EGYPTIAN ACADEMIC JOURNAL OF

BIOLOGICAL SCIENCES

F

TOXICOLOGY & PEST CONTROL

ISSN
2090-0791

WWW.EAJBS.EG.NET

Vol. 16 No. 2 (2024)

www.eajbs.eg.net

Citation: *Egypt. Acad. J. Biolog. Sci.* (F. Toxicology& Pest control) *Vol.16(2) pp113-132 (2024)*
DOI: 10.21608/EAJBSF.2024.399472

Egypt. Acad. J. Biology. Sci., 16(2):113-132 (2024)

Egyptian Academic Journal of Biological Sciences
F. Toxicology & Pest Control
ISSN: 2090 - 0791
http://eajbsf.journals.ekb.eg/

Role of Biological Control Agents in Regulating Pests′ Populations on Cauliflower: A Field Study on Cabbage Aphid *Brevicoryne brassicae* and Diamondback Moth *Plutella xylostella*

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ARTICLE INFO
Article History
Received:21/11/2024
Accepted:24/12/2024
Available:27/12/2024

***Keywords*:**
Cauliflower, Infestation, the cabbage aphid, the diamondback moth, Parasitism, Biological control, Releasing predators, *Chrysoperla carnea*, Populations pests' reduction.

ABSTRACT

The populations' density of both of the cabbage aphid, *Brevicoryne brassicae* (L.) and also the diamondback moth, *Plutella xylostella* (L.), attacking cauliflower field, were recorded during season 2023/2024, in Qalubia Governorate. The field experiment was divided into two experimental areas; unreleased area and released one (where, the second instar larvae of the lacewing predator, *Chrysoperla carnea* (Steph.) were released). The obtained data showed that, the pest of the cabbage aphid on the cauliflower plants had covered the four months of the study (i.e., during the period from January, 2024 until April, 2024). The maximum total numbers of the pest individuals and the mummies of the surveyed aphid parasitoid, *Diaeretiella rapae* (M' Intosh), were recorded during the last week of February, 2024 in the two experimental areas. The synchronization of the increase of the pest numbers with the increase of its parasitoid numbers indicated that, the parasitoid, *D.* is as a suitable biocontrol agent against the aphid populations. The recorded reduction percentage in the total numbers of the cabbage aphid per season in the released area of the predatory larvae of *Ch. carnea* was 43.74%., in comparing with the unreleased one. Moreover, the occurrence period of the diamondback moth on the cauliflower plants was recorded from the second week of January, 2024 until the last week of April, 2024.The two hymenopterous parasitoidś species; *Cotesia plutellae* (Kurdjumov) and *Diadegma semiclausum* (Hellen) were surveyed parasitizing the diamondback moth. The percentages of the pest parasitism were simultaneously increased as the pest populations were increased. The percentages of the reduction in the total numbers of the diamondback moth (larvae & pupae) per season, in released area of the predator was 23.82%, in comparing with unreleased one. The field experiment was also included the measurements of both of the size and the diameters and also the weight of the resulted cauliflower after 103 days post plantation. Generally, such ecological information about the cabbage aphid and the diamondback moth and also the biological control experiment by releasing the predator must be included in future control applications against the two studies pests attacking cauliflower fields as well as other vegetable fields that suffer from the two pestś attack. Therefore, this situation will help to decrease the harmful hazard effects of the extensive uses of the chemical control methods, which will directly or indirectly decrease the environmental pollution for protecting the man health and his surrounding environment.

INTRODUCTION

In Egypt, there is a very highly increased attention that is concentrated towards the extensive cultivating of vegetables. As, they are very important commoditities crops (Habashi *et al.,* 2007), containing rich minerals and vitamins that are strongly needed for the human nutrition (Kassem *et al.,* 2005). Among these vegetables, cauliflower (*Brassica oleracea* L.), is a common cruciferous vegetable crop, that is this plant is susceptible to many insectś pests, which affect on the quantity and the quality of this crop such as the two pests; the cabbage aphid, *Brevicoryne brassicae* (L.) (Homoptera: Aphididae) and the diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae). Many authors such as; Saleh *et al*., (2009) and Rimaz & Valizadegan (2013), were previously recorded the cabbage aphid as a pest of the cruciferous plants including the cauliflower plants. As for the diamondback moth, its pest larvae burrow into the cauliflower leaf and start to feed internally (Metspalul *et al.*, 2005). Also, it was worldwide recorded as a pest of the cruciferous plants including cauliflower plants by many authors such as Pagore *et al.* (2021).

The extensive use of the harmful chemical insecticides has lead to the occurrence of different environmental pollution that affect on the human health (Grafton-Cardwell & O´Connell, 2006), moreover, negative impacts on the natural enemies will be done (Yeo *et al.,* 2003). Recently, the field of the biological control has worldwide received much attention (Sarwar, 2014). Surely, the main concepts is mostly depend strongly on studying the different knowledge concerning; studying the biocontrol agents population density which will help for choosing the suitable ones to be easily mass reared and released (Mostafa, 2006). Many predators were shown to play a noticeable role in the field of the biological control, where they represent one of the most acceptable and having a common value to be mass reared and released against many agricultural pests. Moreover, the parasitoids have an important natural role in regulating the population density of many crucifers' pests (Kassem *et al*., 2008). The predator, *Chrysoperla carnea* (Steph.), had received a very great attention to be extensively applied in the field of the biological control (Sarwar, 2013) and also to be used in planning the recent I.P.M. programs (Rashid *et al*., 2012) and had been considered as one of the most common predators in the cropping systems (Saleh *et al*., 2017). However, Azema & Mirabzadae (2004) revealed that, the lacewing predators have many characters to be preferred in the field of the biological control such as; possessing highly searching ability, easily to be mass reared, the widely geographical distribution and the highly tolerance to the different changes in the environmental factors.

This study was carried up to examine the populations densities, the parasitism of both the cabbage aphid and the diamondback moth, attacking cauliflower plants in the two experimental areas, during the 2023/2024 season, in Qalubia Governorate. Such studies and the performed biological control experiment can applied to manage the two pests in the cauliflower fields and other vegetable crops that are liable to attack by them.

MATERIALS AND METHODS

An experimental area was selected and was cultivated with the cauliflower plants (*B. oleracea*), in the farm of Plant Protection Research Institute (P.P.R.I.), Agriculture Research Center (A.R.C.), that was located in Qaha district (Qalubia Governorate), during 2023/2024 season. This field experiment was conducted according to the following steps:

1- The field experiment areas were cultivated with the cauliflower plants on 5/12/2023 and were ended on 23/4/2024. All the agricultural practices were made in the two

experimental areas but without spraying any chemical insecticides.

2- A total area of 160 m^2, representing the two adjacent cultivated cauliflower experimental areas (unreleased and released ones), i.e., each area was $72m^2$ =16×4.5m^2. Each area had included four rows (representing four replicates)

- The cauliflower seedlings were planted in the middle (i.e., a total number of eight rows for the two the experimental areas were selected). The distance between were 50 cm., while, the outer limit of each area was 25 cm.
- A total number of 32 plants/each row (i.e. 32 plant/row×4 rows=128 plants×2 experimental areas=256 plants for both the two unreleased and the released areas together), while, the distance between cauliflower plants was 50 cm. (Figs, 1&2).
- Random weekly samples of 10 cauliflower plants were early investigated, however, the weekly total numbers of investigated cauliflower leaves were 2 leaves/plant × 10 plants × 4 rows × 2 experimental areas = a total of 160 cauliflower leaves per week).

3-The percentages of aphid individuals, the mean total individuals/one plant and the mean individuals/one leaf were estimated as follow:

$$\text{Adults percentages} = \frac{\text{Numbers of adults}}{\text{Numbers of adults \& nymphs}} x100$$

$$\text{Nymph's percentages} = \frac{\text{Numbers of nymphs}}{\text{Numbers of adults \& nymphs}} x100$$

$$\text{Mean no. of individuals/one plant} = \frac{\text{Numbers of adults \& nymphs}}{\text{Total no.of 40 plants}}$$

$$\text{Mean no. of individuals /one leaf} = \frac{\text{Total no.of adults \& nymphs}}{\text{Total no.of 80 leaves}}$$

- The cauliflower plants that were infested with the aphid were brought to the laboratory for counting and also estimating the percentages of the its parasitism according to the following equation.

$$\text{Percentages of parasitism} = \frac{\text{Total no. of mummies}}{\text{Total no. of aphid individuals}} x100$$

A B C

Fig. 1: The different steps of the development of the cultivated cauliflower plants in the field experimental areas.

- At the same time, the population density of the diamondback moth, *P. xylostella* individuals (larvae & pupae) (the second studied pest) and the percentages of the pest parasitism, that were also evaluated as follow:

$$\text{The percentages of the parasitism of diamondback moth, } P.xylostella = \frac{\text{Total no. of the formed parasitoidś cocoons}}{\text{Total no. of the individuals (larvae \& pupae) of the diamondback moth, } P.xylostella} x100$$

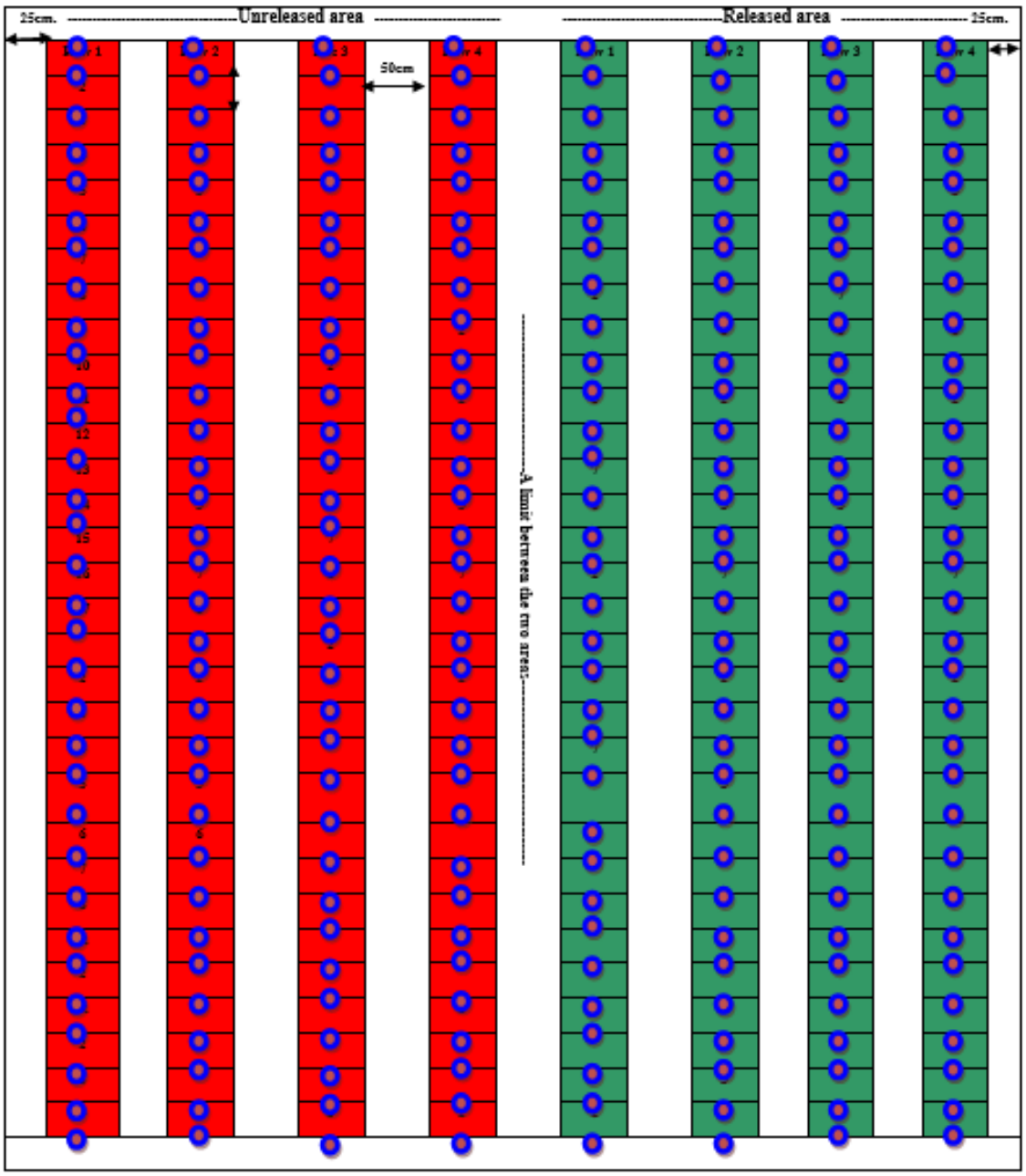

Fig. 2: Two areas field (unreleased area with no predators release) and released one (where, the second instar larvae of the predatory, *Ch. carnea* were released, where, this diagram will give a clear explanation of the designed experiment.

- The emerged parasitoidś species that were emerged were carefully identified at the Department of Biological Control Research, Plant Protection Research Institute, Cairo. Egypt.

4- The source of the second instar larvae of the lacewing predator, *Ch. carnea* (Fig., 3) was obtained from the ″ laboratory mass-rearing unit" that is located at the Faculty of Agricultural, Cairo University, Giza.

Fig. 3: The adult predator that emerged after releasing the predatory second instar larvae of the lacewing predator, *Ch. carnea* (in released area), against the cabbage aphid and the diamondback moth individuals, attacking cauliflower field.

- A field biological control experiment was performed, where releasing of the was only in released experimental area (with a rate of 5 second instar larvae of the predator/one plant×20 plants = a total of 100 second instar larvae), in 27/2/2024 (i.e., in the last week of February, 2024)
- The percentages of reduction in the populations of the two pests′ individuals per season, 2024 after releasing the second instar larvae of the lacewing predator, *Ch. carnea* (in released area), in comparing with unreleased area, were estimated throughout the season to evaluate the role of the released predator in suppressing the population density of the two studied pests, according to the following equation:

$$\textbf{Reduction}\ (\%) = \left(100 - \frac{\text{Total no. of individuals in the released area}}{\text{Total no. of individuals in the unreleased area}}\right) \times 100$$

5- Moreover, taking into consideration the measurements of the cauliflower diameters of the obtained cauliflower crop and their weight, where, they were calculated after103 days post cauliflower planting in13/3/2024 (i.e., in the third week of March, 2024).

6- The means′ values of the resulted data (where, the least significant difference was carried out at 1&5% levels of probability) and also the r-values (correlation coefficient) were estimating by using SPSS computerized program version14.0. As for the means of the temperature and the relative humidity, they were obtained from the Meteorological Station at A.R.C. in order to study their effects on many of the studied ecological factors.

RESULTS AND DISCUSSION

The Population Density of the Aphid (Adults and Nymphs) Infesting Cauliflower and the Percentages of its Parasitism:

As presented in Table (1) and Figures (4,5&6), the adults started with low numbers of 2 & 2 adults, in case of unreleased area and released one, during first week of January, 2024 (i.e., in 2/1/2024).Then, they increased in their numbers until reaching the highest total numbers of 42 &24 adults, in the last and third weeks of January, 2024 (in 30/1/2024 & 23/1/2024, respectively); in case of unreleased area and released one. Finally, their numbers gradually declined until they completely disappeared by the end of the season in the third week of April 2024 (in 23/4/2024).at the end of the season in third week of April, 2024 (in 23/4/2024). The recorded adults per season were; 12.76±3.00 (0-42) & 6.47±1.93 (0-24), respectively.

Table 1: The individuals of the cabbage aphid, *B. brassicae*, recorded in both unreleased and released areas of cauliflower field experiment, during season 2023/2024, in Qalubia Governorate.

Dates of inspection	The unreleased area (no predatory larvae release)					The released area of the predatory larvae of *Ch. carnea*					Mean weather factors	
	A	%	N	%	Total	A	%	N	%	Total	C°	R.H.%
2/1/2024	2	20.00	8	80.00	10 (0.25&0.13)#	2	20.00	8	80.00	10 (0.25&0.13)	17.20	71.80
9/1	8	16.67	40	83.33	48 (0.35&0.60)	6	12.50	35	87.50	41 (1.03&0.51)	17.90	60.86
16/1	21	11.73	158	88.27	179 (4.48 &2.24)	15	10.64	126	89.36	141 (3.53&1.76)	16.09	49.77
23/1	35	11.33	274	88.67	309 (7.73&3.86)	24	10.21	211	89.79	235 (5.88&2.94)	18.09	45.40
30/1	42	6.56	598	93.44	640 (16.00&8.00)	21	8.02	243	92.05	264 (6.60&3.30)	15.43	60.09
6/2	26	5.99	408	94.01	434 (10.85&5.43)	15	5.02	284	94.98	299 (7.48&3.74)	13.17	55.91
13/2	18	2.16	817	997.84	835 (20.88&10.44)	11	1.90	569	98.10	580 (14.50&7.25)	17.13	60.73
20/2	16	1.11	1421	98.89	1437 (35.93&17.96)	8	0.61	1294	99.39	1302 (32.55&16.28)	16.63	54.80
27/2*	12	0.75	1584	99.25	1596 (39.90&19.95)	5	0.37	1347	99.63	1352 (33.80&16.90)	17.07	62.70
5/3	11	0.95	1152	99.05	1163 (29.081&14.54)	2	0.32	631	99.68	633 (15.83&7.91)	19.26	48.96
12/3	10	0.91	1091	99.09	1101 (27.53 &13.76)	1	0.31	322	99.69	323 (8.08&4.04)	18.33	52.64
19/3	8	1.25	631	98.75	639 (15.98&7.99)	0	0.00	85	100.00	85 (2.13&1.06)	18.69	58.81
26/3	6	1.07	555	98.93	561 (14.03&7.01)	0	0.00	57	100.00	57 (1.43&0.71)	17.96	48.24
2/4	2	0.58	342	99.42	344 (8.60&4.30)	0	0.00	34	100.00	34 (085&0.43)	23.50	45.07
9/4	0	0.00	141	100.00	141 (3.53&1.76)	0	0.00	16	100.00	16 (0.40&0.20)	22.20	54.65
16/4	0	0.00	86	100.00	86 (2.15&1.08)	0	0.00	7	100.00	7 (0.18&0.09)	25.21	45.11
23/4	0	0.00	25	100.00	25 (0.63&0.31)	0	0.00	3	100.00	3 (0.08&0.04)	25.21	45.11
Total /season	217	2.27% (0..00-20.00%)	9331	97.73% (0.00-100.00%)	9548 (14.04&7.02) individuals	110	2.05% (0.00-20.00%)	5272	97.95% (0.00-100.00%)	5382 (7.91&3.96) individuals	Mean /season	
Mean total /season	12.76± 3.00 (0-42)		548.88 ± 122.30 (8-1548)		561.65± 122.91 (10-1596)	6.47 ± 1.93 (0-24)		310.12 ± 103.13 (3-1347)		316.59 ± 103.41 (0-1352)	18.77 C°	54.16 R.H.%
% of reduction in the adults was 49.31%.			**% of reduction in the nymphs was 43.61%.**			**% of reduction in the aphid individuals (adults & the nymphs) was 43.74%.**						

Note: A=Adults of the aphid N=Nymphs of the aphid % = The percentages of the occurrence. *The date of releasing the predatory larvae of the lacewing, *Ch. carnea*. # Mean total numbers of aphid individuals/one plant &the mean total numbers of aphid individuals/one leaf.

Fig. 4: Aphid individuals that were recorded in unreleased area attacking cauliflower plants.

As for nymphs, they started in low numbers of 8 & 8, in case of unreleased area and released one, during the first week of January, 2024 (in 2/1/2024). Aphid nymphs increased in their numbers until reaching the highest total numbers of 1584 & 1352,

during the last week of February, 2024 (in 27/2/2024). They gradually decreased until they were appeared with low numbers of 25&3, in third week of April, 2024 (in 23/4/2024), respectively. The mean total numbers of nymphs per the season were; 548.88±122.30 (8-1548) & 310.12±103.13 (3-1347), respectively. Also, he recorded total numbers of nymphs on cauliflower plants were higher than those for adults' ones.

Generally, the aphid individuals (nymphs & adults), started to appear with low numbers of 10 & 10, in case of unreleased area and released one in first week of January, 2024 (in 2/1/2024). Aphid individuals were increased to the highest of 1596&1352, during last week of February, 2024 (in 27/2/2024). They gradually decreased in their numbers until they were appeared with low numbers of 25 & 3, at the end of the season, respectively. The mean total numbers of individuals were; 561.65±122.91 (10-1596) & 316.59±103.41 (0-1352), respectively. The cabbage aphid, *B. brassicae* was recorded infesting the cauliflower plants by Saleh (2000) and Rimaz & Valizadegan (2013).

In addition, from Table (1) and Figs (5&6), the percentage of aphid reduction in released area was 43.74%., in comparing with unreleased one, this indicated that the predator had a role in suppressing the pest population.

Fig. 5: The infestation comparison between released experimental area A (showing no pests′ infestation to the plants) and unreleased one B (showing pest infestation).

In similar results, Driesche *et al.* (1987) found that, releasing the lacewing predator, *Ch. carnea* could be highly controlled aphidś species; *Myzus persicae, Aphis gossypii* and *Macrosiphum euphorbiae* in greenhouse crops.

The occurrence of the mummies of the parasitized the cabbage aphid (attacking the cauliflower plants), were shown in Table (2) and Figures (6&7). They started to appear with low numbers (2&1 mummies), during the first week of January, 2024 (in 9/1/2024). Then, they had maximum total numbers of 391&317, during the last week of February, 2024 (in 27/2/2024), for unreleased area and released one. Finally, the total numbers of mummies decreased until reaching 1&0, respectively, in the end of cauliflower seasonal experiment, during the last week of April 20204 (in 23/4/2024). The mean mummies per the season were; 123.53±31.83 (0-391) & 65.06±25.33 (0-317), respectively.

Table 2: The aphid parasitoid mummies and the percentages of the its parasitism, that were recorded in the both unreleased and released areas of the cauliflower field, during season 2024, in Qalubia Governorate.

Dates of inspection	The unreleased area		The released area	
	Total no. of mummies	% Parasitism	Total no. of mummies	% parasitism
2/1/2024	0	0.00	0	0.00
9/1	2	4.17	1	2.44
16/1	17	9.50	11	7.80
23/1	31	10.03	18	7.66
30/1	89	13.91	31	11.83
6/2	187	43.09	102	34.11
13/2	244	29.22	156	26.90
20/2	360	25.05	308	23.66
27/2*	391	24.50	317	23.45
5/3	258	22.18	119	18.80
12/3	234	21.25	27	17.65
19/3	129	20.19	11	12.94
26/3	90	16.04	4	7.02
2/4	51	14.83	1	2.94
9/4	11	7.80	0	0.00
16/4	5	5.81	0	0.00
23/4	1	4.00	0	0.00
Total no. /season	Total no. of the formed mummies of the cabbage aphid *B. brassicae* /season 2100(0-391)	Mean % of parasitism /season 21.99% (0.00-43.09%)	Total no. of the formed mummies of the cabbage aphid *B. brassicae* /season 1106(0-317)	Mean % of parasitism /season 20.55% (0.00-34.11%)
Mean total no./season	The mean total no. /season was 123.53±31.83 Mummies		The mean total no. /season was 65.06±25.33 mummies	

*The date of releasing the predatory larvae of *Ch. Carnea*

Fig. 6: The mummies of the aphid parasitoid that were recorded in cauliflower field.

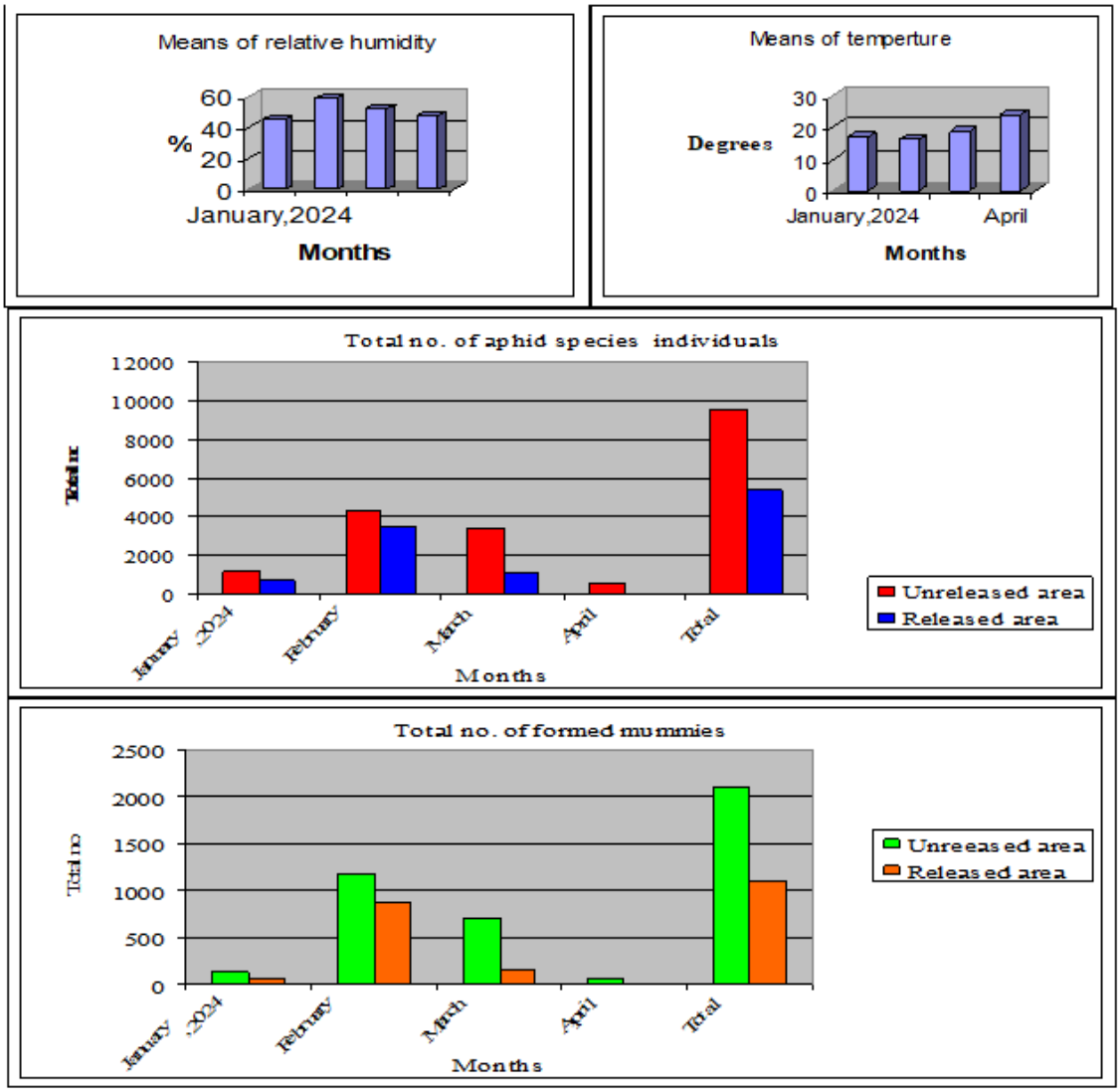

Fig. 7: Monthly aphid individuals (nymphs & adults) and formed mummies, which were recorded in unreleased and released areas, in cauliflower field during season 2024, in Qalubia Governorate.

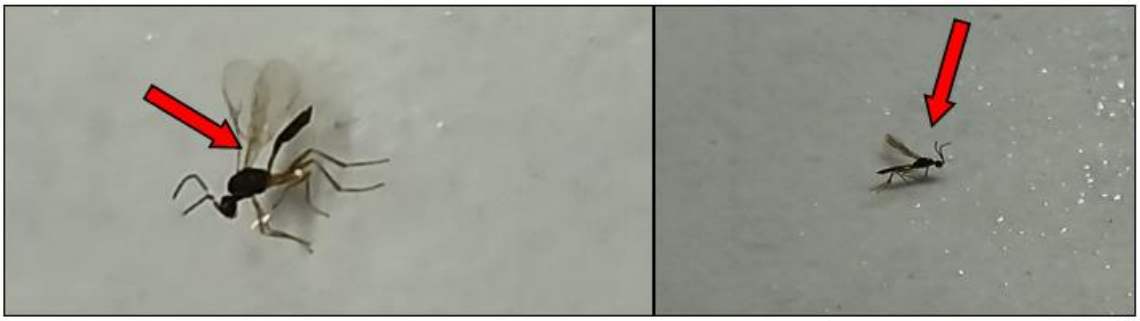

Fig. 8: The hymenopterous primary parasitoid, *D. rapae* that was recorded parasitizing the cabbage aphid, *B. brassicae in* cauliflower field experiment.

The highest percentages of parasitism of the cabbage aphid, *B. brassicae* by D rapae (Fig.8) were; 43.09 & 34.11, in case of the unreleased area and released one, respectively, that were obtained during the second week of February, 2024 (in 6/2/2024). While, the seasonal mean percentages of parasitism recorded were 21.99% (0.00-43.09%) & 20.55% (0.00-34.11%), respectively. This important parasitoid role was indicated by

many authors such; Stark & Acheampong (2007) and Saleh *et al.* (2009). Also, Jankowska & Wiech (2003) stated that, the parasitoid, *D. rapae* is a good biological control agent against *B. brassicae* population. While, Singh & Singh (2015) and Abdel-Galil *et al.* (2019) showed that, the parasitoid, *D. rapae* exclusively parasitizes the aphids infesting many of the cultivated agricultural plants and the wild ones.

It was clear from the obtained data that, the total numbers of the aphid mummies were higher in the unreleased area than in the released one. As, the occurrence of the predator in the released area had decreased the population of the aphid species and hence the recorded percentages of parasitism.

The Population Density of the Diamondback Moth, *P. xylostella* Individuals (Larvae and Pupae) Attacking Cauliflower Plants, the Total Numbers of Parasitoidś Cocoons and the Percentages of its Parasitism:

Table (3) and Figures (9&10), demonstrated that, the diamondback moth, *P. xylostella* larvae started to appear with low numbers of 1&1 larvae, in case of the unreleased area and released one, in second week of January, 2024 (in 9/1/2024). Pest larvae increased in their numbers until reaching the maximum total numbers of 76 & 52, respectively, during second week of April, 2024 (in 9/4/2024). Finally, they gradually deceased in their numbers until they were appeared with low numbers of 11&7, respectively, in the end of cauliflower seasonal experiment in last week of April, 2024 (in 23/4/2024). The mean total numbers of larvae per season were 21.59±5.11&15.76±3.70, respectively.

The pupae were started to appear with low numbers of 1&1, in case of unreleased area and released one, respectively, during the third week of January, 2024 (in 23/1/2024). Then, they reached their maximum of 9&8, during the second week of April, 2024 (in 9/4/2024), respectively. Finally, the total numbers of the pupae decreased to reach the total numbers of 3&1, respectively, during the last week of April, 2024 (in 23/4/2024),while, the mean per season were 3.35±0.66 (0-9) & 3.06±0.58 (0-8), respectively. Moreover, the obtained results revealed that, larvae of the diamondback recorded in cauliflower field were higher in their numbers than those of the pest pupae.

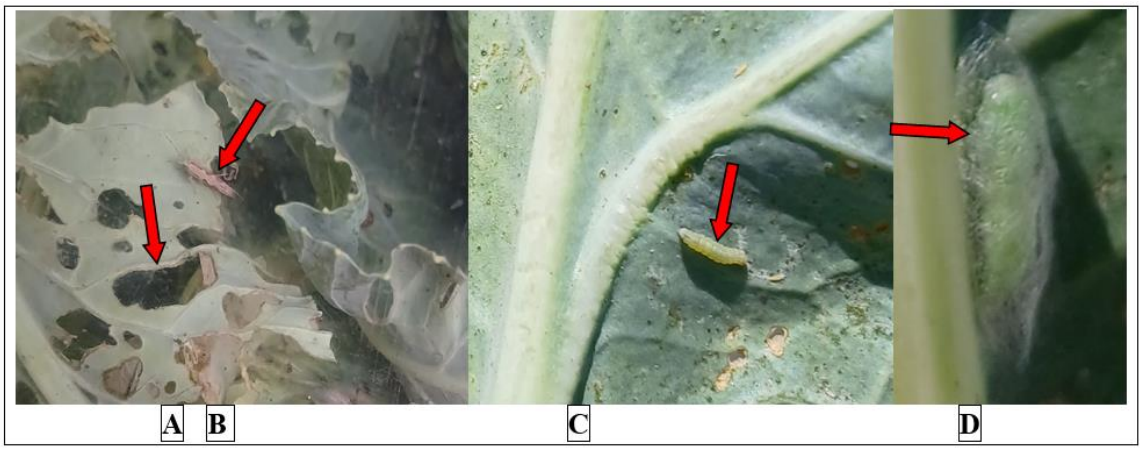

Fig. 9: The infestation of cauliflower plants by the diamondback moth, *P. xylostella*, that was recorded in unreleased area in cauliflower field. A= the damage of cauliflower plants by the pest & B= adults of the pest C= larva of the pest D= pupa of the pest.

Generally, the diamondback moth, *P. xylostella* individuals (larvae & pupae) were started to appear with low numbers of 1&1, in case of the unreleased area and released one, during second week of January, 2024 (in 9/1/2024). Then, pest individuals

(larvae & pupae), were increased in their numbers to 85&60, respectively, in second week of April, 2024 (in 9/4/2024). Finally, they gradually deceased in their numbers until they were appeared with low numbers of 14&8 individuals at the end of the season, also, the mean total numbers of individuals (larvae & pupae) per the season were; 24.94±5.73 (0-85) &19.00±4.21 (0-60), respectively. However, the diamondback moth, *P. xylostella* was shown to attack cauliflower plants by Tabone *et al.* (2010) and Pagore *et al.* (2021).

Table 3: Weekly total numbers of the diamondback moth, *P. xylostella* (larvae & pupae), total numbers of the parasitoidś cocoons and the percentages of parasitism, that were recorded in cauliflower field, during season 2024, in Qalubia Governorate.

Dates of inspection	The unreleased area								The released							
	The pest species			The pest parasitoids					The pest species			The pest parasitoids				
	L	P	Total no.	Total no. of cocoons	% of parasitism	Total no. of adults	A	B	L	P	Total no.	Total no. of cocoons	% of parasitism	Total no. of adults	A	B
2/1/2024	0	0	0	0	0.00	0	0	0	0	0	0	0	0.00	0	0	0
9/1	1	0	1	0	0.00	0	0	0	1	0	1	0	0.00	0	0	0
16/1	3	0	3	0	0.00	0	0	0	2	0	2	0	0.00	0	0	0
23/1	4	1	5	0	0.00	0	0	0	3	1	4	0	0.00	0	0	0
30/1	6	2	8	0	0.00	0	0	0	5	2	7	0	0.00	0	0	0
6/2	8	2	10	0	0.00	0	0	0	7	2	9	0	0.00	0	0	0
13/2	10	3	13	2	15.38	1	1	0	9	3	12	1	8.33	1	1	0
20/2	14	3	17	3	17.65	2	1	1	10	4	14	2	14.29	1	1	0
27/2*	17	2	19	4	21.05	3	2	1	12	5	17	3	17.65	2	2	0
5/3	21	4	25	6	24.00	5	4	1	14	5	19	4	21.05	3	3	0
12/3	27	5	32	9	28.12	8	5	3	20	6	26	7	26.92	4	3	1
19/3	35	3	38	12	31.58	10	6	4	24	3	27	8	28.57	5	4	1
26/3	40	5	45	16	35.56	12	8	4	30	5	35	11	31.43	8	5	3
2/4	49	7	56	22	39.29	14	9	5	44	6	50	17	34.00	11	8	3
9/4	76	9	85	25	29.41	18	10	8	52	8	60	14	23.33	12	8	4
16/4	45	8	53	6	11.32	4	2	2	28	4	32	2	6.25	1	1	0
23/4	11	3	14	1	4.55	1	1	0	7	1	8	0	0.00	0	0	0
Total no. /season	367 (0-76)	57 (0-9)	424 (0-85	107 (0-25)	Mean % of parasitism season 25.24% (0.00-39.29%)	78 (0-18)	49 (0-10)	29 (0-8)	268 (0-52)	55 (0-8)	323 (0-60)	69 (0-17)	Mean % of parasitism season 21.36% (0.00-34.00%)	48 (0-12)	36 (0-8	12 (0-4)
Mean total no./season	21.59 ± 5.11	3.35 ± 0.66	24.94 ± 5.73	6.24 ± 1.95		4.59 ± 1.39 % of** adults /season 72.90%			15.76 ± 3.70	3.23 ± 0.58	19.00 ± 4.21	4.06 ± 1.32		2.82 ± 0.96 % of adults /season 69.57%		
The reduction percentage in the total numbers of the diamondback moth, *P. xylostella* (larvae & pupae) per season, in the released area was 23.82%.																

Note: L= Larvae of the pest P= Pupae of the pest A= the parasitoid, *D. semiclausum* B= the parasitoid, *C. plutellae*

*The day of the releasing of the second instars larvae of the lacewing predator, *C. carnea*.

** Percentages of adults' parasitoids emergence from their cocoons.

However, from Table (3) and Figure (10), it was clear that , the reduction percentage in the total numbers of the diamondback moth, *P. xylostella* (larvae & pupae) per season, in the released area was 23.82%, in comparing with the unreleased one, this indicated that the predator had a role in suppressing the pest population. Similarly, Lingren *et al.* (1968) showed that, the common lacewing predator, *Ch. carnea* preyed on the corn earworm, *Helicoverpa zea* (which is a Lepidopteron pest).

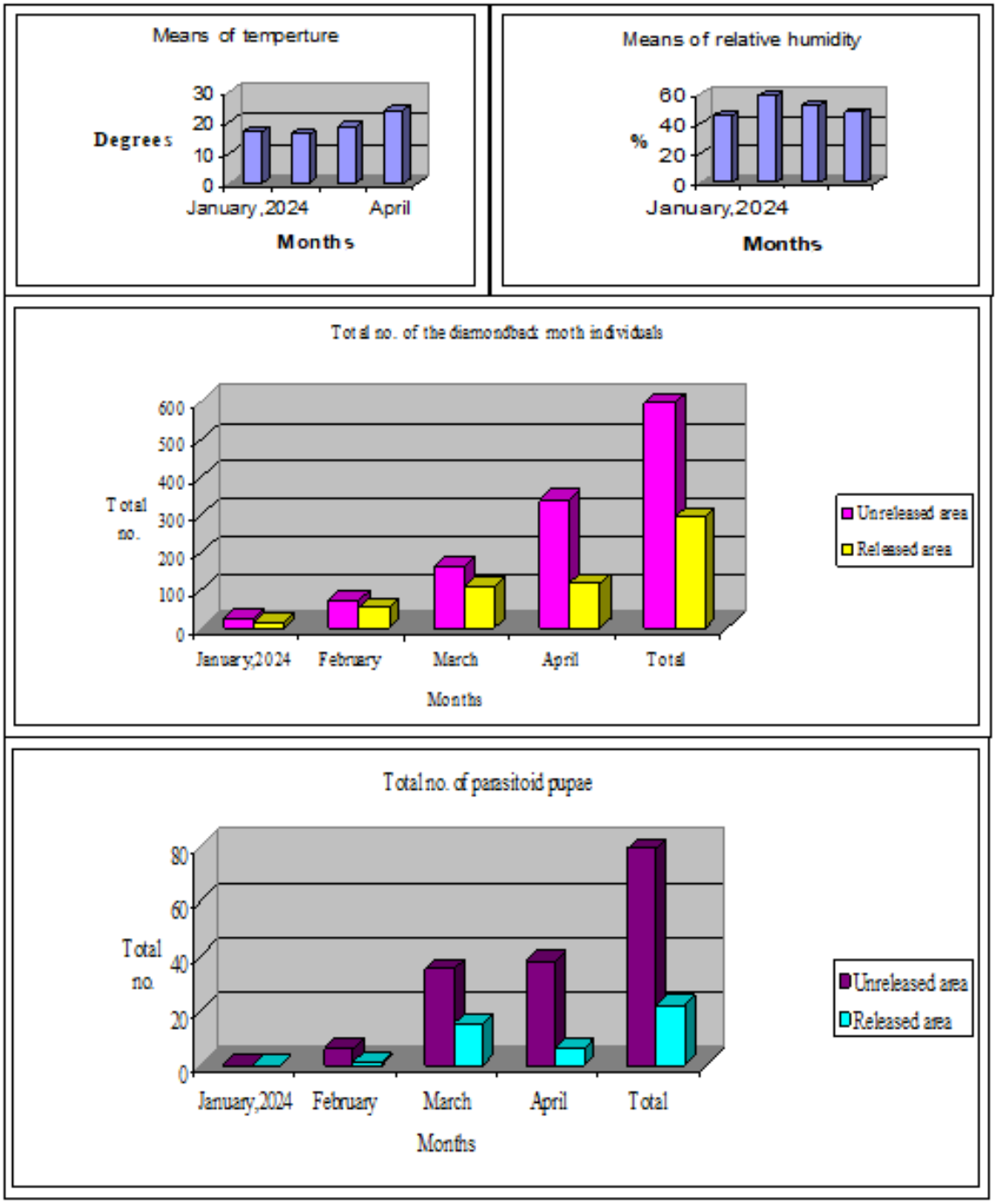

Fig. (10): Monthly total numbers of the diamondback moth, *P. xylostella* individuals (larvae & pupae) and parasitoidś cocoons, that recorded in cauliflower field during season 2024, in Qalubia Governorate.

As shown in Figure (11), the two hymenopterous endoparasitoid species; *Cotesia plutellae* (Kurdjumov) (Braconidae) and *Diadegma semiclausum* (Hellen) (Ichneumonidae) were the parasitoids species that were only surveyed parasitizing the diamondback moth, *P. xylostella* attacking the cauliflower plants. results were similar to Azidah *et al.* (2000) where, the two previous parasitoidś species were shown to parasitize the pest species and they were considered as an important limiting factor in controlling it.

It was obvious from Table (3), that, the beginning of the parasitism of the diamondback moth, *P. xylostella* were recoded in second week of February, 2024 (in 13/2/2024), where the percentages of parasitism were; 15.38% & 8.33%, for unreleased

and released areas, in addition, maximum percentages of parasitism were; 39.29% & 34.00%, which were obtained during first week of April, 2024 (in 2/4/2024). But, the mean percentages of parasitism per season were; 25.24% (0.00-39.29%) & 21.36% (0.00-34.00%), respectively. The obtained results indicated the occurrence of a positive relationship where, the percentages of the parasitism of pest populations were simultaneously increased as the pest populations were increased. The first parasitoid species, *D. semiclausum* had more numbers per the season (which were 49&36) than the second parasitoid, *C. plutellae* (which were 29&12), in comparing unreleased area with releasing one, respectively. This finding had been considered as an indicator of the great important role of the two surveyed parasitoidś species; *D. semiclausum* and *C. plutellae*, as natural enemies against the diamondback moth, *P. xylostella* populations.

Therefore, the total numbers of the diamondback moth, *P. xylostella* cocoons was higher in the unreleased area than in the released one. Where, the predator in the released area had suppressed the total numbers of the pest and also had suppressed the percentages of its parasitism.

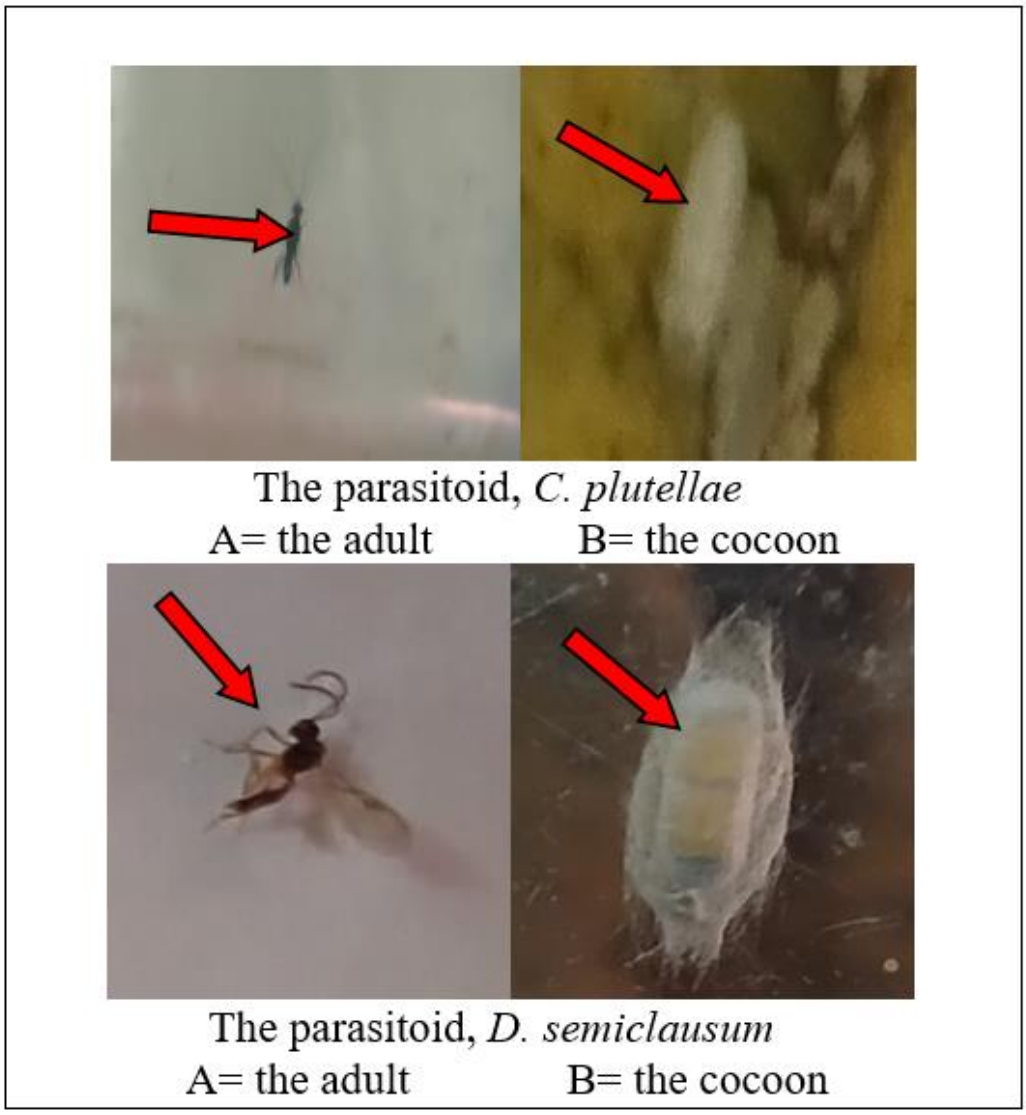

Fig. 11: The two parasitoidś species which were surveyed parasitizing the diamondback moth, *P. xylostella* in experimental cauliflower field.

The Meanś Calculations of the Measurements of the Length of the Half Circle (cm.), the Cauliflower Diameter (cm.), and also the Estimation of the Means of the Weight (gm.), of Resulted Cauliflower:

The meanś calculations of the measurements of the length of the half circle (cm.), the cauliflower diameter (cm.), and also the estimation of the means of the weight (gm.) of the resulted cauliflower after 103 days from cauliflower planting, for both the unreleased area and the released one during season 2024, in Qalubia Governorate, were shown in Table (4) and Figure (12). The obtained data revealed that, the means of the measurements of the length of the half circle (cm.), the cauliflower diameter (cm.), and also the estimation of the weight (gm.), of the resulted cauliflower were; (36.34±1.76cm. (30-45cm.)) & (37.22±1.44cm. (31-45cm.)), (12.89±0.59cm. (11-16cm.) & (13.00±0.69cm. (11-16cm.)) and (300.67±25.37gm. (100-650gm.)) & (396.33±53.51gm. (100-650gm.)), for the three tested groups of the field experiment, in case of unreleased area and released one, respectively.

Fig. 12: The different resulted cauliflower weights and sizes that were recorded after 103 **days** from the cauliflower planting.
A= the highest weight & size B= the lowest weight & size

Table 4: The means′ calculations of the measurements of the cauliflower diameter (cm.), the length of the half fruit circle (cm.) and also the estimation of the means weight (gm.), of the resulted cauliflower after 103 days post planting, for both the unreleased and the released areas of the cauliflower field during season 2024, in Qalubia Governorate.

Tested groups	The unreleased area			The released area		
	The measurements mean (cm.) *		The means weight of the resulted cauliflower (gm.) **	The measurements means (cm.)		The means weight of the resulted cauliflower (gm.)
	Length of the half circle (cm.)	The cauliflower Diameter (cm.)		Length of the half circle (cm.)	The cauliflower Diameter (cm.)	
Group1	33.67 (31-38)	12.00 (11-13)	270.00 (100-650)	39.67 (31-45)	14.00 (12-16)	290.00 (100-550)
Group 2	39.67 (31-45)	14.00 (12-16)	281.00 (100-550)	34.67 (32-38)	11.67 (11-12)	460.00 (150-650)
Group 3	35.67 (30-43)	12.67 (12-13)	351.00 (250-450)	37.33 (31-43)	13.33 (12-16)	439.00 (100-650)
The means of all the three groups ±S.E.	36.34±1.76cm. (30-45cm.)	12.89±0.59cm. (11-16cm.)	300.67 ±25.37gm. (100-650gm.)	37.22±1.44cm. (31-45cm.)	13.00±0.69cm. (11-16cm.)	396.33±53.51gm. (100-650gm.)

Note: * = representing 3 replicates of each group. ** = representing 10 replicates of each group.

Correlations that were Recorded in Cauliflower Experiment:

As shown in Table (5), statistical analysis of the obtained data revealed highly positive relationships that found in case of comparing adults, nymphs, aphid individuals (adults & nymphs) and mummies of the parasitoid *D. rapae* (r-values were; 0.948****, 0.893***, 0.892*** and 0.901****, respectively).

Moreover, highly positive relationships were shown for larvae, pupae and the diamondback moth, *P. xylostella* larvae & pupae and also parasitoids′ cocoons (r-values were; 0.985****, 0.846***, 0.983****and 0.980****, respectively).

As for the resulted cauliflower after 103 days post planting, highly negative relationships were observed in comparing the means of the measurements of the cauliflower diameter (cm.) and the length of the half cauliflower circle (cm.) (r-values were; -0.988****and-0.999****, respectively). Besides, a positive relationship was indicated in comparing the weight (gm.) (r-value was 0.510*).

Table 5: Correlations that existed in the cauliflower experiment (by comparing means).

Tested factors	The correlations (r-values)
A- The cabbage aphid	
Adults	0.948****
Nymphs	0.893***
Individuals (adults & nymphs)	0.892***
Mummies of the parasitoid, *D. rapae*	0.901****
B- The diamondback moth	
Larvae	0.985****
Pupae	0.846***
Individuals (larvae & pupae)	0.983****
Parasitoids′ cocoons	0.981****
C- The resulted cauliflower	
Length of half circle	-0.988****
Diameter	-0.999****
Weight	0.510*

• Significant r-values (0.500-0.600) **Moderate significant (0.600-0.800) ***Highly significant (0.800-0.900) ****Very highly significant>0.900.

The Natural Relationships that were Existed in the Unreleased area in the Cauliflower Field, Between Many Tested Factors and Temperature & Relative Humidity:

The natural relationships that were existed (in the unreleased area in cauliflower field, between the cabbage aphid, the diamondback moth populations and f the weather factors (such as; temperature and relative humidity), during the season, 2023/2024 (in Qalubia Governorate), were shown in Table (6). However, the following relationships were recorded during the study:

Table 6: The natural relationships between the studied ecological factors and some weather factors (Temperature & Relative humidity) in the unreleased area of cauliflower field for the two studied pests.

Tested factors	Tested factors × means of temp. (°c)	Tested factors × means of R.H.%
A- The cabbage aphid		
Adults	-0.682** (▪sign=0.003)	0.084 (▪sign=0.748)
Nymphs	-0.352 (sign=0.165)	0.152 (▪sign=0.561)
Individuals (adults & nymphs)	-0.368 (sign=0.146)	0.153 (▪sign=0.558)
Mummies of the parasitoid, *D. rapae*	-0.422 (sign=0.091)	0.221 (▪sign=0.393)
B- The diamondback moth		
Larvae	0.585* (sign=0.014)	-0.352 (▪sign=0.166)
Pupae	0.663** (sign=0.004)	-0.473 (▪sign=0.055)
Individuals (larvae & pupae)	0.598* (sign=0.011)	-0.368 (▪sign=0.146)
Parasitoids' cocoons	0.470 (sign=0.057)	-0.290 (▪sign=0.259)

-The Relationships Recorded Between Many Ecological Factors and Means of Temperature:

A negative moderate relationship was recorded in case of the mean total numbers of the cabbage aphid adults (r-value was -0.682**).

But no relationships were recorded for nymphs, aphid individuals (adults & nymphs) and mummies of the parasitoid *D. rapae* (r-values were; -0.352, -0.368 and -0.422, respectively).

Positive relationships were found in case of the diamondback moth larvae, pupae and pest individuals (larvae & pupae) (r-values were; 0.585*, 0.663**and 0.598*, respectively), while, no relationship was recorded for parasitoids′ cocoons (r-value was 0.470).

- The Relationships Observed Between Many Ecological Factors and Means of Relative Humidity:

No relationships were recorded in case of adults, nymphs, aphid individuals (adults & nymphs) and mummies of the parasitoid *D. rapae* (r-values were; 0.084, 0.152, 0.153 and 0.221, respectively).

No relationships were recorded in case of larvae, pupae, the diamondback moth individuals (larvae & pupae) and parasitoids′ cocoons (r-values were; -0.352, -0.473, -0.368 and -0.290, respectively).

In conclusion, the obtained results indicated the population densities of two major cauliflower pests; the cabbage aphid, *B. brassicae* and the diamondback moth, *P. xylostella*. Also, supporting the important role of the biological control via releasing the second instar larvae of the lacewing predator, *Ch. carnea* against the two pests, in order to decrease their infestation levels in the cauliflower fields. Many attempts were made to use the lacewing predator, *Ch. carnea* in the field of the biological control (Nordlund & Marrison, 1992), where, it is taken as representative of Chrysopidae to be used in the applications of the biocontrol control programs. This magnification of the role of this important predator by the direct and the extensive field releases has becomes very necessary for future more concentrated perfect wide spread applications. The natural role

of the common parasitoids in the ecosystem can share in suppressing the two pests' populations in cauliflower fields. However, the findings were similar to those of Talakar & Shelton (1993), who stated that, the hymenopterous parasitoids can play an important role in the regulation of the populations of the diamondback moth, *P. xylostella*. Such ecological information and also, the performed biological control experiment by using the predator must be carefully taken in consideration in the field of the biological control. Therefore, research attempts and applications control methods must be continuously developed and encouraged for substituting the harmful hazard effects of the extensive uses of the chemical control methods, in order to decrease the environmental pollution and hence will directly or indirectly help in improving man heath and also his surrounding environment.

Declarations

Ethical Approval: Not applicable.

Competing Interests: The authors declare that there were no conflicts of interest.

Authors' Contributions: All authors contributed to the study plan, sample collection and preparation of field experiment and carrying out it, interpretation of results, and writing, reviewing, and editing the manuscript.

Funding: No funding was received.

Availability of Data and Materials: All datasets analyzed and described during the present study are available.

Acknowledgements: Not applicable.

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ARABIC SUMMARY

دور عوامل الأعداء الحيوية في تنظيم تعداد الآفات على القرنبيط: دراسة حقلية على من° الكرنب والفراشة ذات الظهر الماسي.

إسماعيل عبد الحليم بهى الدين، محمد أحمد محمد على ، محمد عبد اللطيف عبد الله بازيد ومصطفى أحمد محمد الخواص.

قسم بحوث المكافحة الحيوية – معهد بحوث وقاية النباتات – مركز البحوث الزراعية.

أجريت الدراسة الحالية بهدف دراسة عملية الإطلاق الحقلي لمفترس أسد المن the lacewing (Neuroptera: Chrysopidae) predator, *Chrysoperla carnea* (Stephens) ومدى تأثيره على كثافة التعداد ونسب التطفل لكلا" من منْ الكرنب the cabbage aphid, *Brevicoryne brassicae* L. (Homoptera: Aphididae) والفراشة ذات الظهر الماسي the diamondback moth, *Plutella xylostella* L. (Lepidoptera: plutellidae) , المهاجمة لنباتات القرنبيط, في محافظة القليوبية خلال الموسم 2024/2023م. وقد تم تقسيم التجربة في الحقل إلى منطقتين: المنطقة الأولي وتمثل المنطقة التي بدون إطلاق ليرقات المفترس (الكنترول) والثانية والتي تمثل منطقة الإطلاق ليرقات العمر الثاني لمفترس أسد *Ch. carnea*.

أظهرت النتائج المتحصل عليها أن فترة تواجد من° الكرنب *B. brassicae* علي نباتات القرنبيط , كان خلال الأربعة أشهر للدراسة (أي خلال الفترة من شهر يناير حتى شهر ابريل 2024). وكان أعلي تعداد لأفراد من° الكرنب *B. brassicae* (حشرات كاملة & حوريات), وكذلك أعلى تعداد لمومياوات طفيل المن° *Diaeretiella rapae* (M' Intosh) (Hymenoptera: Aphidiidae) الوحيد المسجل متطفلا" على الآفة في خلال الأسبوع الأخير من شهر فبراير 2024م , في كلا" من منطقتي عدم الإطلاق, وكذلك منطقة الإطلاق للمفترس. ويمثل تزامن زيادة تعداد منْ الكرنب *B. brassicae* , مع زيادة تعداد طفيل المن *D. rapae* دليلا" على مدى الأهمية للطفيل كعدو طبيعي ضد الآفة. وقد بلغت نسبة الخفض في تعداد المن° للموسم 43.74 % , في منطقة إطلاق مفترس أسد المن° *Ch. carnea* , بالمقارنة بمنطقة عدم الإطلاق للمفترس.

وعلاوة على ذلك، فإن فترة التواجد للفراشة ذات الظهر الماسي *P. xylostella*, على نباتات القرنبيط كانت خلال الأسبوع الثاني من يناير 2024 حتى الأسبوع الأخير من شهر ابريل 2024. كما بلغ أقصي تعداد للآفة (يرقات & عذارى) خلال الأسبوع الثاني من ابريل 2024. وقد سجل النوعين من الطفيليات التابعيين لرتبة غشائية (Hymenoptera): الطفيل الأول *Cotesia plutellae* (Kurdjumov) (Braconidae) والطفيل الثاني *Diadegma semiclausum* (Hellen) (Ichneumonidae) يتطفلان على الآفة. و أظهرت النتائج تزامن زيادة نسب التطفل للآفة كان مع زيادة أعداد الآفة, كما بلغت النسبة المئوية للخفض في تعداد أفراد الآفة (عذارى & يرقات) للموسم 24.53 % في منطقة الإطلاق ليرقات المفترس, بالمقارنة بمنطقة عدم الإطلاق للمفترس (الكنترول). وشملت التجربة الحقلية في هذه الدراسة أيضا" مقارنة القياس لأقطار وأحجام, وكذلك تقدير الأوزان للقرنبيط الناتج بعد 103 يوما" من تاريخ الزراعة.

وإجمالا", فإن المعلومات البيئية عن الآفتين والدور الطبيعي لأنواع الطفيليات المسجلة وكذلك استخدام المكافحة الحيوية التطبيقية عن طريق تجربة الإطلاق الحقلي ليرقات مفترس أسد المن *Ch. carnea* والتجارب المتحصل عليها من خلال استخدام أسلوب المكافحة الحيوية *Ch. carnea*, يمكن أن تكون ضمن إستراتيجية المكافحة المتكاملة للآفات (I.P.M. strategy), ضد كلا" من منْ الكرنب *B. brassicae* والفراشة ذات الظهر الماسي *P. xylostella*, المهاجمة لحقول القرنبيط, وكذلك حقول محاصيل الخضر الأخرى التي تصاب بالآفتين. وهكذا فان الاتجاه لهذا التطبيق يمكن أن يساعد في تقليل التأثيرات الضارة الحادثة بفعل الاستخدام المكثف لطرق المكافحة الكيميائية, والذي سوف ينعكس بدوره ايجابيا" بتقليل التلوث البيئي بطريقة مباشرة أو غير مباشرة حفاظا" على صحة الإنسان وتحسينا" لبيئته المحيطة