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Kairomone and Synomone Mediating Cowpea Aphid, *Aphis Craccivora* Location by some Natural Enemies

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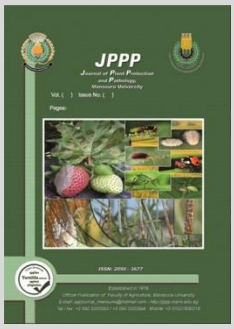

ABSTRACT

The behavior response of the parasitoid females (*Diaeretiella rapae* and *Aphidius* sp) and the aphidophagous predators (*Hippodamia variegata, Coccinella undecimpunctata* and *Cheilomenes vicina isis* (Crotch, 1874) in response to kairomone extracts of *Aphis craccivora* bodies in the three different solvents (ethyl alcohol, petroleum ether and acetone) was evaluated. The tested parasitoids and predators showed different in their response to kairomone extracts of the aphid, depending on the solvent used and the tested species. Both parasitoids and the predator, *H. variegata* exhibited positive response to kairomone extracts by using ethyl alcohol and petroleum ether in comparison with acetone. Acetone approved to be the best solvents to *C.undecimpunctata*, while ethyl alcohol extract elicited positive response to *Che. vicina isis*. Suggested that sensitivity of olfactory chemoreceptors differ according to solvent used and predator species. Volatile components in ethyl alcohol extract of *A.craccivora* were identified by gas chromatography/mass spectrometry (GC/MS). The main volatile components of *A.craccivora* extract are undecane, dodecane, tridecane, tetradecane, nonadecane, pentadecane, hexadecane, heneicosane, heptadecane, docosane and tricosane. Broad bean plants, attacked by *A.craccivora* release volatile chemical signals not only at the damaged site but from the entire plants, that attract the coccinellid predators (*H. variegate, C. undecimpunctata* and *Che. vicina isis*). Volatiles stimulated egg laying behavior by *H. variegate.* The release of chemical volatiles was detected from upper, undamaged leaves after 3 days of continuous nympha1 feeding on lower leaves of the same plant. The released volatiles are D-Limonene, 1,3,6-Octatriene,3,7-Dimethyl and 2-(1H-indol-3-yl) acetaldehyde. So, these allelochemicals could be used to manipulate natural enemies to enhance ovipositional behavior on infested plants with aphid in the field.

Keywords: Kairomone, synomone, *Aphis craccivora*, *Diaeretiella rapae*, *Aphidius* sp., *Hippodamia variegata*, *Coccinella undecimpunctata*. *Cheilomenes vicina isis.*

INTRODUCTION

Aphis craccivora (Hemiptera: Aphididae) one of the most economically important pests in agriculture. Aphid feeding significantly reduced legumins plant dry weights, it may infest flowers and pods (Laamari *et al*., 2008, Berberet *et al*.,2009, Kusi, 2010 and Hawkins *et al.*, 2011). It is an efficient virus vector, (Kitajima *et al*., 2008).

Natural enemies have a significant part in biological control of aphids, and conservation biology have been developed well with indigenous natural enemies. (Aquilino *et al*., 2005 and Vidal and Murphy, 2018). The parasitoids, *Diaeretiella rapae* and *Aphidius* sp. (Hatano *et al.*, 2008 and Ali, 2014) and the predators *Hippodamia variegata*, *Coccinella undecimpunctata* and *Cheilomenes vicina isis* (Crotch, 1874) (= *Cydonia vicina isis*) are important natural enemies of several aphids in many agro-ecosystems (El-Hag and Zaitoon, 1996 and Jafari, 2011 and El-Saeady *et al*., 2020). The foraging behavior of natural enemies is a process of searching for suitable sites for egg laying and feeding sources for ensuring their survival (Kramer, 2001and Webster and Cardé 2017).

Allelochemicals are signals mediate interactions between organisms of different species, olfactory communication has a key role to play in process of predator-prey interaction (Foster and Harris, 1997). Kairomones have a significant impact in almost all stages of prey search and selection (Sheikh *et al*., 2017). Kairomones effectiveness used to enhance strategies of biological control in environmentally safe way via more natural enemies attracted, decreasing populations of pests and crop damage (Ayelo *et al*., 2021). Plants respond to herbivore feeding or oviposition by producing mixtures of volatiles (synomones). Natural enemies of plant-feeding insects use these volatiles as signals to find their prey or host (Takabayashi and Dicke, 1996). Chemical ecology interested with the study of the interactions of organisms with their environment that are mediated by the chemicals they produce. Joo *et al*., (2017) demonstrated that plants emit volatile cues specific to herbivore interactions, which natural enemies learn to associate with prey, increasing pest mortality and thereby plant fitness. Recent progress in the chemical ecology has created new chances to improve our understanding of aphid-natural enemy interactions in the future (Hantano *et al*., 2008). According to Riddick (2020) more research is required for using chemical signals to manipulate natural enemies searching behavior under field conditions. Therefore, the present study aimed to study influence of aphid bodies extract on the searching behavior of some aphidophagous species, and influence of host smell plant infested with *A. craccivora* on the behavior response of their natural enemies.

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MATERIALS AND METHODS

1- Influence of cowpea aphid, *Aphis craccivora* extracts: On the behavior response of the braconid parasitoids, *Diaeretiella rapae* (Maclntosh) and *Aphidius* sp.

i) Source of the aphid and the parasitoids, *D. rapae* and *Aphidius* sp.: Infested plants with the cowpea aphid, *A. craccivora* were collected from cultivated broad bean fields located at the Experimental Research station of the Faculty of Agriculture, Mansoura University at Mansoura district, Egypt. The aphids present on the collected broad bean plants were gently removed with the help of soft camel hairbrush and colonized in the lab oratory on cultivated broad bean plants under laboratory conditions. The parasitoids, *D. rapae* and *Aphidius sp*. were collected from the host, *A. craccivora* on broad bean leaves. Leaves heavily infested with *A. craccivora* were kept in glass tubes closed by muslin fixed in place by rubber bands until emerging of the adult parasitoids. Newly emerged parasitoid females were collected in glass tubes for kairomonal tests and were provided with honey drops for feeding.

ii) Kairomone extraction: The kairomone of *A. craccivora* nymphs was extracted by immersing nymphs (100 aphid bodies /5ml solvent) during 24 hours in three different solvents (ethyl alcohol, acetone, and petroleum ether). All extracts were stored at -4 ºC for laboratory bioassay.

iii) Bioassay of crude extracts: The responses of parasitoid females, *D. rapae* and *Aphidius* sp. to aphid extracts were evaluated using an experimental olfactometer. The olfactometer consists of a specially constructed Y-tube (Abd El-Kareim *et al*., 2007) which have three branching dark tubes (1.5 cm diameter x 5 cm highest) and exposure chamber attached at the base of tubes (4.0 cm in diameter x 2 cm high) while the top of tubes is closed by plastic cover and its black interior wall was coated by sticky material (Tangle foot). One of tubes cover was coated with 0.25 ml of the extract and a similar quantity of pure solvent was coated in second and third covers. The parasitoids were released inside the exposure chamber and closed immediately. Each treatment was repeated five times by using five individuals of parasitoids /time. Twenty-five minutes after exposure of parasitoids the counts were done. After each trial, the experimental Y-tube was cleaned with ethanol, and distilled water. The parasitoids used in the bioassays were used only once. All solvents were tested individually to determine the best solvent for kairomone extractions of *A. craccivora*.

On the behavior response of the coccinellid predators:

The response of three coccinellid predators (*Hippodamia variegata, Coccinella undecimpunctata*. and *Cheilomenes vicina isis* (Crotch, 1874) to aphid extracts was evaluated.

i) **Source of insect predators:** The ladybeetles, *H. variegate, C. undecimpunctata,* and *Che. vicina isis* were collected from fields at the above-mentioned Experimental farm. They were reared for one generation before their individuals being used in the experimental study.

ii) **Bioassay:** The previously mentioned tube was used to evaluate the reactions of tested predators in response to kairomone extracts of the aphid, *A. craccivora* bodies in the three different solvents. Five nymph equivalents (0.25ml extract) of the kairomone extracts were dispensed on one tube cover and the other covers with similar quantity of pure solvent. The tested predators were released inside the exposure chamber as mentioned above. Each treatment was repeated five times by using five individuals of predators / time.

Identification of allelochemicals (kairomone):

Gas chromatography- Mass spectrometry (GC-MS): The obtained extract analyzed using GC-MS apparatus. Separation was performed on Trace GC Ultra Chromatography (Thermo Scientific, USA), equipped with A3000 autosampler and TG-5MS. The GC used a Capillary column (30 m length, 0.25 mm I.D.) coated with 0.25 µm film thickness. Temperature was programmed from 50˚C - 280˚C at a rate of 10˚C/min. Mass spectrometer in EI mode at 70 eV, source temperature, 200˚C; interface temperature, 220˚C; injector temperature, 220˚C. Diluted sample of 1 µl injected in split less mode and mass scan, 50 - 600 amu. Helium was used as a carrier gas with 1 mL/min flow rate. The components of the extract were identified tentatively by comparing their relative retention times and mass spectra with those of Wiley (Wiley Registry of Mass Spectral Data, 9th Edition Version 1.02) and NIST 05 (NIST/EPA/NIH mass spectral library version 2.0d) mass spectral database. Theoretical Calculations with the associated HyperChem professional 7.5 program was used for the structural investigation of the studied compounds in their ground and charged states-in the gas phase.

2. Influence of *A. craccivora* feeding activity on induction of plant synomone.

i). Insect and plant sources: Cowpea aphid, *A. craccivora* and the predators, *H. variegata, C. undecimpunctata* and *Che. vicina isisi* were collected and colonized in the laboratory as mentioned above.

ii). Bioassay: Groups of broad bean plants were transferred in pots and kept under laboratory conditions. Some of these plants groups were exposed to *A. craccivora*, and another set was free from *A. craccivora* infestation. The leaves of plant infested with *A. craccivora* nymphs were removed and the remaining leaves that had never carried aphids was tested. The predator response to leaves of damaged and undamaged plants by feeding activity of *A. craccivora* were investigated using large Y-tube (Abd El- Kareim *et al*.2011) which consists of three dark branches (3.5 cm diameter x 10 cm height) and an exposure chamber (6.0 cm in diameter x 5.0 cm height). Previously damaged leaves by *A. craccivora* feeding were introduced in one arm of the Y-tube and leaves of the healthy plants inserted into the second arm to test predators however the third one of the Y-tube were odorless (as control). Five females/predator species/time were released within the exposure chamber as mentioned above. Each treatment was repeated five times and counts were done 25 min. after exposure of predators.

Additional bioassay was carried out to test if the induction of volatiles was extended systemically over undamaged leaves of the same plant by using induction chamber (Meiners and Hilker, 2000) after modification (Fig.1). The upper part of five broad bean plants (bearing five leaves/ plant) has been isolated inside a transparent flexible plastic jar (B) with black cover (Fig.1). The lower part of each broad bean plant that carried (5 leaves) offered to *A. craccivora* for feeding in a transparent flexible plastic and

prevented the aphids from contact with the upper part using the plastic jar bottom (C). After of three days, the plant was cut into two pieces and then the upper part was tested for an emission of attractive volatiles in the arm experimental tube. The reaction behavior of *H. variegata* females in response to leaves of the upper part previously damaged and undamaged plants by feeding activity of *A. craccivora* was estimated as mentioned above.

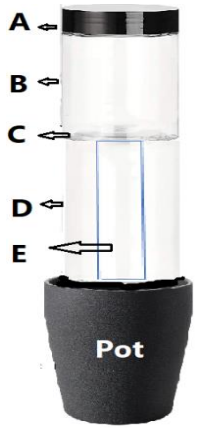

Fig. 1. Modified induction chamber for systemic induction of broad bean leaves. A: The cover of transparent plastic cylinder jar (B); C: The bottom of the jar was cut to allow the passage of the plant and then it was plastered to isolate the upper part of the plant; D:Transparent flexible plastic cylinder surrounding the lower part of test plant. E: entry door for insects.

iii). Identification of allelochemicals (synomone):

To definite the volatile components emitted from infested plants, Confinement / Wash Method (Kataria and Kumar, 2015) was used. About 4-8 upper leaves of damage plants were kept in sterilized conical flask (100ml) which had a Whatman filter paper at its base and was covered with a silver foil. After 24hrs, the broad bean leaves were removed, and the entire surface of the flask was washed and rinsed with little quantities of ethanol. The crude extract was used for identification.

All obtained data analysis was conducted using (F-Test) one-way ANOVA and mean comparison were carried out using L.S.D. at 5%.

RESULTS AND DISCUSSION

Results

1. Influence of *A. craccivora* extracts on the searching behavior of:

The parasitoids, *D. rapae* and *Aphidius* sp.:

Data illustrated in Figure (2) showed the percentage of *D. rapae* and *Aphidius* sp females attracted to kairomone extracts of aphid bodies in three different solvents. Ethyl alcohol followed by petroleum ether extracts of aphid bodies attracted the highest percent of *D. rapae* (80 ± 20 & 64 ±17.88) and *Aphidius* sp. (54±17.88 & 52±21.90) females with no significant differences between the two solvents. Both parasitoids exhibited no response to acetone extract. Generally, ethyl alcohol approved to be the best solvent for kairomone extraction, while the results showed that acetone is not a good solvent for extracting kairomone from *A. craccivora.*

The coccinellid predators (*H variegata, C. undecimpunctata* and *Che. vicina isis*):

The reaction behavior of the tested predators (*H variegata*, *C. undecimpunctata* and *Che. vicina isis*) to kairomone extracts of *A. craccivora* bodies in the three different solvents was evaluated by using the Y- tube method. The obtained results revealed that *H. variegata* was significantly attracted to kairomone extracts in ethyl alcohol or petroleum ether in comparison with acetone (Table, 1). On contrary, eleven-spotted predator, it exhibited positive reaction to acetone extract of *A. craccivora*. As seen in Table (1), *Che. vicina isis* exhibited significantly high degrees of attractiveness in response to kairomone extract in ethyl alcohol in comparison with petroleum ether and acetone extracts.

Table 1. Percentage of attracted predator adults to kairomone extracts from *A. craccivora* with different solvents by using Y tube method.

Predators	Ethyl alcohol	petroleum ether	Acetone	L.S.D.
Hippodamia variegata	72±21.9	68±21.9	44±17.9	14.23
Coccinella undecimpunctata	16±17.9	32±45.6	60±28.3	22.50
Cheilomenes vicina isis	64±17.9	28±21.9	36±179	13.31

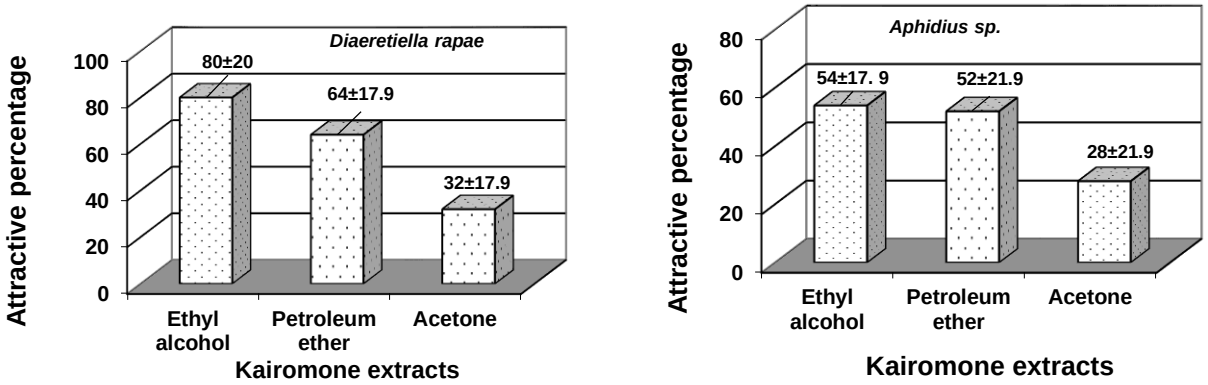

Figure 2. Percentage of attracted parasitoids (*Diaeretiella rapae* and *Aphidius* sp.) to kairomone extracts from *A. craccivora* with different solvents. (L.S.D. value was 18.827 and 14.23 for *D. rapae* and *Aphidius* sp.).

The chemical composition of the ethyl alcohol extract of *A. craccivora*:

The obtained extract analyzed using GC-MS apparatus indicated the chemical composition of the ethyl alcohol extract of *A. craccivora* as shown in Tables (2) consists of compounds belonging three major classes of compounds 14 saturated hydrocarbons, one terpene and three fatty acids compounds.

Table 2. The main components of ethanol extract of *A. craccivora* using GC-MS.

No.	RT (min.)	Compound	Peak area (%)	Molecular formula	M.W.
1	7.98	Undecane	3.74	$C_{11}H_{24}$	156
2	10.41	Dodecane	4.54	$C_{12}H_{26}$	170
3	12.85	Tridecane	4.39	$C_{13}H_{28}$	184
4	12.85	Tetradecane	4.39	$C_{14}H_{30}$	198
5	12.85	Nonadecane	4.39	$C_{19}H_{40}$	268
6	17.50	pentadecane	4.46	$C_{15}H_{32}$	212
7	19.66	Hexadecane	4.23	$C_{16}H_{34}$	226
8	20.62	Dotriacontane	1.66	$C_{32}H_{66}$	450
9	21.73	Heneicosane	4.36	$C_{21}H_{44}$	296
10	21.73	Heptadecane	4.36	$C_{17}H_{36}$	240
11	23.70	Docosane	4.91	$C_{22}H_{46}$	310
12	23.70	Tricosane	4.91	$C_{23}H_{48}$	324
13	25.56	Pentacosane	2.32	$C_{25}H_{52}$	352
14	25.56	Pentatriacontane	2.32	$C_{35}H_{72}$	492
15	18.24	1-Heptatriacotanol	1.01	C37H76O	536
16	9.53	Isopulegol	1.64	$C_{10}H_{18}O$	154
17	9.53	7-Hexadecenal, (Z)-	1.64	$C_{16}H_{30}O$	238
18	35.26	9-Octadecenoic acid1,2,3-propanetriyl ester, (E, E, E)-	0.37	$C_{57}H_{104}O6$	884

1. Reaction behavior of aphidophagous predators in response to damaged and undamaged plants by feeding of *A. craccivora*.

Responses (%) of *H. variegata*, *C. undecimpunctata*, and *Che. vicina isis* adult females to infected and uninfected of broad bean leaves with *A. craccivora* in the olfactometer Y-tube are shown in Table (3). Damaged broad bean leaves by *A. craccivora* feeding produced synomone that attracted *H. variegata* (60 ± 28.28) and *Che. vicina isis* (56 ±17.88 %) of tested adult females. On the contrary, *C. undecimpunctata* females showed no response to volatiles released from infected leaves. So, volatiles released from broad bean plants without aphid infestation are not attractive.

Table 3. Response of *Hippodamia variegata, Cheilomenes vicina isis* and *Coccinella undecimpunctata* adults in Y- tube to damaged and undamaged leaves of broad bean with *A. craccivora* and to control arms.

Treatments	*Hippodamia variegata*	*Che. vicina isis*	*Coccinella undecimpunctata*
Damaged	60±28.28	56±17.88	44±17.88
undamaged	28±21.90	20±28.28	40±28.28
Control	12±21.90	24±17.88	16±17.88
L.S.D.	16.688	15.095	15.095

2. Reaction behavior of *H. variegata* females to upper healthy leaves on previously damaged and undamaged host plants by feeding activity of *A. craccivora*.

The obtained results cleared that volatile are released not only from damaged site but through the entire bean plant. After three days of aphid feeding on lower leaves, the release volatiles from undamaged upper leaves of the same plant were detected. Attractiveness % of *H. variegata* females to infected and uninfected leaves of broad bean with *A. craccivora* in the experimental Y- tube are showed in Figure (3).

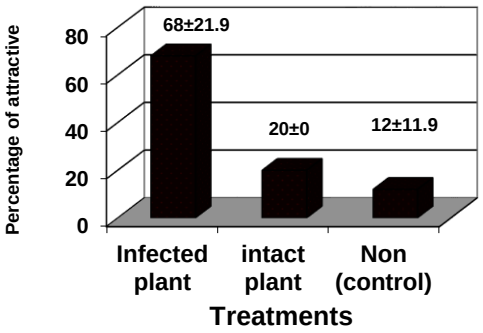

Fig. 3. Attractant percentages of the predator, *Hippodamia variegata* females to volatiles induced from leaves of upper part of intact and infested broad been plants, (lower part was infested with *A. craccivora*) by using the experimental Y- tube (L. S. D. (p = 5%) = 12.32).

As shown in Figure (3) broad bean leaves of the upper part of infected broad bean with *A. craccivora*, attracted the highest percentage of *H. variegata* females (68±21.90) in comparison with uninfected (20±0) and control (12±11.90) in the experimental olfactometer covers. So, aphids feeding on the lower part of the tested plant was enough to elicit volatiles emission from leaves on the upper part of the same plant that attract *H. variegata* females. Moreover, volatile compounds stimulated oviposition behavior by somewhat tested beetle, *H. variegata*.

3. Induced compounds released from upper undamaged Leaves:

Volatile components in the ethyl alcohol extract of *A. craccivora* were identified by gas chromatography/mass spectrometry (GC/MS). Induced compounds released were D-Limonene; 2-(1H-indol-3-yl) acetaldehyde and 1,3,6-Octatriene, 3,7-Dimethyl (Table,4).

Table 4. induced compounds released systemically from upper undamaged Leaves with *A. craccivora*.

No.	RT (min.)	Compound	Peak area (%)	Molecular formula	M.W.
1	6.53	D-Limonene	21.07	$C_{10}H_{16}$	136
2	9.53	1,3,6-Octatriene, 3,7-Dimethyl	1.64	C10H16	154
3	19.02	2-(1H-indol-3-yl) acetaldehyde	0.52	$C_{10}H_9NO$	159

Discussion:

1.Olfactory stimulant (kairomones) mediated host location behavior.

The tested parasitoid and predators showed different in their responses to kairomone extracts of *A. craccivora* depending on the solvent used. The parasitoids (*D. rapae* and *Aphidius* sp.) and the predator, *H. variegata* elicited positive response to ethyl alcohol and petroleum ether extracts, while *Che. vicina isis*, only react positive response to ethyl alcohol extract. All tested natural enemies except *C. undecimpunctata*, showed no response to acetone extract. Similar differences were obtained by Abd El-Kareim *et al*., (2017) hexane was the most effective solvent to extract kairomone from *A. gossypii, A. fabae and M. persicae* for adults of *Cyd. vicina isis*, meanwhile, the acetone approved to be the most effective solvent for kairomones extraction from all tested aphid to adults of *C. undecimpunctata* .While adults of *C. septempunctata* showed attraction to acetone extracts *from A. gossypii* and to hexane extract of both, *A. fabae* and *M. persicae*. Moreover, present study

results agreed with those by Abd El-Kareim and Abd-Allah (1991) Abd El-Kareim, (1992) and Abd El-Kareim *et al*., (2017), which suggest that natural enemies showed different in their responses to kairomone extracts of their host. Abd El-Kareim *et al*., (2017) suggested that these variation was due to those organic solvents that differ in their efficiency in extractive components of kairomone for each insect species. So, may be each extract components have olfactory receptors that differ according to insect species. Acetone extracts of the aphid did not provide a signal to searching behavior of all tested natural enemies, except the black ladybirds, *Che. vicina isis*. Perhaps there some secondary stimulating compounds from aphid's bodies, which were not volatile enough to be detected during extraction. But in the state of kairomone extraction by acetone which elicited positive response due to acetone ability to extract the stimulating chemicals for *Che. vicina isis*. Hatano *et al*., (2008) demonstrated that predatory and parasitic insects have specialized sensory nervous systems that allow them to use a variety of cues to find and identify target hosts. According to (Batra *et al*., 2019) there is more than one receptor to receive the components of the olfactory stimulants. Antennae of insects from several orders detected some volatile through specialized sensory neurons of the olfactory system that elicits chemosensory and behavioral activity across multiple insect orders and receptors. Volatile compounds are adequate stimuli of powerful chemosensory systems that enable insects to discriminate the relevant compounds in a complex chemical world that surrounds them (Renou, 2014). In the present study, using gas chromatography/mass spectrometry, the major volatile components in the ethanol extract of *A.craccivora* were identified (GC/MS) belong to saturated hydrocarbon compounds (undecane, dodecane, tridecane, tetradecane, nonadecane, pentadecane, hexadecane, heneicosane, heptadecane, docosane and tricosane). It known that hydrocarbons are commonly involved in insect communication (Chapman, 1998).Also, in the present study results coupled with those by Padmavathi and Paul, (1997), Srivastava *et al*., (2008), Maruthadurai *et al*., (2011) and Parthiban *et al*., (2015a and 2015b) that Several hydrocarbon components (heneicosane, tricosane, tridecane pentacosane, docosane; nonacosane, hexacosane, undecane, and hexadecenoic acids) of the whole-body extracts of some insect species significantly exerted higher level of kairomonal effect on some parasitoids and predators. Shonouda *et al*., (1998) indicate the presence of saturated hydrocarbons, ranging from docosane to octacosane based on gas chromatography-mass spectrometry analysis of *Aphis fabae* extracts. They added that the attractive compound to *M. corollae* females was tricosane, and a mixture of hydrocarbons, (tricosane, tetracosane, pentosane, hexacosane and octacosane) stimulated egg laying behavior of *M. corollae* than tricosane alone or any other mixture.

2.Olfactory stimulant (synomones) mediated host location behavior.

The feeding activity of *A. craccivora* on broad bean was adequate to stimulate volatiles emission (synomones) that attract the tested ladybirds (*H. variegata* and *Che. vicina isis*) except, *C. undecimpunctata*. *A. gossypii* feeding on chamomile seedlings was adequate to elicit synomones attracting *C. undecimpunctata*, while feeding by *A. fabae* on white bean seedlings was sufficient to elicit emission of volatiles that attract the coccinilld predators (C. *undecimpunctata* and *C. septempunctata*), except, *Cyd. vicina isis* Abdel-Kareim *et al*., (2007&2017). These results are in agreement with previous observations from Rose *et al*., (1996), Dicke and van Loor (2000), Miners *et al*., (2000) and Hatano *et al.,* (2008) that the attractiveness of these induced volatiles has been shown to be specific to plants and insect species. Ninkovic *et al*., (2001) indicated that *C. septempunctata* attracted to odors from previously infested barley plants by *Rhopalosiphum* padi, also to odors from tea plants damaged by feeding activity with *Toxoptera aurantii* (Han and Chen, 2002). The release of volatiles was detected from upper undamaged leaves after three days of continuous nymphal feeding on lower leaves of the same plant that *H. variegata* confirmed evidence that volatiles are released not only at the damaged site but from the entire host plant and this results agreed whit those by Meiners and Hilker (2000), Ahmad *et al.,* (2004), Hulcr, *et al.,* (2005) and Hatano *et al*., (2008), whom stated that insects predatory were considerably attracted to odor from leaves of the host plant which were systematically induced by feeding of insect pests. Moreover, volatile compounds stimulated egg laying behavior by few individuals of *H. variegate* females. These results agree with those of Meiners and Hilker (2000) when damaged leaves of *Ulmus minor* by the beetle, *Xanthogaleruca luteola* emit volatiles that elicited egg laying behavior of the parasitoid, *Oomyzus gallerucae* to oviposition. In the present study, the major volatile components emitted from damaged host plant were D-Limonene; 1,3,6-Octatriene, 3,7-Dimethyl and 2-(1H-indol-3-yl) acetaldehyde. According to (Leroy *et al*., (2012) limonene was the most effective compound released from the aphid, *Megoura viciae* Buckton honeydew that attracted the predator, *Harmonia axyridis*. Van Emden & Hagen (1976) reported that 2-(1H-indol-3-yl) acetaldehyde (Indoleacetaldehyde) attract *Chrysoperla carnea*. 1,3,6-Octatriene, 3,7-dimethyl is called (E)-ß-ocimene, according to Du *et al*., (1998) (E)-ß-ocimene, with other compounds emitted from broad bean plants due to aphid infestation, which attracted the pea aphid parasitoid, *Aphidius ervi.*

So, it could be recommended that a synchronization between the tested natural enemies (parasitoids and predators) and aphid population can be done by applying attractive baits earlier in aphid-infested fields, that lead to increase natural enemy's populations and their searching efficiency (Zhu, 2011 and Sheikh *et al.,* 2017). Riddick (2020) suggested that more research is necessary to understand the physiological mechanisms responsible for odor detection and oviposition stimulation in coccinellids.

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الكيرومون والسينومون يتوسطان موقع من البقوليات للاعداء الحيوية

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تم دراسة الاستجابة السلوكية لاناث الطفيليات *Diaeretiella rapae* and *Aphidius* sp و ابو العيد *Hippodamia variegata* وابو العيد ذو احدى عشر نقطة وابو العيد الاسود لمستخلص حشرة من البقوليات (الكيرومون) فى ثلاثة مذيبات (ايثيل اكحول وإيثر بترولي واسيتون). اظهرت الطفيليات والمفترسات موضع الدراسة اختلافا فى استجابتها للكيرمون اعتمادا على نوع المذيب المستخدم. حيث ابدى كلا من الطفيلين و ابو العيد ذو الثلاثة عشر نقطة استجابة موجبة لمستخلص ايثيل الكحول واثير بترولى مقارنة بالاستيون. بينما يعتبر الاستيون من افضل المذيبات لمستخلص الكيرومون لابو العيد ذو احدى عشر نقطة .بينما مستخلص الكيرمون بالايثيل الكحول كان الاكثر جذبا لابو العيد الاسود. باستخدام ال (GC-MS) تم التعريف على المواد الطيارة من مستخلص حشرة من البقوليات بمذيب ايثيل الكحول وكانت المركبات كالتالى: undecane, dodecane, tridecane, tetradecane, nonadecane, pentadecane, hexadecane, heneicosane, heptadecane, docosane and tricosane. كما اثبتت الدراسة ان تعرض نبات الفول للاصابة بالمن انبعث منه اشارات كيميائية طيارة (سينمون) ليس فقط من الاجزاء المصابة بل من النبات كله.والتى جذبت المفترسات تحت الدراسة .وتحفز هذه المواد سلوك وضع البيض لمفترس ال *Hippodamia variegata*. وتم تحديد المركبات االمتطايرة من الاوراق العلوية غير المصابة بعد ثلاثة ايام من الاصابة على الاوراق السفلية لنفس النبات باستخدام (GC-MS) وهذة المركبات هى D-Limonene, 2-(1H-indol-3-yl) acetaldehyde . 2- [2 carboxymethyl) phenyl] acetic acid, 1,3,6-Octatriene,3,7-Dimethyl وبذلك يمكن استخدام هذة المركبات لتحفيز الاعداء الحيوية لوضع مزيد من البيض على النباتات المصابة فى الحقل.