p.

Bruce TJA, Wadhams LJ, Woodcock CM (2005) Insect host location: a volatile situation. Trends in Plant Sci 6, 269-274.https://doi.org/10.1016/j.tplants.2005.04.003

Bruinsma M and Dicke M (2008) Herbivore-induced indirect defence: from induction mechanisms to community ecology. Induced Plant Resistance to Herbivory (ed. by A

Schaller), pp. 31–60. Springer, Berlin, Germany. https://link.springer.com/ chapter/ 10.1007/978-1-4020-8182-8_2

Brunner J (1915) The Zimmerman pine moth. (*Pinipestis zimmermani* Grote). Bureau Entomol United States Agri Dept 295.

Chandrasekaran M, Senthilkumar A, Venkatesalu V (2011) Antibacterial and antifungal efficacy of fatty acid methyl esters from the leaves of *Sesuvium portulacastrum* L. Europ Rev for Med Pharmacol Sci 15:775- 80. https://www.europeanreview. org/wp/ wp-content/uploads/995.pdf

Cornell HV and Hawkins BA (2003) Herbivore Responses to Plant Secondary Compounds: A Test of Phytochemical Coevolution Theory. The American naturalist, 161 (4): 507–522. DOI: 10.1086/368346

Davies NW (1990) Gas chromatographic retention indices of monoterpenes and sesquiterpenes on methyl silicone and Carbowax 20 M phases. J Chromatogr A 503:1–24 (British Pharmacopeia 1998, Vol. II, HMSO, London)

Derksen SJ (2006) Semiochemical- Mediated Oviposition behavior by peach tree borer, *Synanthedon exitiosa* (Lepidoptera: sesiidae). MSc., Simon Fraser University, 35pp.

Dicke M (2009) Behavioural and community ecology of plants that cry for help. Plant, Cell Environ 32: 654–665. https://doi.org/10.1111/j.1365-3040.2008.01913.x

Duke JA and Duke's Dr (1992) Phytochemical and Ethnobotanical Database. Phytochemical Database. Beltsville, Meryland: USDA-ARS-NGRL, Beltsville Agricultural Research Center. http://dx.doi.org/10.15482/USDA.ADC/1239279

Duncan A and Magalhães S. (2017) The medicinal value of phytochemicals is hindered by pathogen evolution of resistance. Peer Comm Evolut Biol 100007. 10.24072/pci. evolbiol.100007

Dyer LA, Letourneau DK, Dodson CD, Tobler MA, Stireman JO, Hsu A (2004) Ecological causes and consequences of variation in defensive chemistry of a neotropical shrub. Ecology, 85(10):2795–2803. doi.org/10.1890/03-0233

Eby C, Gardiner MGT, Gries R, Judd GJR, Khaskin G, Gries G (2013) Phenylacetaldehyde attracts male and female apple clearwing moths, *Synanthedon myopaeformis*, to inflorescences of showy milkweed, *Asclepias speciose*. The Netherlands Entomol Soci Entomol Experimen et Appl 147: 82–92. https://doi.org/10.1111/eea.12045

El-Sayed AM, Heppelthwaite VJ, Manning LM, Gibb AR, Suckling DM (2005) Volatile constituents of fermented sugar baits and their attraction to lepidopteran species. J Agril Food Chem 53: 953–958. DOI: 10.1021/jf048521j

Ferree DC and Warrington IJ (2003) Apples: botany, production and uses. CABI publishing. DOI:10.1079/9780851995922.0000

Fürstenberg-Hägg J, Zagrobelny M, Bak S (2013) Plant Defense against Insect Herbivores. Inter J Molec Sci 14, 10242-10297. https://doi.org/10.3390/ijms140510242

Girgis GN (1987) Studies on some Scolytidae in Egypt (Coleoptera : Scolytidae). Ph.D. Thesis, Faculty of Agriculture, Menoufia University, Shibin El- Kom, 144 pp.

Girgis GN, Batt AM, Haggag SM, Okil AM (1995) Ecological studies on *Zeuzera pyrina* L. and *Synanthedon myopaeformis* Brokh. on apple and plum trees in Egypt. Egyp j of appl sci 10 (9): 304-318.

Gomathy S and Rathinam KM (2017) Identification of insecticidal compounds in *Terminalia arjuna* bark extract using gas chromatography and mass spectroscopic technique. Inter J Entomol Res 2 (6): 108-112.

Guoqing L, Zhaogun H, Lili M, Xiaoran Q, Changkun G, Yinchang W (2001) Natural oviposition-deterring chemicals from female cotton bollworm, *Helicoverpa armigera* (Hübner). J Insect Physiol 47: 951-956.https://doi.org/10.1016/S0022-1910(01)00051-8

Hegazi EM, Khafagi WE, Konstantopouulou MA, Schlyter F, Raptopoulos D, Showeil IS, Abd El-Rahman S, Atwa A, Ali SE, Tawfik H (2010) Suppression of Leopard moth (Lepidoptera: Cossidae) populations in olive trees in Egypt through mating disruption. J Econ Entomol 103 (5), 1621-1627. https://doi.org/10.1603/EC09435

Hegazi EM, Schlyter F, Khafagi WE, Atwa A, Agamy E, Konstantopoulou M (2014) Population dynamics and economic losses caused by *Zeuzera pyrina*, a cryptic wood-borer moth, in an olive orchard in Egypt. Agri Forest Entomol 17: 9-19. https://doi.org/10.1111/afe.12075

Himanen SJ, Li T, Blande JD, and Holopainen JK (2017) Volatile organic compounds in integrated pest management of *Brassica* oilseed crops. in: Reddy, G.V.P. (Ed.) Integrated management of insect pests on canola and other *Brassica* oilseed crops. CABI Publishing, UK. pp. 281-294.

Inbar M, Doostdar H, Leibee GL, Mayer RT (1999) The role of plant rapidly induced responses in asymmetric interspecific interactions among insect herbivores. J Chem Ecolo 25, 1961–197910. doi:10.1023/A:1020998219928

Jeffrey PS (1991) Phytochemicals at the plant-insect interface. Insect biochem physiol, 17 (4): 191-200. https://doi.org/10.1002/arch.940170403

Johnson JM (1993) Flight, emergence, and oviposition patterns of the Douglas-fir pitch moth, *Synanthedon novaroensis* (Hy. Edwards) (Lepidoptera: Sesiidae), in Western Washington. M.sc. thesis, University of Washington, Seattle, Wa. 56 pp.

Joo Y, Schuman MC, Goldberg JK, Kim SG, Yon F, Brütting C, Baldwin IT (2017). Herbivore-induced volatile blends with both "fast" and "slow" components provide robust indirect defence in nature. Func Ecol 1–14. https://doi.org/10.1111/1365-2435.12947

Jordan MD, Anderson A, Begum D, Carraher C, Authier A, Marshall SDG, Kiely A,Gatehouse LN, Greenwood DR, Christie DL, Kralicek AV, Trowell SC, Newcomb RD (2009) Odorant receptors from the light brown apple moth (Epiphyas: postvittana) recognize important volatile compounds produced by plants. Chem Senses 34: 383–394. https://doi.org/10.1093/chemse/bjp010

Kain DP and Straub RW (2001) Status of borer infesting apple burr Knot and their management in New York orchards. New York Fruit Quarterly, 9: 10-12.

Kala S C and Ammani K (2017) GC–MS analysis of biologically active compounds in Canthium parviflorum Lam. leaf and callus extracts. Inter J ChemTech Res 10(6): 1039-1058.

Kaplan I and Lewis D (2015) What happens when crops are turned on? Simulating constitutive volatiles for tritrophic pest suppression across an agricultural landscape. Pest Manag Sci 71: 139–150. https://doi.org/10.1002/ps.3779

Karaca G, Karaca I, Yardimci N, Demirözer O, Aslan B, Kiliç HC (2010) Investigations on pests, diseases and present early warning system of apple orchards in Isparta, Turkey. Afri J Biotech 9(6), 834-841. https://doi.org/10.5897/AJB09.1625

Khalil NM, Shalaby EA, Ali DM, Ali EM, Aboul-Enein AM (2014) Biological activities of secondary metabolites from *Emericella nidulans* EGCU 312. Afri j Microbiol Res 8 (20):2011-2021. https://doi.org/10.5897/AJMR2014.6827

Kinawy MM (1981) Studies on orrtain fig tree borers in A.R.E. Ph.D. Thesis, Faculty of Agriculture, Cairo University, Cairo, Egypt, 218pp.

Knudsen GK, Bengtsson M, Kobro S, Jaastad G, Hofsvang T, Witzgall P (2008) Discrepancy in laboratory and field attraction of apple fruit moth Argyresthia conjugella to host plant volatiles. Physiol Entomol 33: 1–6. https://doi.org/10.1111/j.1365-3032.2007.00592.x

Kumar PP, Kumaravel S, Lalitha C (2010) Screening of antioxidant activity, total phenolics and GC-MS study of Vitex negundo. Afri j Biochem Res 4, 191–195.

Kursar TA, Kyle GD, John LR, Toby P, James ER, Marjorie GW, Eric TM, Camilla D, Ruth

MG, Phyllis DC (2009) The evolution of antiherbivore defenses and their contribution to species coexistence in the tropical tree genus Inga. Proceedings of the National Academy of Sciences of the United States of America 106(43):18073–18078. https://doi.org/10.1073/pnas.0904786106

Lämke JS, Unsicker SB (2018) Phytochemical variation in treetops: causes and consequences for tree-insect herbivore interactions. Oecologia, 187, (2): 377–388. DOI:10.1007/s00442-018-4087-5

Lankau RA (2007) Specialist and generalist herbivores exert opposing selection on a chemical defense. New Phytologist 175(1):176–184. https://doi.org/10.1111/j.1469-8137.2007.02090.x

Mark DH and Jack CS (1993) Induced Plant Defenses Breached? Phytochemical Induction Protects an Herbivore from Disease. Oecologia, 94 (2): 195-203. https://link.springer.com/article/10.1007/BF00341317

Marquis RJ, Diniz IR, Morais HC (2001) Patterns and correlates of interspecific variation in foliar insect herbivory and pathogen attack in Brazilian cerrado. J Trop Ecol 17, 127–148. DOI: 10.1017/S0266467401001080

Nykänen H and Koricheva J (2004) Damage-induced changes in woody plants and their effects on insect herbivore performance: a metaanalysis. Oikos, 104:247–268. https://doi.org/10.1111/j.0030-1299.2004.12768.x

Pfammatter W, Vuignier R (1998) Amélioration de la lutte biologique dans les cultures fruitières au moyen de bandes de plantes sauvages, in : 1er Colloque transnational sur les luttes biologique, intégrée et raisonnée, Lille, January 21–23, 1998, Région Nord-Pas-de-Calais, Lille, France, pp. 71–72 (in French).

Poorter L, Plassche MV, Willems S and Boot RGA (2004) Leaf traits and herbivory rates of tropical tree species differing in successional status. Plant Biol 6, 746–754. https://doi.org/10.1055/s-2004-821269

Rajalakshmi K and Mohan VR (2016) GC-MS Analysis of Bioactive Components of *Myxopyrum serratulum* A.W. Hill (Oleaceae). Inter J Pharma Sci Rev Res38(1): 30-35.

Salem MZM, Zayed MZ, Ali HM and Abd El-Kareem MSM (2016) Chemical composition, antioxidant and antibacterial activities of extracts from *Schinus molle* wood branch growing in Egypt. J Wood Sci 62:548–56. https://link.springer.com/article/ 10.1007/s10086-016-1583-2

Saravanan P, Chandramohan G, Mariajancyrani J and Shanmugasundaram P (2014) GC-MS Analysis of Phytochemical Constituents In ethanolic Bark Extract of *Ficus Religiosa* Linn. Inter J Pharm Pharma Sci 6(1): 457-460.

Schultz JC (1988) Many factors influence the evolution of herbivore diets, but plant chemistry is central. Ecology 69, 896- 897. https://doi.org/10.2307/1941239

Schuman MC, and Baldwin IT (2016) The layers of plant responses to insect herbivores. Ann Rev Entomol 61, 373–394. https://doi.org/10.1146/annurev-ento-010715-023851

Schuman MC, Allmann S and Baldwin IT (2015) Plant defense phenotypes determine the consequences of volatile emission for individuals and neighbors. eLife, 4, 1–43. doi: 10.7554/eLife.04490

Sharma D, Rani R, Chaturved M, Yadav JP (2018) Anibacterial Efficacy and Gas Chromatography-Mass Spectrometery Analysis of Bioactive Compounds Present In Different Extracts of *Allium Sativum*. Asian J Pharma Clin Res 11(4): 280-286. DOI: http://dx.doi.org/10.22159/ajpcr.2018.v11i4.24053

Shehata WA, Naser FN, Tadros AW (1999) Application of some bacterial varieties of *Bacillus thuringiensis* and bioproduct Delfin on *Synanthedon myopaeformis* Borkh (Lep., Aegeriidae) in apple orchards. Anzeiger fur Schadlingskunde. J Pest Sci 72 (5): 129-132.

Simon S, Bouvier J, Debras J, Sauphanor B (2010) Biodiversity and pest management in orchard systems. A review. Agronomy for Sustainable Development, Springer, 30: 139–152. https://link.springer.com/article/10.1051/agro/2009013

SAS institute (2001). Version 8.02.SAS Institute, Cary, N C.

Suckling DM, Twidle AM, Gibb AR, Manning LM, Mitchell VJ, Sullivan TES, Wee SL, El-Sayed AM (2012) Volatiles from Apple Trees Infested with Light Brown Apple Moth Larvae Attract the Parasitoid *Dolichogenidia tasmanica*. J Agri Food Chem 60 (38), 9562-9566. 10.1021/jf302874g

Tadros AW (1993) Tree borer sex pheromones: (5) New omni-directional sticky and funnel-like trap designated for *Synanthedon myopaeformis* and other insects in Egypt. Inter J Pest Manag London. United Kingdom.

Tadros AW (1994a) Monitoring the population of the shot hole bark beetles *Scollytus amygdali* Guer.(Coleoptera: scolytidae) on peach with special reference to its hosts in Egypt. Egyp J Agri Res72(1):91-102.

Tadros AW (1994b) Tree borer sex pheromones: (1) Attraction of male *Synanthedon myopaeformis* to blends of (Z, Z) and (Z, E) isomers of 3, 13-ODDA. Egyp J Agri Res 72(3):699-705.

Tadros AW, Amina MA bdel-Rahaman, Abdel-Moaty RM (2003) Rearing fruit tree borers in their nature hosts and artificial medium diets (2) *Synanthedon myopaeformis*, Borkh (Lepidoptera: Aegeriidae). Egyp J Agri Res 81(4):1535-1548.

Tertyshny AS (1995) Apple, Plum and Black Current Control from Pests Using Ecologically Safety Technologies, ISHS Acta Horticulturae, 422. www.actahort.org/ books/422/422 63.htm

Traw MB, Dawson TE (2002) Reduced performance of two specialist herbivores (Lepidoptera: Pieridae, Coleoptera: Chrysomelidae) on new leaves of damaged black mustard plants. Environl Entomol 31, 714–722. doi:10.1603/0046-225X-31.4.714)

Vijayabaskar G and Elango V (2018) Determination of phytocompounds in *Withania somnifera* and *Smilax china* using GC-MS technique. J Pharma & Phytochem 7(6): 554-557.

Wiley NIST (2008) The Wiley/NBS registry of mass spectral data, 8th edn. Wiley, New York.

Willcocks FC (1924) A survey of the important economic insects and mites of Egypt with notes on life history, habits, natural enemies and suggestion for control. Bull Sult Agri Soc Technol Sec.II:482pp.

Wink M (2006) Importance of plant secondary metabolites for protection against insects and microbial infections. In: Rai M, Carpinella MC, editors. Naturally occurring bioactive compounds. Advances in phytomedicine 3:251-268. https://doi.org/10.1016/S1572-557X(06)03011-X

Young H, Gilbert JM, Murray SH and Ball RD (1996) Causal effects of aroma compounds on Royal Gala apple flavours. J Sci Food Agri 71: 329–336.https://doi.org/10.1002/(SICI)1097-0010(199607)71:3<329::AID-JSFA588>3.0. CO, 2-8