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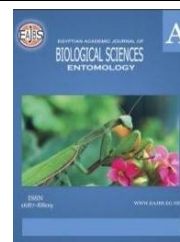
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Biological Natural Role of Major Parasitoids and Predatory Species Associated with Common Insects' Pests, in Cowpea Fields

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ABSTRACT

Cowpea is an important strategic vegetable, representing a part of traditional cropping systems. Several insects' pests attack cowpea during its field development stage (from germination to maturity) and also in stores. In cowpea field, results recoded occurrence of following insects' pests: the leafminer, *Liriomyza trifolii* Burgess (which had highest recorded total numbers of infested leaflets, pest mines and pest larvae during second week of May, 2024), the cowpea aphid, *Aphis craccivora* Koch. (which had highest recorded total number of pest individuals during second week of April, 2024), the leafhopper, *Empoasca* sp. and the green bug *Nezara viridula* L., were also recorded. Two parasitoids' species; *Diglyphus isaea* (Walker) (a larval ectoparasitoid of the leafminer, *L. trifolii*, that was recorded with a maximum parasitism percentage (34.81%) during third week of April, 2024) and *Diaeretiella rapae* (M'Intosh) (a primary endoparasitoid of the cowpea aphid, *A. craccivora*, that was recorded with a maximum parasitism percentage (39.83%) during last week of April, 2024). Two common predatory species were also recorded in cowpea field; including *Chrysoperla carnea* (Steph.) (Neuroptera: Chrysopidae) and Coccinellidae (Coleoptera) predators (which mainly included *Hippodamia convergens* (Geur.) and *Coccinella undecimpunctata* L.), (where, maximum total number of all recorded predatory species individuals (108 individuals) was during second half of April 2024). Means calculations of resulted cowpea green pods yield weight and length after 117days post cowpea grains sowing were evaluated. Generally, occurrence of major natural enemies was directly related with that of recorded pests' species populations. Natural role of two recorded parasitoids species (*D. isaea* and *D. rapae*), besides predatory species (*Ch. carnea* and Coccinellidae), must be continuously protected and they can be used by their mass rearing and releasing against pests' species attacking cowpea fields or other related fields that suffer from common pests' attacks when planning I.P.M. programs.

INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp.) (Fabaceae) being a common crop yield (El-Solimany *et al.*, 2024), representing one of most important strategic vegetables' legume crops (El-Sayed *et al.*, 2021), considering a very important source for farmers' income (Salman *et al.*, 2022) and participating in traditional cropping systems of strategic crop

regions (Isubikalu *et al.*, 2000). It also characterizes by having annually self-pollinated (El-Ghamery *et al.*, 2021), with ability to be cultivated in various occurring agro-ecosystems in the world (Ammar *et al.*, 2024), being mainly cultivated in tropic and subtropics regions. It also has more advantages such as having a great ecological diversity, high temperatures adaptation, its growing ability in a wide soil texture and increasing soil fertility (Mahdy *et al.*, 2021), by providing soil with nitrogen especially in poor one (El-Sayed *et al.*, 2021), that enhance rapid vegetative growth (Giridhar *et al.*, 2020). Cowpea is consumed by human as dried grains and also it is cultivating for gaining money (Ammar *et al.*, 2024), as well as feeding on cowpea plants leaflets and fresh green pods (Sharma *et al.*, 2019), besides using it for animals' feeding in many countries (Hamd Alla *et al.*, 2014). It is characterized by possessing higher lysine and tryptophan amino acids contents compared with those found in cereal grains (El-Afifi *et al.*, 2016), with an excellent alternative rich seeds' protein source reaching up to 23% (El-Sayed *et al.*, 2021) and also carbohydrate reaching up to 57%. While, leaves contain 27–34% protein (Belane & Dakora, 2009), being a good source of vitamins and containing a high proportion of minerals, iron, zinc, fibre and fat (El-Sayed *et al.*, 2021) and it has the highest content of potassium, magnesium and phosphorus in comparing with other legume crops (Hussein & El-Diweany, 2024). Several insect pests were recorded attacking cowpea plants in field (Oyewale & Bamaiyi, 2013), during their normal development stage from grain germination until crop yield maturity (Sardhana *et al.*, 1986), as well as during the grain storage process in stores (Togola *et al.*, 2017), where their infestations were directly or indirectly responsible for obtaining heavy yield losses (Soratur *et al.*, 2017). The leafminer, *Liriomyza trifolii* Burgess (Diptera: Agromyzidae) (Eid, 2008); the cowpea aphid, *Aphis craccivora* Koch. (Homoptera: Aphididae) (Obopile & Ostitile, 2010); the leafhopper, *Empoasca* sp. (Singh, C. & Singh, N, 2014) and the green bug, *Nezara viridula* L. (Homoptera: Pentatomidae) (Ssengoo *et al.*, 2024), were among the common insects' pests attacking cowpea.

For a long time, controlling cowpea pests was mainly depended on using extensive harmful chemicals' insecticides that were responsible for the occurrence of several problems, such as for example: insecticides' resistance and increase in pests' outbreaks (Yeo, 2000) and also disruption of balance between natural enemies and common pests. In modern and newly sustainable agricultural production, Integrated Pest Management (I.P.M.) are preferred control technique (Mohamed *et al.*, 2012), to achieve an acceptable safer agricultural yield production (Rimaz & Valizadegan, 2013). Protection of natural enemies (which represent an important main concept of biological control), are now considered as an essential factor in these applied techniques for building acceptable control strategies (Ghanim *et al.*, 2015). As a result, studying population pests' dynamics (Mostafa, 2006), as well as natural interactions happening in the ecosystem between pests and their natural enemies, side by side with studying the possibility of protecting such beneficial agents, becomes very necessary and represents an essential factor of building I.P.M. strategies (Singh, C. & Singh, N, 2014). Now, modern developed research were focused on the roles of two main principle biological control agents; first one was importance of parasitoids' species (El-Khawas *et al.*, 2008) and second one was great importance of predatory species (Kacar, 2015). Where they play highly noticeable roles against different insects' pests (Abul Fadl & El-Khawas, 2009). For example, two parasitoid' species including *Diglyphus isaea* (Walker) (Hymenoptera: Eulophidae), a primary larval ectoparasitoid of the leafminer, *L. trifolii* (Aamer & Hegazi, 2014) and *Diaeretiella rapae* (M'Intosh) (Hymenoptera: Aphidiidae), a primary endoparasitoid of the cowpea aphid, *A. craccivora* (Saleh *et al.*, 2009) and also, predatory species belonging to many Coccinellidae (Coleoptera) (Bahy El-Din *et al.*, 2013) and lacewing predatory larvae of *Chrysoperla carnea* (Steph.) (Neuroptera: Chrysopidae) (Saleh *et al.*, 2017), were considered as important natural enemies against

insect pests and sharing in their obvious control roles. Hence, the present work was conducted in cowpea field during 2024 season, located at the Plant Protection Research Station in Qaha district, Qalubia Governorate, Egypt. It is mainly carried out for studying population dynamics of common insects' pests attacking cowpea plants and also for focusing light on interaction natural existed between them and their major natural enemies' complex. So, it included the following principle points:

1. Infestation of cowpea plants by the leafminer, *L. trifolii*, total numbers of pest larvae and percentages of its parasitism by *D. isaea* parasitoid species.
2. Total numbers of the cowpea aphid, *A. craccivora* individuals (adults & nymphs) attacking cowpea plants, total numbers of *D. rapae* parasitoid mummies, percentages of its parasitism and percentages of its adults' parasitoid species emergence.
3. Total numbers of other common recorded piercing sucking insect pests including the leafhopper, *Empoasca* sp. and the green bug, *N. viridula*.
4. Recording the total number of common predatory species that were surveyed in cowpea field.
5. Means calculations of some ecological features that were concerned mainly on evaluating of two main characteristics of cowpea green pods yield (including their weight and length), after 117days post post-cowpea grains sowing.
6. Statistical analysis of obtained data that was concerned on studying relationships that existed in cowpea field between principal weather factors (including temperature and relative humidity), with some major recorded ecological factors.

MATERIALS AND METHODS

1. Experimental Design:

1.1. An experimental area of 135 m² (9m. × 15m.), was selected and used in farm at Plant Protection Research Station in Qaha district, Qalubia Governorate, which affiliated to Plan Protection Research Institute (P.P.R.I.), Agriculture Research Center (A.R.C.), where, all agricultural practices were followed except no use at all of any chemical insecticides in this experimental area.

1.2. Cowpea (cultivar Balady) grains were sown in the third week of January 20, 2024 (as a new selected early cowpea cultivation period, to test if there was a possibility of cultivating cowpea in this period, which will help to increase cowpea production by adding a new plantation period in the studied locality) during season 2024. Cultivating cowpea was at distances of 25 cm. from each other, on beds (each of 50 cm. on both sides of them), where distances between these beds were 15cm. Different steps of development of cultivated cowpea plants in field experimental area (from grain germination until the formation of green pods yield, after 117 days post-cowpea sowing) during season 2024, were configured in Figure (1).

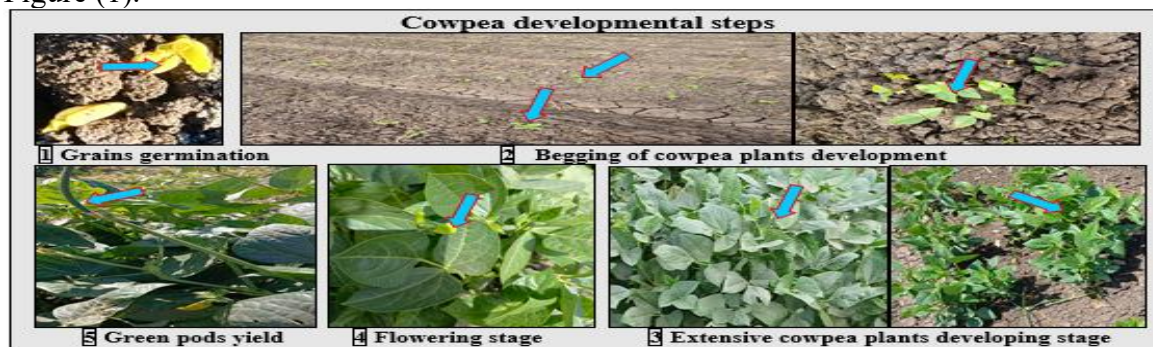


Fig. 1: A diagram (of five images 1, 2, 3 4 & 5) showing developmental steps from grains' germination until formation of green pods yields after 117 days post season 2024.

2. Investigation of Field Samples and Data Calculations.

2.1. Field sampling began in third week of February 20, 2024 (after one-month post cowpea sowing) and ended in second week of May 14, 2024 during season 2024. Random weekly total number of 100 cowpea plants (representing one sample) were directly investigated in cowpea field, for evaluating population dynamics of common insect pests attacking cowpea plants.

2.2. Infested cowpea leaflets with the leafminer, *L. trifolii* were picked up from studied cowpea area, counted and transferred directly to the laboratory for careful investigations under a stereomicroscope, where total numbers of pest larvae were counted. Each infested leaflet was put individually in Petri dishes covered with a layer of filter, waiting until emergence of either adults' pest flies and/or emergence of adults of *D. isaea* parasitoid species. Where, mean total number of the leafminer, *L. trifolii* larvae per one plant, total numbers of emerged adults of *D. isaea* parasitoid species and percentages of parasitism by *D. isaea* parasitoid species were recorded according to techniques described by (El-Khawas, M. & El-Khawas, S., 2005 and Aamer & Hegazi, 2014) as follow:

a. Mean total no. of the leafminer, *L. trifolii* larvae/one plant =
$$\frac{\text{Total no. of pest larvae}}{100 \text{ plants sample}}$$

b. Parasitism (%) =
$$\frac{\text{Total no. of emerged } D. isaea \text{ adults/ parasitoid species}}{\text{Total no. of } L. trifolii \text{ larvae}} \times 100$$

2.3. At the same time, infested leaflets samples with the cowpea aphid, *A. craccivora* were directly investigated in the cowpea field, where total numbers of pest individuals (adults & nymphs) were counted (according to the technique described by Kumar, A. & Kumar, A. (2015). Mean total number of aphid individuals per one plant was estimated according to following equation:

Mean total no. of the cowpea aphid individuals/one plant =
$$\frac{\text{Total no. of pest individuals (adults & nymphs)}}{100 \text{ plants sample}}$$

After that, infested cowpea plants with aphid species were directly brought to the laboratory for calculating percentages of pest parasitism according to technique described by Bahy El-Din *et al.* (2024) as follow:

Parasitism (%) =
$$\frac{\text{Total no. of all aphid mummies) counted in both field and laboratory}}{\text{Total no. of all aphid individuals}} \times 100$$

2.4. Emerged adults' parasitoids' species of either the leafminer, *L. trifolii* and/or the cowpea aphid, *A. craccivora*, were daily collected, counted and stored in 70% ethyl alcohol for identification purposes. Where they were identified at the Department of Biological Control Research, Plant Protection Research Institute, Cairo. Egypt.

2.5. In addition, other piercing sucking insect pests observed during weekly investigation of cowpea plants' were recorded and counted.

Mean total number of each pest species was separately evaluated, along with also estimating the mean total number of all recorded individuals (adults & nymphs) of all piercing sucking insect pests per one cowpea plant, according to the following equation:

Mean total no. of all piercing sucking insects/one plant =
$$\frac{\text{Total numbers of all individuals (adults & nymphs)}}{100 \text{ plants sample}}$$

2.6. At the same time, common predatory species that were surveyed in field cowpea experiment were directly identified and counted.

The percentage of occurrence of each recorded predatory species to each other was calculated according to the equation shown by Facylate (1971) as follow:

Occurrence of each recorded predatory species (%) =
$$\frac{\text{Total no. of each predatory species alone}}{\text{Total no. of all recorded predatory species}} \times 100$$

3. As for cowpea green pods yield, they were examined after 117 days post cowpea sowing in the second week of May, 2024 (i.e., in 14/5/2024), to determine two main principal yield ecological factors, including:

3.1. Calculating a mean of green pod weight (gm.), which represents a mean of 5 groups, where each one group was 5 cowpea green pods (i.e., 5 group × 5 replicates/each group = a

total of 25 investigated green pods yield).

3.2. Calculating a mean of green pod length (cm.), which represents a mean of 5 groups where each one group was 15 cowpea green pods (i.e., 5 groups $\times$ 15 replicates/each group = a total of 75 investigated green pods yield).

4. Statistical Analysis of Obtained Data.

Means' values of resulting data (where the least significant difference was carried out at L.S.D.0.01 and 0.05 levels of probability) and also r-values (correlation coefficient), were estimated by using SPSS computerized program version 15.0. Means of temperature and relative humidity were obtained from the Meteorological Station at A.R.C., to calculate relationships between these two main weather factors and many other field ecological recorded factors.

RESULTS AND DISCUSSION

1. Infestation of Cowpea Leaflets by the Leafminer, *L. trifolii*, Population Dynamics of Pest and also Pest Parasitism by *D. isaea* Parasitoid Species:

1.1. Infestation of Cowpea Leaflets by the Leafminer, *L. trifolii* and Population Dynamics of Pest:

As demonstrated in Table (1) and illustrated in Figures (2&7), mean total number of infested leaflets, mean total number of infested leaflets per one plant, total number of pest mines, mean total number of pest mines per one infested leaflet, mean total number of *L. trifolii* larvae and mean total number of larvae per one infested leaflet per season were; 79.15 ± 24.46 (1-235 leaflets), 0.79 (0.01-2.49 leaflets), 238.54 ± 80.80 (1-791 mines), 2.33 (1.00-3.71 mines), 147.38 ± 50.08 (0-516 larvae) and 1.34 (0.00-2.07 larvae, respectively.

Table 1: Infestation of cowpea leaflets by the leafminer, *L. trifolii*, population dynamics of pest and also pest parasitism by *D. isaea* parasitoid species, in cowpea field recorded during season 2024.

Dates of inspection	Total no. of infested leaflets	Mean total no. of infested leaflets/ one plant	Total no. of pest mines	Mean total no. of mines /one infested leaflet	Total no. of <i>L. trifolii</i> larvae	Mean total no. of larvae /one infested leaflet	Total no. of emerged <i>D. isaea</i> parasitoid	% parasitism by <i>D. isaea</i> parasitoid	Mean weather factors	
									Temp. (C°)	R.H. (%)
20/2/2024	1	0.01	1	1.00	0	0.00	0	0.00	16.63	54.80
27/2	4	0.04	6	1.50	2	0.50	0	0.00	17.07	62.70
5/3	6	0.06	10	1.67	4	0.67	0	0.00	19.26	48.96
12/3	11	0.11	19	1.73	10	0.91	1	10.00	18.33	52.64
19/3	14	0.14	27	1.93	18	1.29	3	16.67	18.69	58.81
26/3	29	0.29	61	2.10	41	1.41	10	24.39	17.96	48.24
2/4	42	0.42	95	2.26	65	1.55	19	29.23	23.50	45.07
9/4	58	0.58	148	2.55	94	1.62	31	32.98	22.93	52.08
16/4	92	0.92	245	2.66	158	1.72	55	34.81	25.14	58.01
23/4	127	1.27	358	2.82	233	1.83	59	25.32	25.07	44.79
30/4	161	1.61	597	3.71	308	1.91	63	20.45	26.07	43.57
7/5	235	2.35	743	3.16	467	1.99	69	14.78	23.64	53.83
14/5	249	2.49	791	3.18	516	2.07	73	14.15	24.50	47.14
Mean /season	79.15	0.79	238.54	2.33	147.38	1.34	29.46	19.99%	21.45C°	51.59%
(range)	± 24.46 (1-235)	(0.01-2.49)	± 80.80 (1-791)	(1.00-3.71)	± 50.08 (0-516)	(0.00-2.07)	± 8.29 (0-73)	(0.00-34.81%)	(16.63-26.07 C°)	(43.57-62.70%)

Highest recorded total numbers of infested leaflets, *L. trifolii* mines and pest larvae (249,791 & 616, respectively), were during second week of May 2024 (i.e., in 14/5/2024). The leafminer, *L. trifolii* was recorded as a common pest attacking cowpea plants by

Awadalla & Fathy (1998).

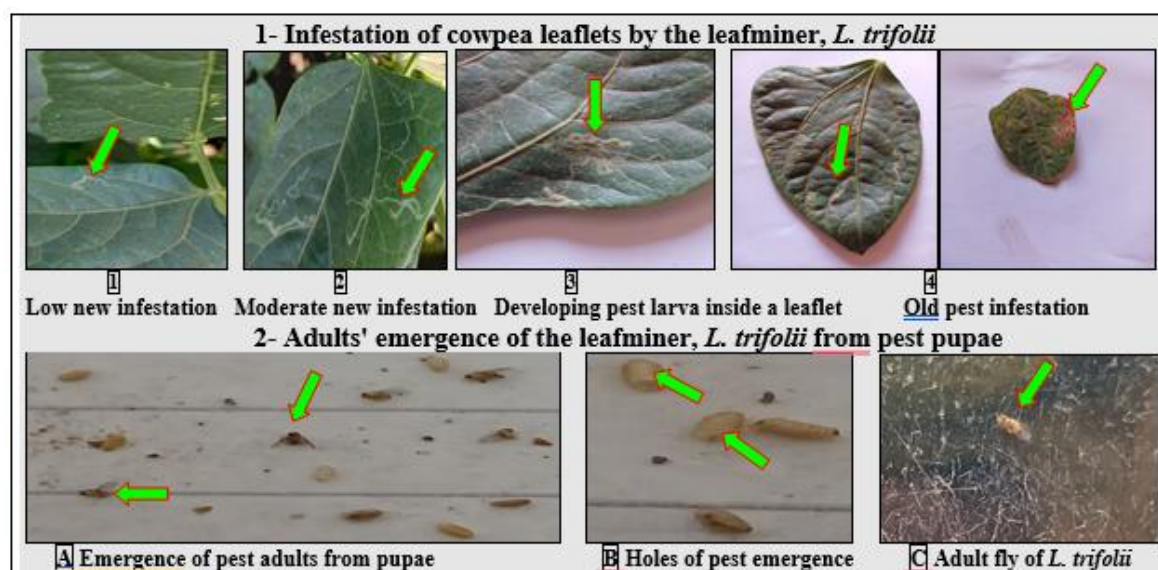


Fig. 2: Infestation of cowpea leaflets by the leafminer, *L. trifolii*, pest larvae inside mines and adults' emergence of pest species from their pupae in cowpea fields, during season 2024.

1.2 Parasitism of the Leafminer, *L. trifolii* by *D. isaea* Parasitoid.

As shown in Table (1) and Figures (3&7), the parasitoid species; *Diglyphus isaea* (Walker) (which is a larval ectoparasitoid), was the only recorded one parasitizing the leafminer, *L. trifolii*. Parasitism percentages of the leafminer, *L. trifolii* by the parasitoid, *D. isaea* and its total numbers of emerged parasitoid adults were evaluated.

Mean total numbers of emerged *D. isaea* parasitoid species and mean percentage of pest parasitism were; 29.46 ± 8.29 (0-73) and 19.99% (0.00-34.81%), respectively. Maximum percentage of pest parasitism by *D. isaea* parasitoid species (34.81%), was during third week of April, 2024 (i.e., in 16/4 /2024).



Fig. 3: Adults of *D. isaea* parasitoid that were recorded parasitizing the leafminer, *L. trifolii*, in cowpea field during season 2024.

The parasitoid, *D. isaea* was recorded attacking the leafminer, *L. trifolii* by many authors such as: El-Khawas M. & El-Khawas S. (2005) and Abul Fadl & El-Khawas (2009), considering as one of the most common parasitoids' species of *L. trifolii*, as an obvious important mortality factor of leafminers was effects of their parasitoids (Çikaman *et al.*, 2006), being widely distributed in different regions (Zhu *et al.*, 2000). It was shown to be widely spread allover Egypt with recoded percentages of parasitism of 86.64 & 65.49%, in two studied successive seasons, respectively (Eid, 2008). During this study, *D. isaea* parasitoid had emerged from *L. trifolii* with the highest total numbers among other

parasitoids' species of lower numbers. This situation greatly shown important natural role of this parasitoid species as an effective control agent against such pest. In similar results, *D. isaea* parasitoid was shown to have a percentage of 68.30% of total recorded parasitoids' species during growing season and being occurred along cowpea season, with ability to increase in its numbers according to pest population increase (El-Khawas, 2008 and Aamer & Hegazi, 2014).

2. Population Dynamics of the Cowpea Aphid, *A. craccivora* and Percentages of its Parasitism by *D. rapae* Parasitoid Species:

2.1. Population Dynamics of the Cowpea Aphid, *A. craccivora*.

From Table (2) and Figure (7), mean total numbers of the cowpea aphid, *A. craccivora* individuals (adults & nymphs) and mean total number of pest individuals per one plant, that were recorded in cowpea field per season 2024 were 1158.69 ± 284.01 (29-3018 individuals) and 11.59 (0.29-28.13 individuals), respectively. peak of pest population (3018 individuals) was recorded during second week of April 2024 (i.e., in 9/4/2024). So, the cowpea aphid, *A. craccivora* was recorded as one of the most injurious pest species infesting cowpea plants (Togola *et al.*, 2017), where its infestation resulted in significant reductions in cowpea yield (Ofuya, 1989).

Table 2: Population dynamics of the cowpea aphid, *A. craccivora* individuals (adults & nymphs) and percentages of its parasitism by *D. rapae* parasitoid species, that were recorded in cowpea field during season 2024.

Dates of inspection	Total no. of the cowpea aphid, <i>A. craccivora</i> individuals (A+N)	Mean total no. of the cowpea aphid, <i>A. craccivora</i> individuals (A+N)/one plant	Total no. of <i>D. rapae</i> parasitoid mummies	Mean total no. of <i>D. rapae</i> parasitoid mummies/one plant	% Parasitism of the cowpea aphid, <i>A. craccivora</i>	Total no. of emerged adults of <i>D. rapae</i> parasitoid species	% Adults emergence of <i>D. rapae</i> parasitoid species
20/2/2024	48	0.48	5	0.05	2.08	1	20.00
27/2	320	3.20	45	0.45	14.63	11	24.44
5/3	509	5.09	108	1.08	21.22	56	51.85
12/3	939	9.39	225	2.25	23.96	148	65.78
19/3	1123	11.23	387	3.87	34.46	273	70.54
26/3	1815	18.15	723	7.23	39.83	546	75.52
2/4	2813	28.13	515	5.15	18.31	437	84.85
9/4	3018	30.18	426	4.26	14.12	312	73.24
16/4	2197	21.97	248	2.48	11.29	159	64.11
23/4	1337	13.37	131	1.31	9.80	78	59.54
30/4	758	7.58	41	0.41	5.41	15	36.59
7/5	157	1.57	6	0.06	3.82	2	33.33
14/5	29	0.29	0	0.00	0.00	0	0.00
Mean /season (range)	1158.69 ± 284.01 (29-3018)	11.59 (0.29-28.13)	220.00 ± 63.79 (0-723)	2.20 (0.01-7.23)	17.58% (0.00-39.83%)	156.77 ± 50.52 (0-546)	71.26% (0.00-84.85%)

2.2. Parasitism of the Cowpea Aphid, *A. craccivora* by *D. rapae* Parasitoid Species.

As shown in Table (2) and illustrated in Figures (4&7), the parasitoid species, *Diaeretiella rapae* (M'Intosh) (which is a primary endoparasitoid), was the most recorded parasitoid species found parasitizing the cowpea aphid, *A. craccivora*. In similar line, *D. rapae* was demonstrated as one of common associated pest parasitoids in cowpea fields (Saleh *et al.*, 2009). Mean total number of parasitoid *D. rapae* mummies, mean total number of *D. rapae* parasitoid mummies per one cowpea plant, mean percentage of aphid parasitism, mean total number of emerged *D. rapae* parasitoid species and mean percentage of emergence of adults *D. rapae* parasitoid species per season were; 220.00 ± 63.79 (0-723), 2.20 (0.01-7.23), 17.58% (0.00-39.83%), 156.77 ± 50.52 (0-546) and 71.26% (0.00-84.85%),

respectively. Respective recorded peaks of previous ecological parameters were; 723, 7.23, 39.83% and 546, respectively (all were recorded during last week of March, i.e., in 26/3/2024) and 84.85% (during first week of April, i.e., in 2/4/2024), at means of temperature of 17.96 °C & 23.50°C and means of relative humidity of 48.24% & 45.07%, respectively. From obtained data, *D. rapae* parasitoid was recorded early in studied season, following incidence of aphid species in cowpea field. Also, there were increases in total numbers of parasitoid mummies and percentages of aphid parasitism which were directly related to increase happened in the cowpea aphid, *A. craccivora* population. Similarly, peak of aphids' parasitoids were shown to happen after two weeks following aphids peak (Megahed, 2000). Moreover, Sobhy *et al.* (2004) found same observations, when studying relationships between cereal aphids and their associated primary parasitoids' species in wheat fields. Results emphasized strongly important natural role of *D. rapae* parasitoid as a biocontrol agent against the cowpea aphid, *A. craccivora* attacking cowpea plants.



Fig. 4: An adult of *D. rapae* parasitoid species that emerged from the cowpea aphid, *A. craccivora* in cowpea field, during season 2024.

3. Population Dynamics of other Common Piercing Sucking Insects' Pests Recorded Attacking Cowpea Field:

Table (3) and Figures (5&7) showed population dynamics of the leafhopper, *Empoasca* sp. and the green bug *N. viridula* surveyed attacking cowpea plants, during season 2024.

Table 3: Other common piercing sucking insects' pests that were observed attacking cowpea plants.

Dates of inspection	Other piercing sucking insects' pests (A+N)		Total no. of all piercing sucking insects' pests (the cowpea aphid+ <i>Empoasca</i> sp. + <i>N. viridula</i>)	Mean weekly total no. of all piercing sucking insects' pests' individuals (A+N)/one plant
	The leafhopper, <i>Empoasca</i> sp.	The green bug, <i>N. viridula</i>		
20/2/2024	0	0	48	0.48
27/2	0	0	320	3.20
5/3	1	0	510	5.10
12/3	2	0	941	9.41
19/3	6	0	1129	11.29
26/3	18	1	1834	18.34
2/4	44	3	2860	28.60
9/4	73	8	3099	30.99
16/4	81	17	2295	22.95
23/4	117	25	1479	14.79
30/4	183	42	983	9.83
7/5	214	74	445	4.45
14/5	265	25	319	3.19
Mean/season (range)	77.23±25.30 (0-265)	15.00±6.16 (0-74)	1250.92± 277.93 (48-3099)	

Mean total number of the leafhopper, *Empoasca* sp., the green bug *N. viridula* and mean total number of all common piercing sucking insects' pests individuals (adults & nymphs) per season were 77.23 ± 25.30 (0-265), 15.00 ± 6.16 (0-74) and 1250.92 ± 277.93 (48-3099) per season 2024, respectively. Respective maximum total numbers of previous parameters were; 265 (during second week of May, i.e., in 14/5/2024), 74 (recorded during first week of May, i.e., in 7/5/2024) and 3099 (recorded during second week of April, i.e., in 9/4/2024), at means of temperature of 24.50°C , 23.64°C & 22.93°C and means of relative humidity of 47.14%, 53.83% & 52.08 %, respectively. The leafhopper, *Empoasca* sp. was recorded attacking cowpea plants by many authors such as Satpathy *et al.* (2009), while the green bug *N. viridula* was found attacking cowpea fields where it only sporadically occurs (Ssengoo *et al.*, 2024).

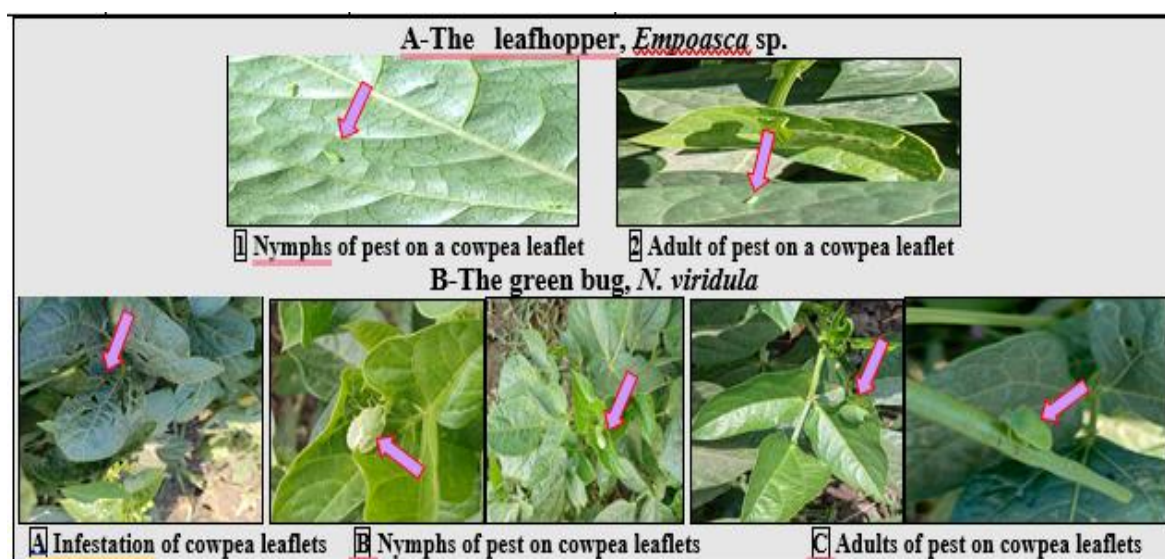


Fig. 5: Individuals (nymphs and adults) of the leafhopper, *Empoasca* sp. and the green bug, *N. viridula* that were recorded attacking cowpea field, during season 2024.

4. Population Dynamics of Common Predatory Species that were Recorded in Cowpea Field:

Data presented in Table (4) and Figures (6&7), indicated that, two common predatory species were recorded in cowpea field including: *Chrysoperla carnea* (Steph.) (Neuroptera: Chrysopidae) which represented 54.07% (0.00-65.38%) of total recorded predators per season and Coccinellidae which represented 45.93% (0.00-96.43%) of total recorded predators per season, indicating that *Ch. carnea* predator were more abundant than Coccinellidae one.

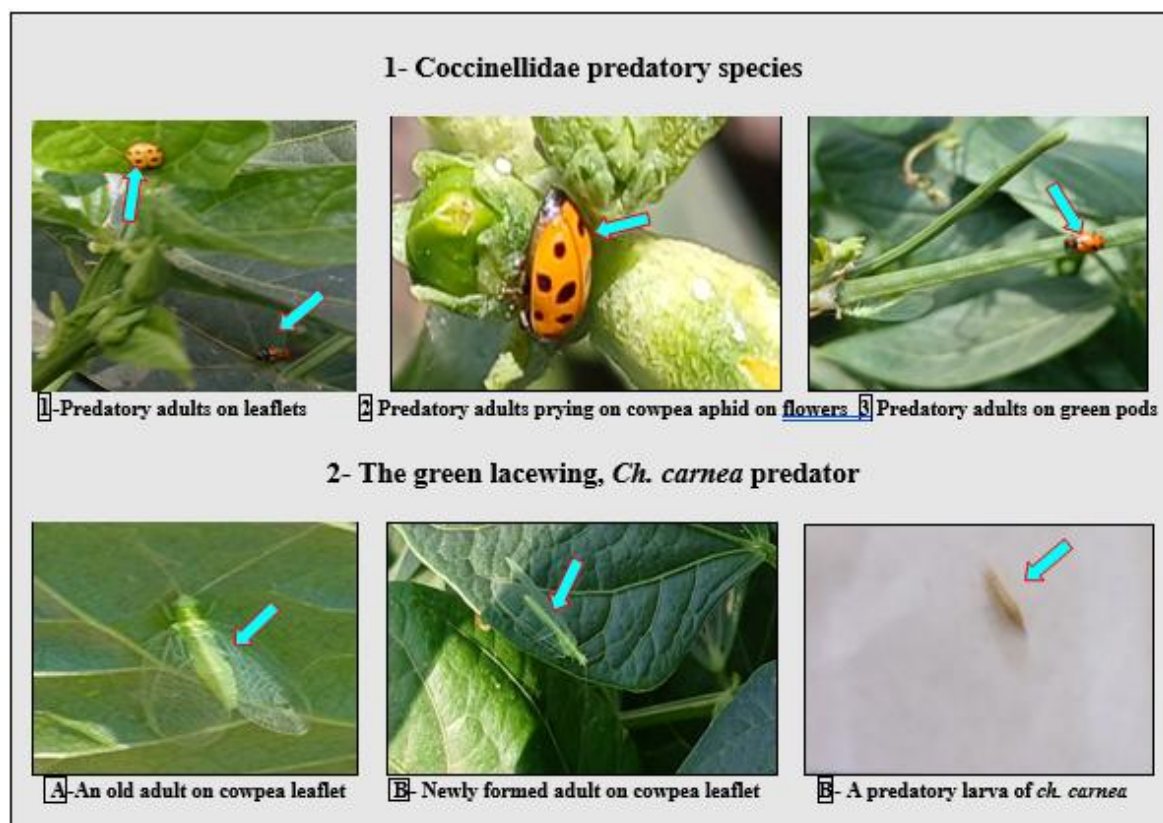
Moreover, Coccinellidae predators included *Hippodamia convergens* (Geur.) and *Coccinella undecimpunctata* L., where first one was higher in its total seasonal numbers (133 individuals, with a mean percentage of occurrence per season of 60.45% (0.00-100.00%)) than second one (87 individuals, with a mean percentage of occurrence per season of 39.55% (0.00-44.44%)). Mean total numbers of *Ch. carnea* (adults & larvae), Coccinellidae (adults & larvae), *H. convergens* predator, *C. undecimpunctata* predator and mean total numbers of both predatory species (*Ch. carnea*+ Coccinellidae together) per season were; 43.17 ± 19.95 (0-108), 36.67 ± 14.44 (0-93), 22.17 ± 8.45 (0-53), 14.50 ± 6.08 (0-40) and 79.83 ± 33.67 (0-201), respectively.

Respective highest total numbers of predatory species; *Ch. carnea*, Coccinellidae, *H. convergens*, *C. undecimpunctata* and all predatory species were 108, 93, 53, 40 and 201 individuals, that were surveyed during second half of April, 2024.

Table 4: Bimonthly total numbers of predatory species (Coccinellidae and the green lacewing, *Ch. carnea*) that were recorded in the cowpea field, during season 2024.

Months	Total no. of predatory species/sample (A+L)					
	Ch. carnea (% occurrence) *	Coccinellidae (% occurrence) *	Total no. of species of Coccinellidae predators		Total no. of all predatory species (Ch. carnea + Coccinellidae)	Mean total no. of all predatory species/one plant
			H. convergens (% occurrence) *	C. undecimpunctata (% occurrence) *		
Second half of February	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0	0-00
First half of March	0(0.00)	1(100.00)	1(100.00)	0(0.00)	1	0.01
Second half of March	1(3.57)	27(96.43)	15(55.56)	12(44.44)	28	0.28
First half of April	65(54.62)	54(45.38)	34(62.96)	20(37.04)	119	0.49
Second half of April	108(53.73)	93(46.27)	53(56.99)	40(43.01)	201	2.01
First half of May	85(65.38)	45(43.62)	30(73.33)	15(26.67)	130	1.10
Total no./season (range)	259(0-108)	220(0-93)	133(0-53)	87(0-40)	Total no. of all predatory species 479(0-201)	
Mean total no./season	43.17±19.95	36.67±14.44	22.17±8.45	14.50±6.08		
% occurrence/season	54.07% (0.00-65.38%)	45.93% (0.00-96.43%)	60.45% (0.00-100.00%)	39.55% (0.00-44.44%)	Mean total no. of all predatory species 79.83±33.67	

*Note: (%) = Representing percentage of occurrence of predatory species to each other in cowpea field during season 2024.

**Fig. 6:** Predatory species, including Coccinellidae predators and the green lacewing, *Ch. carnea* those observed in the cowpea field during season 2024.

Predatory species of Coccinellidae were recorded in cowpea field by Ghanim *et al.* (2015) and also by Ali *et al.*, (2013) who indicated that, *C. undecimpunctata* and *Ch. carnea* predators were surveyed among common predatory species in cowpea fields. The green lacewing, *Ch. carnea* and Coccinellidae predatory species were seen feeding on larvae of the leafminer, *L. trifolii* (Eid, 2008).

In general, Chrysopidae and Coccinellidae were shown as major groups of biological control agents for controlling aphids, where the first ones were recorded as commonly

polyphagous predators found in agricultural systems (Saleh *et al.*, 2017). Besides, second ones were shown to comprise one of the most active groups, preying on different insect pests, including aphids (Bahy El-Din *et al.*, 2013).

Therefore, the present results through light on many important points, including:

1. Protecting beneficial biocontrol agents from undesirable insecticides is very important and has become more necessary, as naturally occurring parasitoids and predators were recorded as important factors in regulating population densities of agricultural pests (Frag, 2008).
2. Parasitoid species; (*D. isaea* a parasitoid of the leafminer, *L. trifolii* and *D. rapae*, a parasitoid of the cowpea aphid, *A. craccivora*),
3. Predatory species (either *Ch. carnea* or Coccinellidae predators), play an important natural role against common cowpea insect pests. So, they can be mass-reared in the laboratory and released in the cowpea field against these common insect pests.
4. Surely, using biological control does require a great detailed knowledge on any pest.
5. So, present study is believed to be highly practical and applied recommendations for using these biocontrol agents against major pests in cowpea fields or other related fields that are subjected to attack by studied pest' species. For example, the green lacewing, *Ch. carnea* and the ladybird, *C. undecimpunctata* were shown to be effectively used in I.P.M. programs (Sunitha *et al.*, 2005).

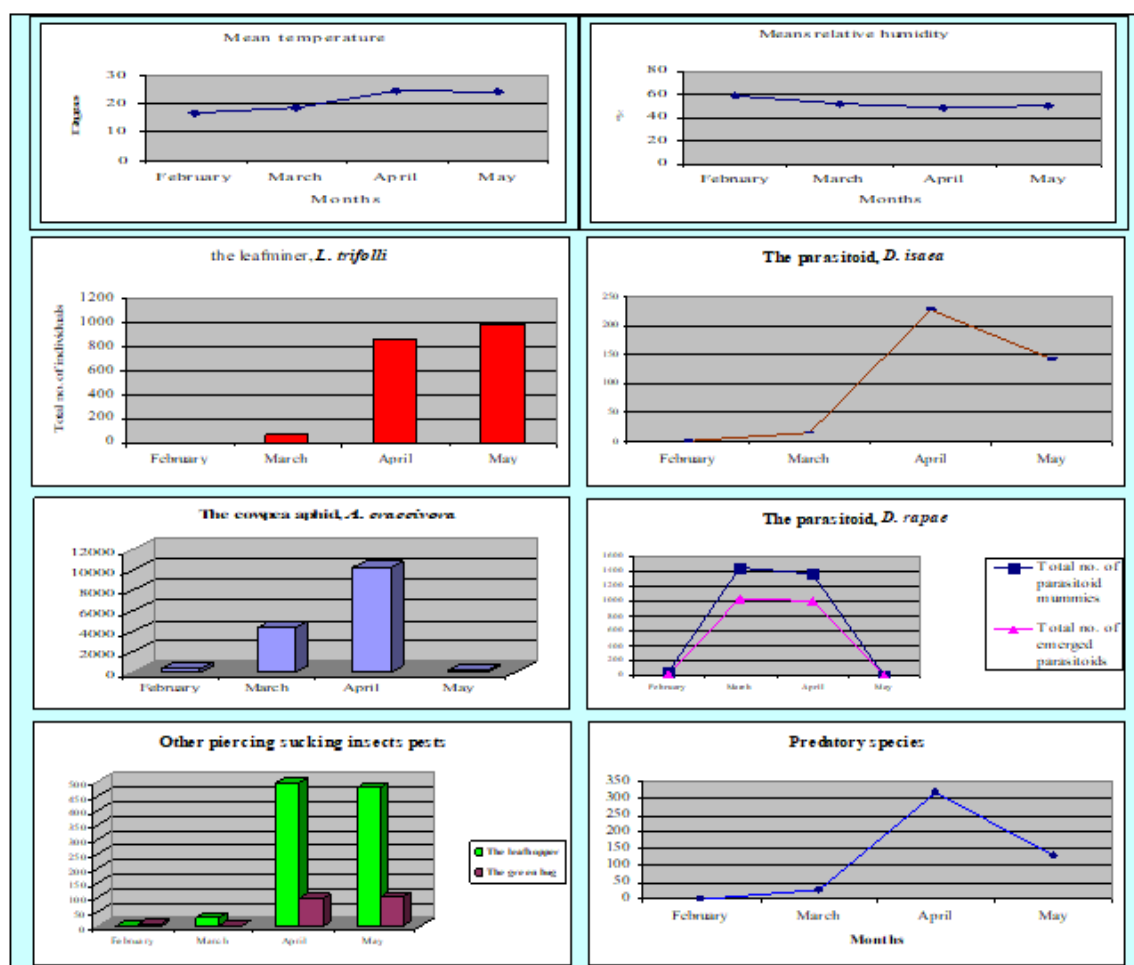


Fig. 7: Monthly total numbers of the leafminer, *L. trifolii*, the cowpea aphid, *A. craccivora*, their parasitism, other common recorded piercing sucking insect pests and predatory species, which were recorded in the cowpea field, in relation to weather factors, during season 2024.

5. Resulted cowpea green pods' yield that was recoded after 117 days post cowpea grains sowing:

Results concerning cowpea green pods yield that were recoded after 117 days post cowpea grains sowing, during season 2024, were tabulated in Table (5) and illustrated Figure (8). Where, means of green pod weight (gm.) and green pod length (cm.) were; 10.28 ± 0.66 gm. (9.20-12.80gm. and 12.02 ± 0.56 cm. (10.51-12.72cm.), respectively.

Table 5: Resulted cowpea green pods yield represented by calculations of means green pods' weight (gm.) and length (cm.) recoded after 117 days post cowpea grains sowing, during season 2024.

Tested groups	Mean green pod weight (gm.)	Mean green pod length (cm.)
1	10.40(8-13)	10.93(4.00-15.40)
2	12.80(11.5-14)	12.72(9.70-16.90)
3	9.60(8.5-10.5)	13.45(10.90-16.80)
4	9.40(8.5-10)	12.49(10.20-15.50)
5	9.20(8.5-10)	10.51(7.50-13.30)
Mean for each one green pod/season (range)	10.28 ± 0.66 gm. (9.20-12.80gm.)	12.02 ± 0.56 cm. (10.51-12.72cm.)



Fig. 8: Resulted cowpea green pods yield after 117 days post cowpea grains sowing.

6. Statistical Analysis of Obtained Data:

As shown in Table (6), the following relationships were recorded between many ecological factors and means of some weather factors (including; means of temperature and means of relative humidity) in cowpea field during season, 2024 (in Qalubia Governorate),

6.1. Relationships between many Tested Ecological Factors and Means of Temperature:

Relationships between; mines of the leafminer, *L. trifolii*, *L. trifolii* larvae, emerged *D. isaea* parasitoid of *L. trifolii*, individuals of the cowpea aphid, *A. craccivora*, mummies of *D. rapae* parasitoid of pest, adults of *D. rapae* parasitoid of *A. craccivora*, the leafhopper, *Empoasca* sp. individuals, the green bug, *N. viridula* individuals, *Ch. carnea* predator, total Coccinellidae predators, *H. convergens* predator, *C. undecimpunctata* predator and means of temperature were recorded. R-values obtained were; 0.742** (significant=0.004), 0.728** (significant=0.005), 0.899*** (significant=0.000), 0.282 (significant=0.350), -0.152 (significant=0.620), -0.130 (significant=0.673), 0.777** (significant=0.002), 0.648** (significant=0.017), 0.374 (significant=0.209), 0.981**** (significant=0.001), 0.970**** (significant=0.001), 0.937**** (significant=0.006) and 0.853*** (significant=0.031), respectively.

Generally, statistical analysis of obtained data in relation to means of temperature revealed that:

a- There were moderate positive significant relationships in case of mines of the leafminer, *L. trifolii*, the leafminer, *L. trifolii* larvae, the leafhopper, *Empoasca* sp. individuals and the

green bug, *N. viridula* individuals.

b- There were highly positive significant relationships in case of emerged *D. isaea* parasitoid of the leafminer, *L. trifolii* and *C. undecimpunctata* predator.

c- There were no relationships in case of; individuals of the cowpea aphid, *A. craccivora*, mummies of *D. rapae* parasitoid of pest, adults of *D. rapae* parasitoid of pest and all piercing sucking insect pests.

d- There were very highly positive significant relationships in case of *Ch. carnea* predator, total predatory species of Coccinellidae and *H. convergens* predator.

3.6.2. Relationships between many Tested Ecological Factors and Means of Relative Humidity.

In general, statistical analysis of obtained data in relation to means of relative humidity indicated that:

a- No relationships were found in case of; mines of the leafminer, *L. trifolii*, the leafminer, *L. trifolii* larvae, emerged *D. isaea* parasitoid of pest, individuals of the cowpea aphid, *A. craccivora*, mummies of *D. rapae* parasitoid of pest, adults of *D. rapae* parasitoid of pest, the leafhopper, *Empoasca* sp. individuals, the green bug, *N. viridula* individuals and all piercing sucking insects' pests. R-values obtained were; -0.384 (significant=0.195), -0.361 (significant=0.226), -0.395 (significant=0.182), -0.168 (significant=0.583), -0.117 (significant=0.704), -0.157 (significant=0.608), -0.416 (significant=0.157), -0.228 (significant=0.454) and -0.215 (significant=0.481), respectively.

b- Negative moderate significant relationships were found in case of *Ch. carnea* predator, total predatory species of Coccinellidae and *H. convergens* predator and *C. undecimpunctata* predator. Where, respective r-values were; -0.694** (significant=0.126), -0.710** (significant=0.114), 0.722** (significant=0.105) and -0.651** (significant=0.161)

Table 6: Effect of weather factors on many ecological parameters recorded in cowpea field during season 2024.

Tested ecological factors	Tested factors × means of temp. (C°)	Tested factors × means of R.H.%
1- The leafminer, <i>L. trifolii</i>.		
a- Mines of the leafminer, <i>L. trifolii</i> .	r = 0.742** (significant=0.004)	r = -0.384 (significant=0.195)
b- The leafminer, <i>L. trifolii</i> larvae.	r = 0.728** (significant=0.005)	r = -0.361 (significant=0.226)
b- Emerged <i>D. isaea</i> parasitoid of pest.	r = 0.899*** (significant=0.000)	r = -0.395 (significant=0.182)
2-The cowpea aphid, <i>A. craccivora</i>.		
a- Individuals of the cowpea aphid, <i>A. craccivora</i> .	r = 0.282 (significant=0.350)	r = -0.168 (significant=0.583)
b- Mummies of <i>D. rapae</i> parasitoid of pest.	r = -0.152 (significant=0.620)	r = -0.117 (significant=0.704)
c- Adults of <i>D. rapae</i> parasitoid of pest.	r = -0.130 (significant=0.673)	r = -0.157 (significant=0.608)
3- Other piercing sucking insects' pests.		
a-The leafhopper, <i>Empoasca</i> sp. individuals.	r = 0.777** (significant=0.002)	r = -0.416 (significant=0.157)
b- The green bug, <i>N. viridula</i> individuals.	r = 0.648** (significant=0.017)	r = -0.228 (significant=0.454)
c-Total of piercing sucking insects' pests.	r = 0.374 (significant=0.209)	r = -0.215 (significant=0.481)
4 – Predatory species.		
a- <i>Ch. carnea</i> .	r = 0.981**** (significant=0.001)	r = -0.694** (significant=0.126)
b- Total Coccinellidae.	r = 0.970**** (significant=0.001)	r = -0.710** (significant=0.114)
1- <i>H. convergens</i> .	r = 0.937**** (significant=0.006)	r = -0.722** (significant=0.105)
2- <i>C. undecimpunctata</i> .	r = 0.853*** (significant=0.031)	r = -0.651** (significant=0.161)

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

In similar findings, insect occurrence and their distribution were recorded to be significantly affected by meteorological conditions (showing either negative or positive significant correlations). For example, aphid and jassids showed a positive correlation with temperature and a negative one with relative humidity and these variable conditions affected also on population of predatory species inhabiting cowpea plants (Nechols *et al.*, 1999).

Such basic information relationships can share in determining appropriate time of action and choosing effective more suitable pest control method to be used (Sharma *et al.*, 2019).

In conclusion, present study aims to through light on following points:

1. Studying population dynamics and seasonal occurrence of common insect pests attacking cowpea field will be necessary to known periods of their peaks activity and to select appropriate time of applying their control programs, which was in accordance with results of Abul Fadl & El-Khawas (2009).
2. Studying existed natural roles of natural enemies found associated with common insects' pests attacking cowpea field and their relationships will be important and can be helpful knowledge when planning I.P.M. against these pests, as protecting beneficial biocontrol agents became very necessary (El-Khawas, 2005).
3. Because of using long-term of insecticidal pesticides had led to sever problems concerning safety degrees of human being and his surrounding environment. Modern new agricultural systems are being built around collecting of efficient I.P.M. approaches about heavy production of cowpea and finding more safety control techniques with concentrated on using biological control programs (Mohamed *et al.*, 2012).
4. Results gave an important recommendation on possibility of using two recorded parasitoids' species; first one was *D. isaea* and second one was *D. rapae*, by mass rearing in the laboratory and releasing them in cowpea field against the leafminer, *L. trifolii* and the cowpea aphid, *A. craccivora*, respectively. Similar results stated that, the parasitoid *Diglyphus* sp. was proved to be the most efficient parasitoid on the leafminer, *L. trifolii* population (Parrella *et al.*, 1983), where this parasitoid had previously been used against the leafminer, *L. trifolii* in tomato greenhouses (Akihto, 2001). Second one (*D. rapae*) was effectively released against many aphids' species (Ragab *et al.*, 2002).
5. Observed predatory species in cowpea field, either *Ch. carnea* and/or Coccinellidae predators had also similar important natural roles against common insect pests in cowpea field and can be used for getting more effective control against common insect pests. Different successfully attempts were made in this direction for using these effective predatory species, for example the green lacewing, *Ch. carnea* predator has mainly been clearly used as an effective agent against many aphids' species (El-Arnaouty *et al.*, 1993).
6. In general, magnifying both of natural and applied roles of biocontrol agents, have received attention towards their protection, mass rearing on a long scale and release for controlling many agricultural pests (Mondor & Warren, 2000), which can be applied in cowpea fields or other related fields that are subjected to attack by these pests' species.
7. There was a possibility of using in same time more than one biocontrol agents in integrated control programs. For example, using parasitoids of aphids' species (Boivin *et al.*, 2012) and the green lacewing predator, *Ch. carnea* (Ragsdale *et al.*, 2011), were commonly applied in biological control programs.
8. Statistical analysis of obtained data concerning relationships between means of temperature and relative humidity with many tested ecological factors.
 - 8.1. In case of means of temperature and many tested ecological factors:
 - a- There were moderate positive significant relationships in case of mines of the leafminer, *L. trifolii*, *L. trifolii* larvae, the leafhopper, *Empoasca* sp. and the green bug, *N. viridula* individuals.
 - b- There were highly positive significant relationships in case of emerged *D. isaea* parasitoid of the leafminer, *L. trifolii* and *C. undecimpunctata* predator.
 - c- There were no relationships in case of; individuals of the cowpea aphid, *A. craccivora*, mummies of *D. rapae* parasitoid of pest, adults of *D. rapae* parasitoid of pest and all piercing sucking insect pests.
 - d- There were very highly positive significant relationships in case of *Ch. carnea* predator,

total predatory species of Coccinellidae and *H. convergens* predator.

8.2. In case of means of temperature and many tested ecological factors:

a- No relationships were found in case of; mines of the leafminer, *L. trifolii*, the leafminer, *L. trifolii* larvae, emerged *D. isaea* parasitoid of pest, individuals of the cowpea aphid, *A. craccivora*, mummies of *D. rapae* parasitoid of pest, adults of *D. rapae* parasitoid of pest, the leafhopper, *Empoasca* sp. individuals, the green bug, *N. viridula* individuals and all piercing sucking insect pests.

b- Negative moderate significant relationships were found in case of *Ch. carnea* predator, total predatory species of Coccinellidae and *H. convergens* predator and *C. undecimpunctata* predator.

Declarations:

Ethics Approval: This study did not involve human participants or animals. The research was limited to sampling without any insecticide in a farm of Agricultural Research Center (A.R.C.), located in Giza Governorate.

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.

Competing Interests: The author declares no conflict of interest of any kind.

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

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ARABIC SUMMARY

الدور الحيوى الطبيعى للطفيليات والمفترسات الهامة المرتبطة بالآفات الحشرية الشائعة فى حقول اللوبيا

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يمثل محصول اللوبيا أحد أهم محاصيل الخضر الاستراتيجية حيث يعد جزء من نظم التراكيب المحصولية. ويهاجم محصول اللوبيا بالعديد من الآفات خلال مراحل نموه فى الحقل (من الانبات حتى النضج) وكذلك فى المخازن. أظهرت النتائج المسجلة تواجد الآفات التالية على محصول اللوبيا:- صانعة الانفاق *Liriomyza trifolii* Burgess (حيث سجل أعلى تعداد لإجمالى عدد الأوراق المصابة، عدد الأنفاق المتواجدة على كل ورقة وعدد اليرقات للآفة المسجلة داخل الأنفاق خلال الأسبوع الثانى من مايو 2024 م)، ومن اللوبيا *Aphis craccivora* Koch (حيث سجل أعلى تعداد للآفة خلال الأسبوع الثانى من أبريل 2024 م)، كما تم تسجيل تواجد نطاط الأوراق *Empoasca* sp. والبقعة الخضراء *Nezara viridula* L. تم تسجيل نوعين من الطفيليات أحدهما طفيل خارجى *Diglyphus isaea* (Walker) على يرقات صانعات الأنفاق *L. trifolii* (حيث كانت أعلى نسبة تطفل خلال الأسبوع الثالث من أبريل 2024 م)، والآخر طفيل أولى داخلى *Diaeretiella rapae* (M'Intosh) على من اللوبيا (وسجلت أعلى نسبة تطفل خلال الأسبوع الأخير من أبريل 2024 م).

كما تم تسجيل تواجد عدة مفترسات على محصول اللوبيا شملت: مفترس أسد المن *Chrysoperla carnea* (Steph.) وأخرى من عائلة أبى العيد *Coccinellidae* (حيث سجل منها نوعين هما أبى العيد ذو الثلاثة عشرة نقطة *Coccinella undecimpunctata* (Hippodamia convergens) (Geur.))، وأبى العيد ذو الأحد عشرة نقطة (L.). وسجل أعلى تعداد لإجمالى المفترسات السابقة خلال النصف الثانى من شهر أبريل 2024 م. وعلاوة على ذلك، فقد تم تقدير المتوسطات لأوزان وأطوال القرون الخضراء لمحصول اللوبيا الناتج بعد 117 يوماً من الزراعة.

وإجمالاً، فقد وجد من الدراسة أن هناك ارتباطاً متزامناً بين الدور الطبيعى الذى تؤديه الأعداء الحيوية وفترة زيادة تعداد الآفات الحشرية فى حقول اللوبيا. ولذا فيجب تشجيع وحماية هذا الدور الطبيعى لنوعى الطفيليات المسجلة خلال هذه الدراسة (*D. isaea* و *D. rapae*) ، بجانب أنواع المفترسات الشائعة (أسد المن *Ch. carnea* ومفترسى أبى العيد *C. undecimpunctata* و *H. convergens*) ، حيث يمكن إستخدامهم عن طريق التربية الكمية والاطلاق لهم لمكافحة تلك الآفات الشائعة التى تهاجم محصول اللوبيا او المحاصيل الأخرى التى تهاجم بنفس الآفات وذلك عند تطبيق برامج مكافحة متكاملة للآفات.