J. Plant Prot. and Path., Mansoura Univ., Vol.8 (1), 1– 6, 2017

Tritrophic Interaction Between Leguminous Crops, Aphid Species and Foraging Behavior of Lady Beetles.

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ABSTRACT

Foraging behavior of some coccinellid predators (*coccinella. Undecinpunctata* L*,, Coccinella septempunctata* L. and *Cydoina vicina isis* L.) in response to different host plants (cowpea, white bean and broad bean) and prey species (*Aphis gossypii* (Glover.) *, Myzus persicae* (Sultzer.) and *Aphis fabae* (Scop.)) were evaluated under laboratory conditions. The lady beetles exhibited different searching rate and matual interferace values in response to differant host plant and prey species. However , the searching rate of *C. undecimpunctata* adults was higher on *A. gossypii* than on *M. persicae* and *A. fabae* especially those reread on cowpea plants. While, *C. septumpunctata* showed the higher searching rate on *M. persicae* than *A. fabae* and *A. gossypii* ,especially on white bean .On contrary, the highest searching rate of the black lady beetles was recorded on *A. fabae* and *M. persicae* reared on white bean (0.769, 0.701)or broad bean (0.746, 0.708) in comparison with A. *gossypii*. The eleven spotted lady beetles recorded relatively higher mutual interference values in comparison with those of seven- spotted or black lady beetle adults, especially on cowpea plants . The present study revealed that the highest searching rate with relatively low mutual interference value for *C. undecimpunctata* (0.763, 1.881), *C. septumpunctata* (0.781, 1.626) and *C. vicina isis* (0.769, 1.684) were recorded on (*A. gossypii* reared on cowpea), (*M. persicae* reared on white bean) and (*A. fabae* reared on white bean), respectively.

INTRODUCTION

Legume crops are widely cultivated crops in many countries as well as in Egypt because the legume crops contain high protein that is characterized as a complete protein compared with those of other vegetables which reaches 20.25% in most dry legumes (Nosser, 1996). Legumes are sometimes called "poor people's meat" because they're an inexpensive source of quality plant protein. These crops are attacked by several insect pests throughout their different stages of their growth. Some of these insects (piercing-sucking insect pests including aphids) are very injurious and cause serious damage to the yield in both quantity and quality (Ward *et al*., 2002).

At the beginning of the twenty-first century, the need for appropriateness and effective biological control are greater than ever, especially on vegetable crops: insect pest resistance continues to be a problem, pesticides are being withdrawn on environmental grounds without suitable replacements. The use of biological control for the management of insect pests has been successfully applied against a range of open-field and greenhouse pests. Augmentative biological control and conservation have been developed with indigenous natural enemies (Bale *et al*, 2008).

The foraging behavior (the searching rate and interference value) of the coccinellid predators may be affected by many factors including their the prey and host plant species (Abd El-Kareim 2002, Marouf, 2007, Sarmento *et al*. 2007 and Al-Deghairi *et al*, 2014), prey density (Matter *et al*. 2011), foraging cues (Hodek & Honek 1996, Pasteels 2007), (Santos-Cividanes *et al*. 2011). According to Snyder & Clevenger (2004), lady bird beetles approved to be agood biological control agents against aphids. So, the present study aims to evaluate the foraging behavior (searching rate and matual interference) of some coccinellid species in response to host plant and aphid species.

MATERIALS AND METHODS

The present experiment aims to compare between the foraging behavior (searching rate, and mutual interference) of some predator species (*Coccinella undecimpunctata L.*, *Coccinella septempunctata L.* and *Cydonia vicina Isis L.)* in response to different prey aphid species reared on various host plants (cowpea, white bean and bean).

Insect and plant sources:

Host plants: Cowpea (*Vigna unguiculata* L.), white bean, (*Phaseolus vulgaris* L.) and broad bean *(vichia faba* L.) were gowning in 15 cm diameter plastic pots under laboratory conditions.

Aphid species: the green peach aphid, *Myzus persicae* Sultzer, the melon aphid, *Aphis gossypii* Glover, and the black broad bean, *Aphis fabae*. Scop. were collected from vegetable fields (broad bean, white bean and cowpea). These insects were used to introduced into cages containing host plant seedlings in a pot filled with soil to establish colonies on each host plant species in the laboratory.

The tested insect predators (*C. undecimpunctata*, *C. septempunctata.* and *Cyd. vicina Isis)* were collected from vegetable fields (broad bean, white bean and cowpea), by using an aspirator, and kept in the laboratory for bioassay. Collected beetle females were starved for 24 hours before bioassay.

The searching rate and mutual interference values of the coccinellid predators in response to each aphid species and host plants were compared: Four densities, namely, 1, 2, 3, 4 and 5 individuals of each species, were examined by confining 50 aphid individuals (mixture of 2nd and 3rd nymphal instars) of *A. faba, A. gossypii* and *M. persica* on each host plant seedling (cowpea, white bean and bean) with each density of predator in a glass containers (6 x 30 cm). The upper rim of the container was covered with mesh screen and fixed with a rubber band. The predators were left in the container for 24 hrs. with their prey, predated

preys were counted and recorded. Each predator density was replicated five times. The experiments were conducted under laboratory conditions (26 ± 2.5 ◦C and 68 ± 4.5 RH%).

The searching rate (at) was calculated according to Varley *et al.* (1978) as followed**:**

$$a_t = (1/p) \log e (N/S)$$

(**Where**, P= number of predators, N= the initial number of prey and S = number of preys not predated)

The relationships between the searching rate (a_t) and predator density (log p) are indicated by the slope of the equation:

$$\text{Log } a_t = \log Q - m \log p$$

(**Where** Q; is the quest value (the search rate when the predator density is one ;m; is the mutual interference value)

RESULTS

1. Tri.trophic interaction between leguminous plants, aphid and searching behavior of coccinellid predators.

Searching rate and mutual interference values of each predators(*C. undecimpunctata*, *C. septempunctata* and *Cyd. Vicina isis*) were estimated in response to both host plants (cowpea, white bean and broad bean)and aphid (*A. gossypii, A. fabae* and *M. persicae*) species.

Eleven-spotted ladybird, *C. undecimpunctata*.

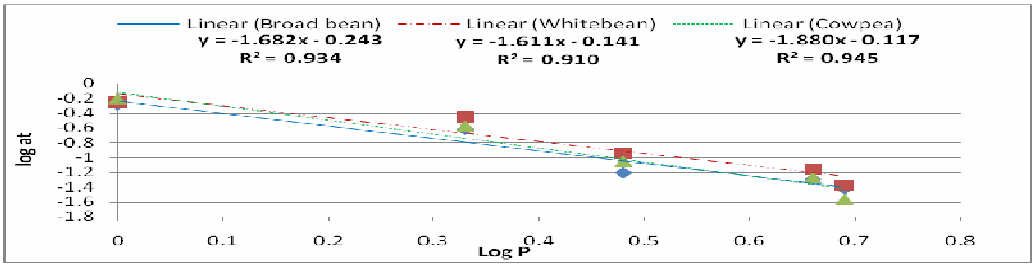
The searching rate (a_t) and mutual interference values(m) for the predator were estimated in response to different aphid species reared on various host plants (cowpea, white bean and broad bean).

In response to *A. gossypii*.

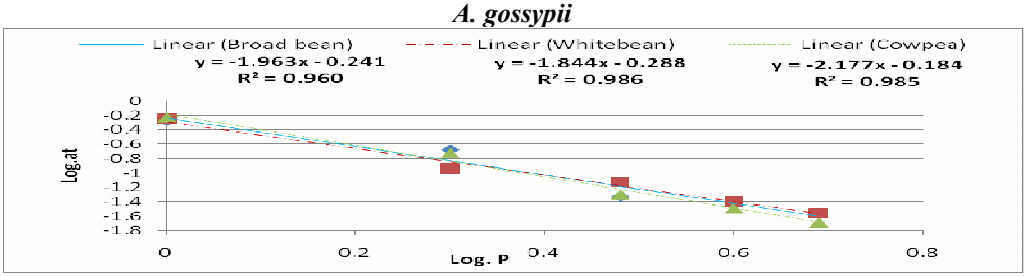
The searching rate of the predator *C. undecimpunctata* at different adult densities is illustrated in Figure (1). The predator showing relatively higher searching rate (0.763) on *A. gossypii* -reared on cowpea in comparison with those reared on white bean (0.721) or broad bean (0.571). On contrary, the highest mutual interference value (1.881) was recorded on cowpea followed by white bean (1.611) and broad bean (1.683). Therefore, by increasing predator density, searching rate per adult was relatively decreased on cowpea (Figure 1)

In response to *M. persicae*.

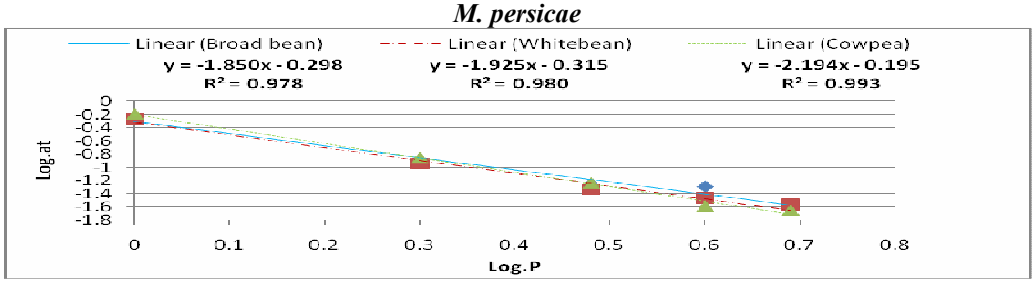
As shown in Figure (1), the predator showing relatively higher searching rate (0.654) on the prey-reared on cowpea followed by 0.574 and 0.515 on broad bean and white bean, respectively. On contrary, mutual interference value was the reverse of that of searching rate, where, the lowest value was (1.844) recorded on white bean followed by (1.964) and (2.177) on broad bean and cowpea, respectively.



A. gossypii



M. persicae



A. fabae

Figure 1. The relation between predator density (log p) and searching rate (log a_t) of *Coccinella undecimpunctata* response to *Aphis gossypii* (Glover.), *Myzus persicae* (Sultzer.) and *Aphis fabae*(Scop.) reared on cowpea, white bean and broad beean.

In response to *A. fabae*.

Data illustrated in Figure(1) and presented in Table (1), cleared that foraging behavior (the searching rate and mutual interference value) of *C. undecimpunctata* adults was similar as mentioned above. The predator showing relatively higher searching

rate (0.0.638) on the prey-reared on cowpea with relatively higher mutual interference (2.195). While, the predator exhibited the lowest mutual interference value (1.850) on broad bean with low searching rate (0.504). Searching rate and mutual interference value of the ladybird on *A. fabae* reared on white bean were in-betweens, represented by,0.484 and 1.925, respectively.

In general, it could be concluded that searching rate of *C. undecimpunctata* adults was higher on *A. gossypii* than on *M. persicae* and *A. fabae*, especially on cowpea plaants.

Seven-spotted ladybird, *C. septumpunctata* L.

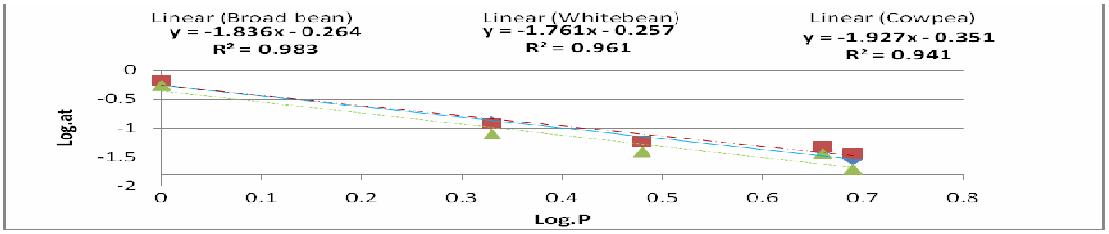
The searching rate (a_t) and mutual interference values for *C. septumpunctata* were estimated in response to different aphid species reared on the previously mentioned host plants.

In response *A. gossypii*.

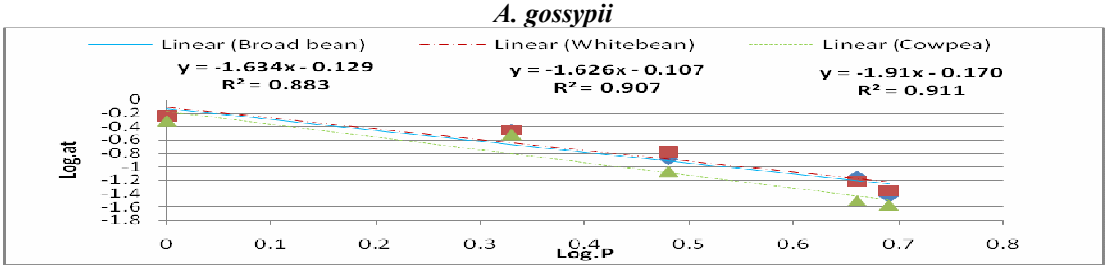
The searching rate of the predator *C. septumpunctata* at different adult densities is illustrated in Figure (2). The predator showing relatively higher searching rate (0.553) on the prey-reared on white bean with low mutual interference value (1.764), in comparison with those reared on broad bean (a_t= 0.543 & m = 1.836) or cowpea (a_t= 0.445 & m = 1.927).

In response to *M. persicae*.

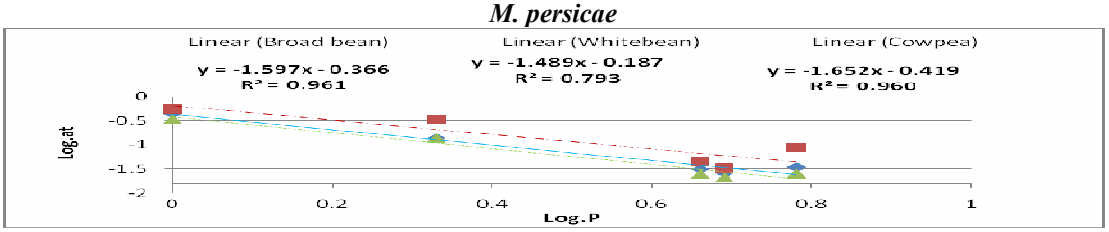
The searching rate of the predator *C. septumpunctata* at different adult densities is illustrated in Figure (2). The predator showing relatively higher searching rate (0.781) on the prey-reared on white bean in comparison with those reared on broad been (0.741) or cowpea (0.675).



A. gossypii



M. persicae



A. fabae

Figure 2. The relation between predator density (log p) and searching rate (log a_t) of *Coccinella septumpunctata* response to *Aphis gossypii* (Glover.), *Myzus persicae* (Sultzer.) and *Aphis fabae* (Scop.) reared on cowpea, white bean and broad beean.

Mutual interference value on all tested host plants (cowpea, broad bean and white bean) was 1.910, 1.634 and 1.626, respectively.

In response to *A. fabae*.

Foraging behavior of the predator *C. septumpunctata* at different adult densities is illustrated in Figure (2). The predator showing relatively higher searching rate (0.649) on the prey-reared on white bean in comparison with those reared on broad bean (0.431) cowpea (0.381). Mutual interference value was 1.652, 1.598 and 1.489 on cowpea, broad bean and white bean, respectively.

In general, it could be concluded that searching rate of *C. septumpunctata* adults was higher on *M. persicae* than on and *A. fabae A. gossypii*, especially on cowpea plants.

Black ladybird, *Cydonia vicina isis*

The searching rate (a_t) and mutual interference values for the predator were estimated in response to different aphid species reared on cowpea, white bean and broad bean.

In response to *A. gossypii*.

The searching rate of the predator *Cydonia vicina isis* at different adult densities is illustrated in Figure (3). The highest searching rate of the black ladybird, was (0.667) recorded on the prey-reared on broad bean in comparison with those reared on white bean (0.659) and cowpea (0.627). While, the predator exhibited the lowest mutual interference value on broad bean (1.579) and the highest on cowpea (1.856) and white bean (1.622)

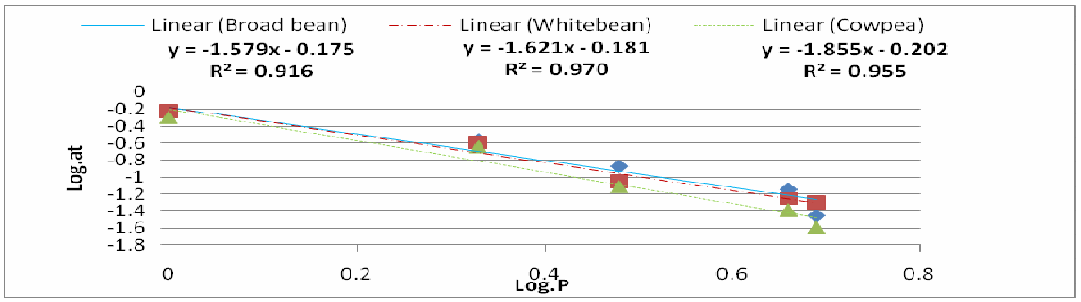
In response to *M. persicae*.

The searching rate of the predator *Cydonia vicina isis* at different adult densities is illustrated in Figure (3). The predator showing relatively higher searching rate (0.708) on the prey-reared on broad bean in comparison with those reared on white bean (0.701) or cowpea (0.618). Mutual interference value on all tested host plants (whitebean, broad bean and cowpea) was 1.777, 1.785 and 1.882, respectively. Therefore, by increasing predator density, searching rate per larvae was relatively decreased (Figure3).

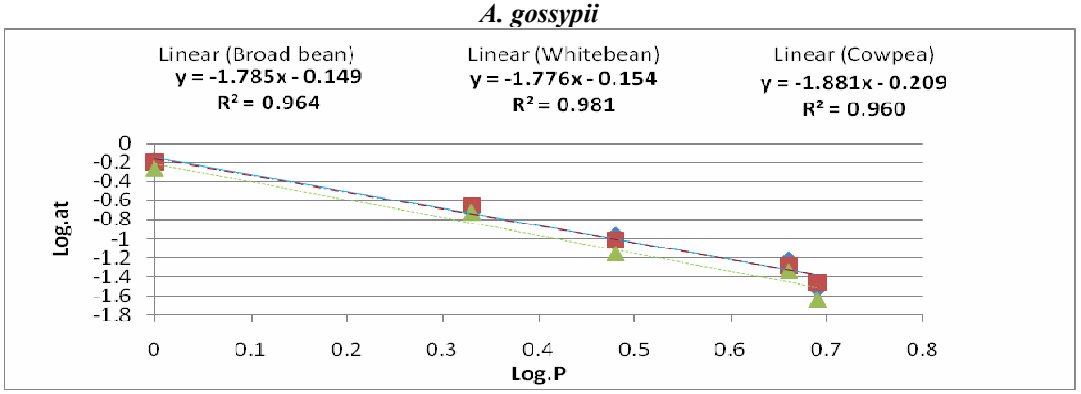
In response to *A. fabae*.

The searching rate of the predator *Cydonia vicina isis* at different adult densities is illustrated in Figure (3). The predator showing relatively higher searching rate (0.769) on the prey-reared on white bean in comparison with those reared on broad bean (0.746) or cowpea (0.579). Mutual interference value on all tested host plants (broad bean, white bean and cowpea) was 1.684, 1.702 and 1.714, respectively. Therefore, by increasing predator density, searching rate per larvae was relatively decreased (Figure3).

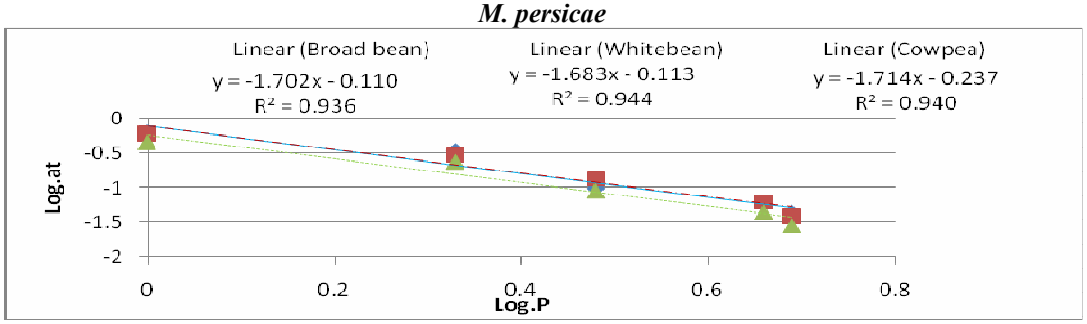
The obtained results revealed that searching rate of *Cyd.vicina isis* adults was higher on *A. fabae* and *M. persicae* than on *A. gossypii*, especially on broad bean and white bean plants.



A. gossypii



M. persicae



A. fabae

Figure 3. The relation between predator density (log p) and searching rate (log a_t) of *Cydonia vicina isis* L.response to *Aphis gossypii* (Glover.), *Myzus persicae* (Sultzer.) and *Aphis fabae* reared on cowpea, white bean and broad beean.

DISCUSSION

The present results indicated that the searching rate of tested predators was decreased as the predator density increased. Similar conclusion wasobtained by Abd El-Fattah *et al*. (1987), Abd El-Kareim (1998) and El-Batran (2003).

According to Abd El-Kareim (2002) the searching characteristics (searching rate and interference value) of the predators (*C. bipustulatus, E. flavipes* and *C. undecimpunctata*) were affected by the prey and host plant species. The present investigation also, revealed that the searching rate and interference value of *C. undecimpunctata*, C. *septeumpunctata*, and Cyd. vicina isis were affected by host plant species. Wu

et al., (2010) demonstrated that the suitability of *A. gossypii* from different host plants (*Cucumis sativus* L., *Cucurbita pepo*., *Cucurbita moschata*, *Cucumis melo* L. and *Lagenaria siceraria*) was different for the ladybird beetle, *H. variegate*. The cocinellid *Nephus reunioni* showed different searching behavior to the mealybugs, *Planococcus citri* and *P. affinis* on six host plants (Copland *et al*., 1993). Also, the efficiency of the coccinellid predators (*R. cardinalis and C. bipustulatus*) was affected by host plant species (Abdel-Mageed, 2005). Heidari *et al*. (1999) added that the type of host plant leaf trichemes have a marked influence on the level of mealybug control by *C. montrouzieri.*

The searching rate of the tested predators was affected according to prey spesies. However, the highest searching rate of *C. undecimpunctata*, *C. septumpunctata* and *Cyd.vicina isis* adults was recorded on *A. gossypii M. persicae* and *A. fabae*, respectively. This results coupled with those recorded by Abdel-kareim (2002), Sarmento *et al*. (2007), Jalali (2012), Al-Deghairi *et al*. (2014), which suggested that foraging behavior of the predators were different with respect to aphid species . Also, the coccenelid predators, R. cardinalis and C. montrouzieri exhibited different response to different host plants (Cardosa, 1990). The coccinellid *Nephus reunioni* showed different searching behavior to the mealybugs, Planococcus citri and *P. affinis* on six host plants (Copland *et al*., 1993).Heidari *et al*. (1999) added that the type of host plant leaf trichomes have a marked influence on the level of mealybug control by C. *montrouzieri.* According to Pervez and Omkar (2005) the coccinellid predators exhibited differences in handling times within and between the predatory species on both prey species (*Aphis craccivora* and *Myzus persicae* indicating that predators respond differentially to prey species.

So, it could be concluded that *C. undecimpunctata* may be more suitable as biological control agent for *A. gossypii* as well as C. septumpunctata and *Cyd.vicinna isis* for *M. persciace* and *A. fabae,* respectively.

Table 1. Searching rate and matual interference values of the coccinellid predators in response to different aphid species reared on various host plants.

Ladybirds/ Aphids	Broad bean		White bean		Cowpea	
	a_t	m	a_t	M	a_t	M
Coccinella undecimpunctata L. *Aphis gossypii*(Glover.)	0.571	1.683	0.721	1.611	0.763	1.881
Myzus persicae(Sultzer.)	0.574	1.964	0.515	1.844	0.654	20177
Aphis fabae (Scop.)	0.504	1.850	0.484	1.925	0.638	2.195
Coccinella septumpunctata L. *Aphis gossypii*(Glover.)	0.543	1.836	0.553	1.761	0.445	1.927
Myzus persicae(Sultzer.)	0.741	1.634	0.781	1.626	0.675	1.910
Aphis fabae(Scop.)	0.431	1.598	0.649	1.489	0.381	1.652
Cydonia vicina isis L. *Aphis gossypii*(Glover.)	0.667	1.579	0.659	1.622	0.627	1.856
Myzus persicae(Sultzer.)	0.708	1.785	0.701	1.777	0.618	1.882
Aphis fabae(Scop.)	0.746	1.702	0.769	1.684	0.579	1.714

REFERENCES

Abdel-Fattah, M.I.; El- nabawi, A. and Hendi, A. (1987). Effect of intra and inter-specific larval competition on the development of certain aphidophagous predators (Coleoptera: Coccinellidae). Bull. Soc. Ent. Egypt, 65: 73-79.

Abd El-Kareim, A.I. (1998). Searching rate and potential of some natural enemies as bio- agent against the cottonwhitefly, *Bamisia tabaci* , Genn (Hom: Aleyrodidae). J.App. Ent., 122: 487-492

Abd El-Kareim, A.I. (2002). The potential of some natural enemies as bio-agent against certain disaspidid species. J. Union Arab. Biol.Cairo,17(A): Zoology, 51-63.

Abdel- Mageed, Sanaa, A.M. (2005). Influence of certain natural enemies on some mealy bug populations. M. Sc. Thesis, Fac. Agric., Mans, Unvi Egypt, P.154.

Al-Deghair, M. A.; N. F. Abdel-Baky; A. H. Fouly; and N. M. Ghanim (2014). Foraging behavior of two coccinellid species (Coleoptera: Coccinellidae) fed on aphids. J. Agric. And Urban Entomol. 30(1):12-24.

Bale, F.B.; Lenteren. J.C.V.; Hokkanen, H.M.T. and Loomans, A.J.M. (2008). Assessing risks of releasing exotic biological control ageist of arthropod pests. Annual. Rev. Entomol. 15: 609-634.

Copland, M.J.W,; Perera, H.A.S. and Heidari, M. (1993). Influence of host plant on the biocontrol of glasshouse mealybug. Bull. Oil/SROP 16(8): 44-47.

Cardosa, A. (1990). Preliminary study of coccinellids found on citrus in portugal. Boletin de Vegetal, Plagas, 16(1): 105-111.

El-Batran, L.A. (2003). Laboratory studies on searching behavior of larvae of *Exochomus flavipes* (Thunb) and *Chrysoperla carnea* (Steph) for *Coccus hesperdum* L. Egypt. J. Bio. P. Cont., 7(2): 103-105.

Heirdie, J.; Picket, J.A.; Pow, E.M. and ; Smiley, D.w.M.(1999). Pheromones of non- Lepidopteran insects associated with agricultural plants. CAB. Inter. PP. 227-250.

Hodek and Honek. (1996). Ecolgy of Coccinellidae. Lin. 54: 95-141.

Jalali, M.A. and Michaud, J.P. (2012). Aphid-plant interactions affect the suitability of *Myzus spp*. As prey for two spot ladybird, *Adalia bipunctata* (Coleoptera: Coccinellidae). Eur.J. Entomol., 109: 345-352.

Marouf, A.H. (2007). Stusies on insect pests and their natural enemies assotiated with marjoram and chamomile plants. M. Sc. Thesis, Fac. Agric. Mans. Unvi. Mans. Egypt, P. 150.

Matter, M.M.M.; Mahasen, E.N.A.; Ferag, E.N.A. and Gasraha, M.A. (2011). Impact of temperature and prey density on the predacious capacity and behavior of *Stethorus punctillum* Weise. Arch. Phytopa. Plant. Protec. 44: 127-134.

Nosser, M.A. (1996). Mechanism of resistance in bean and cowpea varieties to certain sucking insects infestation. M. Sc. Thesis, Fac. Agric., Cairo Univ

Pasteels, J.M. (2007). Chemical defense, offence and alliance in ants-aphids-ladybirds relationsheps. Pop. Ecol. 49: 5-14.

Pervez, A. and Omkar. (2005). Functional responses of coccinellid predators : An illustration of a logistic approach. J. Insect. Sci.5:5.

Santos-Cividanes, T.M.; Anjos, A.C.R. Cividance, F.J. and Dias, P.C. (2011). Effects of food deprevation on the development of *Coleomegilla maculate* (De Geer) (Coleoptera: Coccinellidae). Neeotrop. Entomol. 40: 112-116.

Sarmento, R.A.; Pallini, A.; Venzon, M.; Francisco,o.F.S.; Rugama, A.J.M. and Oliviera, C.L. (2007). Functional response of the predator *Eriops connexa* (Coleoptera: Coccinellidae) to different prey types . Braz. Arch. Biol.Technol. 50(1).

Snyder, W. E., and Garrett M. C. (2004). "Negative Dietary Effects of Colorado Potato Beetle Eggs for The Larvae of Native and Introduced Ladybird Beetles". Biol. Cont. 253:(3) 31- 61.

Varley, G.C.G.R,; Gradwell and Hassell, M.P. (1978). Insec Population. Ecol. Oxford: Blackwell.

Vet, L.E.M. and Dick, M. (1992). Ecology of infochemical use by natural enemies in tritrophic context. Annu. Rev. Entomol. 37: 141-172.

Ward, A.S.W.; Denholm, I. and Nammara, N.M.C. (2002). Foliar insect pest management on cowpea (*Vigna ungiculata* (L.) Walpars) in simulated varietal mixures. Field- Crops-Research. 79(1): 53-65.

Wu, X. H. ; Zhuo, X. R. and pang ,B. P. (2010). Influence of five host plants of *Aphis gossypii* Glover on some population parameters of *Hippodamia variegate* (Goeze). J. Pest Science .83 (2): 77-83.

علاقة المستويات الغذائية الثلاثة بين بعض المحاصيل البقولية وبعض انواع المن والسلوك الغذائى لمفترسات ابو العيد

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تم تقييم السلوك الغذائى لبعض انواع ابو العيد (ابو العيد ١١نقطة، ابو العيد ٧ نقطة و ابو العيد الاسود) بالنسبة لعوائل نباتية مختلفة (اللوبيا ،الفاصوليا و الفول البلدى) وانواع فرائس مختلفة من المن (من القطن، من الخوخ الاخضر و من الفول الاسود)وذلك تحت ظروف المعمل. - ابدت خنافس ابو العيد قيم مختلفة من المعدل البحثى والتداخل التبادلى بالنسبة لكل من نوع العائل النباتى والفرائس. *حيث كان اعلى معدل بحثى لابو العيد ١١ نقطة اعلى على من القطن مقارنة بمن الخوخ الاخضر ومن الفول الاسود خاصة المربى على نبات اللوبيا. *بينما سجل اعلى معدل بحثى لابو العيد ٧ نقطة على من الخوخ مقارنة بمن الفول ومن القطن خاصة على الفاصوليا. *وعلى العكس كان اعلى معدل بحثى الابو العيد الاسود على من الفول الاسود ومن الخوخ الاخضر المربى على كل من الفاصوليا(٠.٧٦٩، ٠.٧٠١) والفول البلدى (٠.٧٤٦، ٠.٧٠٨) مقارنة بمن القطن. * سجل ابو العيد ١١ نقطة اعلى قيم للتداخل التبادلى مقارنة بكل من ابو العيد ٧ نقطة وابو العيد الاسود خاصة على نبات اللوبيا. كما اوضحت الدراسة الحالية ان اعلى معدل بحثى مع قيمة منخفضة للتداخل التبادلى لكل من ابو العيد ١١ نقطة كانت(٠.٧٦٣، ١.٨٨١) وابو العيد ٧ نقطة كانت (٠.٧٨١، ١.٦٢٦) وابو العيد الاسود كانت (٠.٧٦٩، ١.٦٨٤).على كل من (من القطن المربى على نبات اللوبيا) و (من الخوخ الاخضر المربى على الفاصوليا) و (من الفول الاسود على الفاصوليا) نسبيا.