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Research Article
Ecological and Biological Studies of Certain Predatory Insects of Aphid *Aphis craccivora* (Koch.) On Cowpea

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Abstract

Background and Objective: Cowpea and faba bean are commonly cultivated in Egypt. These crops are affected by the insect attack especially aphids, for which different insecticide are used which are effecting the crop badly. This article aims to study the population density of the cowpea aphid, *Aphis craccivora* and its associated predators on cowpea fields. **Materials and Methods:** These experiments were carried out to survey, seasonal abundance of *A. cracciovra* and its associated predators associated with *A. craccivora* and their relative densities, in Zagazig District during the 2 seasons 2018 and 2019. In addition, it was studied biological characters of *C. undecimpunctata* reared on *A. craccivora*. **Results:** Investigation reflect that seven species of predators were found. These predators were *Coccinella undecimpunctata, Metasyrphus corolla, C. carnea, Scymnus* sp., *Orius* sp., *Cydoniavicinaisis* and *P. alfierii*. *Coccinella undecimpunctata* was the dominant predator species with a rate of occurrence reached, 30.92%. *C. carnea*. represented the second one with a percent of 18.44% from the total numbers of predators found in the first season, *C. undecimpunctata* was the dominant predator species with a rate of occurrence reached (31.41%) from the total number of predators in second one. The duration period of the larval stage of the predator *C. undecimpunctata* when reared and fed on *A. craccivora* lasted 14.72±0.18 days. The predator female consumed a total average of 3135.1±39.12 individuals. The average number of eggs deposited per female was 256.6±11.69 eggs. **Conclusion:** Finally, predators could be recommended as biological control agents against this aphid *A. craccivora* under Egyptian conditions.

Key words: *Aphis craccivora*, aphid predators, biology, cowpea, pest, infestation

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Aphids are the most important insect pests of different crops all over the world[1]. On the other hand, faba bean and cowpea plants are of the most important crops in Egypt. The cowpea aphid, *Aphis craccivora* Koch., is the major pest of cowpea in Africa, Asia and Latin America[2,3]. It is considered a key pest of cowpea and faba bean cultivation in Egypt[4]. Insect predators are of the major groups of biological control agents used for aphid control. These belong to family Coccinellidae and Chrysopidae, these feed during the larval and adult stages on different sap-sucking pests including aphids, white flies, jassids and mites as well as other small insects[5,6].

Aphis craccivora Koch., is considered one of the most injurious pests infests these plantations and other leguminous species causes by sucking the plant sap records in Egypt[7-9] and in other countries such as in India[10,11] and indirect damage by transmission of many virus diseases[12].

Use of insecticides in controlling aphids lead to several problems, not only in increasing resistant strains of aphids and destruction of beneficial organisms in Pakistan, Egypt and in all around the world[13-15].

Safety of food, water and human health necessitates decrease pesticides use against aphids. It is necessary before introducing any predator in a biological control program to assess its efficiency under different conditions. The most important factors in evaluating the success of these natural enemies as a biological control agent of aphids are temperature[16], relative humidity[17] and prey availability in time and space[5]. Predators are a major group of natural enemies that play an obvious role in the control of different insect pests[18,19]. Aphidophagous predators can play an important role in natural control of aphids in agricultural ecosystems[20,21]. Coccinellids comprise one of the most efficient predatory species that feed on different sucking pests including aphid, white flies, jassids and mites[22]. Integrated pest management programmers based on bio-control involve various techniques, importation bio-control, Augmentation bio-control and conservation[23,24]. The relationship between *A. craccivora* infested faba bean and cowpea plants and its aphidophagous insects have drawn the attention of many investigators[7,8,25].

Therefore, the present study dealt with the following points:

- Survey predators associated with the cowpea aphid *Aphis craccivora* during two seasons of study 2018 and 2019
- Biological characters of *C. undecimpunctata* reared on cowpea aphid *Aphis craccivora*

MATERIALS AND METHODS

Survey and population density of the cowpea aphid, *Aphis craccivora* on cowpea plants: These experiments were carried out to study seasonal abundance. Of *Aphis cracciovra* Koch., survey and seasonal abundance of insect predators associated with *A. craccivora* and their relative densities, in Zagazig district, Sharkia Governorate during the two successive growing seasons cowpea 2018 and 2019. An area of half feddan, was cultivated with cowpea, *Vignaunguiculata* (L.) cultivar karem 7 were sown in the 1st week of June, 2018 and 2019. Normal agricultural practices were used in the due time and no chemical control was applied.

The sampling: Cowpea plants (30) were weekly examined carefully from seed germination until the end of the season. The samples were examined at random by means of the cross side method, the number of aphid and predators were counted directly in the field and in few cases laboratory rearing was necessary for the predacious immature till the adults emergence to be identified and counted.

Biological studies of the predator *C. undecimpunctata* on *Aphis craccivora*: Permanent cultures of the predator *C. undecimpunctata* and the prey *A. craccivora* were maintained in the laboratory at 26.0±10C and 65±5% relative humidity (RH) during 2019 season.

Twenty newly hatched first instar larvae of the predator were introduced singly into Petri-dishes of 10 cm in diameter. The bottom of each dish was covered with a filter paper to facilitate the predator larval movement. A known number of the different stages of the aphid were introduced daily into each dish. A small plant leaf was introduced daily in each petri-dish as food for the aphids. The number of the aphids consumed per larvae of each predator was recorded. The numbers of aphids was increased daily and as the larvae entered to next instar. The feeding potential was recorded by counting the number of aphids, fed by 1st, 2nd, 3rd and 4th instars of *C. undecimpunctata* up to pupation. The mean number of aphids predated by the predator larvae was also calculated. Twenty newly adults of the predator fed on the prey as that of its larval instars, were sexed and introduced singly into the formerly Petri-dishes. The same technique in the larval stage was adapted in the rearing of the adult stage. Seven days post emergence, adult males and females from each treatment group were transferred to a single large petri dish (200×9 mm) and provided with aphid nymphs and kept in cohort for mating after that separated singly in the dishes.

The total number of the aphids consumed per a male or female and the total number of eggs laid of predator female was recorded.

Statical analysis: Final data were subjected to ANOVA and the obtained results were statistically analyzed by using CoStat Statistical Software[26] computer program.

RESULTS

Population density of the cowpea aphid, *Aphis craccivora* on cowpea plants: Data in Table 1 showed that 2 peaks in 3rd week of July and 4th week of August which were means of number *A. craccivora* were (3903 and 951 individuals/30 plants) in the first season. While in the 2nd season one peak was noticed in the 4th week in July (2994 individuals/30 plants). The mean numbers of *A. craccivora* during the 2 seasons were 1179.44 and 760.19 individuals/30 plants, respectively. The correspondent calculated average mean temperature and relative humidity during these periods were 40.0°C, 63.0% RH and 36.0°C, 55.0% RH, respectively. The mean numbers of *A. craccivora* during the two seasons were 171.25 and 109.53 individuals/plant, respectively (Table 1).

Population density of predators attacking *A. craccivora* on cowpea plants: Seven species of predators were found during the two seasons of this investigation. These predators were *C. undecimpunctata, Metasyrphus corollae*., *C. carnea, Scymnus* sp., *Orius* sp., *Cydonia vicinaisis* (Muls) and *P. alfierii*. The composition of the arthropod predator complex varied among the orchards and *Coccinella undecimpunctata*, *Chrysoperla carnea* and *Metasyrphus corollae* were the dominant species in the field. Predatory families listed in order of abundance were Coccinellidae, Chrysopidae, Cecidomyiidae, Syrphidae and Chamaemyiidae. The predator species differ in their capacity to consume aphids and impact aphid populations:

- ***Coccinella undecimpunctata*:** Data presented in Table 2 and 3) showed that *C. undecimpunctata* was appeared in the 4th week of June (1 individuals/30 leaves) and 3rd week of June (3 individuals/30 leaves) during 2018 and 2019 seasons, respectively. Two peaks of activity were recorded in the 3rd week of July and 2nd week of August (30 and 22 individuals/30 leaves) and (34 and 19 individuals/30 leaves) during 2 seasons respectively

Table 1: Population density of *A. craccivora* on cowpea plants during two seasons 2018 and 2019

	Means					
	First season			Second season		
Date of inspection (weeks)	Aphid/30 plants	Temperature (°C)	RH (%)	Aphid/30 plants	Temperature (°C)	RH (%)
June						
3rd	129	36	61	63	28	51
4th	477	36	59	318	29	49
Mean	303	36	60	190.5	28.5	50
July						
1st	783	24	61	490	40	56
2nd	1488	30	60	990	40	57
3rd	3903	30	60	2292	40	63
4th	3645	30	55	2994	38	59
Mean	2454.75	29.75	59	1691.5	39.5	49.5
August						
1st	3042	32	56	2070	37	59
2nd	2547	32	51	1236	37	58
3rd	615	30	59	552	36	61
4th	951	31	56	339	36	55
Mean	1788.75	31.25	55.5	1049.25	36.5	58.75
September						
1st	342	29	57	234	32	62
2nd	168	31	64	105	34	63
3rd	123	29	58	69	34	60
4th	52	30	56	30	35	55
Mean	171.25	29.75	58.75	109.53	33.75	60
General mean	1179.44	31.69	47.69	760.19	34.56	54.44

RH: Relative humidity

Table 2: Population density of the predatory insects associated with *Aphis craccivora* on cowpea plants during season 2018

Date of inspection (Weeks)	*C. undecimpunctata*	*C. carnea*	*Metasyrphus corollae*	*Scymnus* sp.	*Orius* sp.	*C. vicinaisis*	*P. alfierii*	Total	Corresponding means	
									Temperature (°C)	RH (%)
4th	1	1	0	0	0	0	0	2	29	59
Mean	1	1	0	0	0	0	0	2	29	61
July										
1st	7	5	4	4	2	2	0	24	29	61
2nd	19	9	16	8	6	4	2	64	30	60
3rd	30	23	19	10	13	7	5	107	30	60
4th	26	18	14	9	11	4	3	85	30	55
Mean	20.5	13.75	13.25	7.75	8	4.25	2.5	70	29.75	59
August										
1st	19	12	10	7	5	3	1	57	32	56
2nd	22	7	18	10	9	5	2	73	32	51
3rd	16	15	9	5	6	4	3	58	30	59
4th	13	4	3	3	7	3	1	34	31	56
Mean	17.5	9.5	10	6.25	6.75	3.75	1.75	55.5	31.25	55.5
September										
1st	9	3	2	1	4	2	1	22	29	57
2nd	5	1	2	3	2	1	0	14	31	64
3rd	3	3	1	1	1	0	1	10	29	58
4th	1	1	0	0	0	1	0	3	30	56
Mean	4.5	1.25	2	1.25	1.75	1	0.5	12.25	29.75	58.75
Total	171	102	98	61	66	36	19	553		
Percentage	30.92	18.44	17.72	11.03	11.93	6.51	3.44	100		
General mean	10.88±2.65	6.56±1.69	6.13±1.80	3.81±1.04	4.28±1.18	2.25±0.57	1.18±0.32	34.94±9.11	31.69	47.69

RH: Relative humidity

Table 3: Population density of the predatory insects associated with *Aphis craccivora* on cowpea plants during season 2019

Date of inspection (Weeks)	*C. undecimpunctata*	*C. carnea*	*Metasyrphus corollae*	*Scymnus* sp.	*Orius* sp.	*C. vicinaisis*	*P. alfierii*	Total	Corresponding means	
									Temperature (°C)	RH (%)
June										
3rd	3	0	0	1	1	0	0	5	28	51
4th	7	3	5	5	0	1	0	21	29	59
Mean	5	1.5	2.5	3	0.5	0.5	0	13	28.5	50
July										
1st	9	6	7	7	2	0	0	31	40	56
2nd	11	9	8	4	1	1	2	36	40	67
3rd	34	14	19	14	7	6	5	99	40	63
4th	22	25	13	10	5	4	3	82	38	59
Mean	19	13.5	11.75	8.75	3.75	2.75	2.5	62	39.5	49.5
August										
1st	14	9	8	4	3	2	1	41	37	60
2nd	19	8	11	8	7	5	2	60	37	58
3rd	10	15	8	4	3	2	1	43	36	61
4th	7	3	4	2	1	1	0	18	36	55
Mean	12.5	8.75	7.75	4.5	3.5	2.5	1	40.5	36.5	58.25
September										
1st	5	2	2	1	0	0	0	10	32	62
2nd	4	1	3	2	1	0	1	12	34	63
3rd	2	1	1	2	2	1	1	10	34	60
4th	0	0	0	0	0	0	0	0	35	55
Total	147	96	89	64	33	23	16	468		
Mean	2.75	1.5	1	1.25	0.75	0.25	0.5	8	33.75	60
Percentage	31.41	20.51	19.02	13.68	7.05	4.91	3.42	100		
General mean	9.81±2.47	6.19±1.92	6.37±1.45	4.37±1.06	2.12±0.69	1.57±0.53	1.0±0.39	30.87±8.24	34.56	54.44

RH: Relative humidity

- ***Chrysoperla carnea*:** Data presented in Table 2 and 3 showed that *C. Carnea* was recorded 2 peaks of activity in the 3rd week of July and August with values (23 and 15 individuals/30 leaves) and (25 and 15 individuals/30 leaves), in the 4th week of week of July and August, during 2018-2019 seasons, respectively
- ***Metasyrphus corollae*:** Data presented in Table 2 and 3 showed that *M. corollae* was appeared in the 1st week of July and 4th week of June by (4 and 5 individuals/30 leaves) and recorded two peaks of activity were recorded in the 3rd week of July and 2nd week of August (19 and 18 individuals/30 leaves) and (19 and 11 individuals/30 leaves) during two seasons respectively
- ***Scymnus* sp.:** Table 2 and 3 showed that *Scymnus* sp., was recorded one peak of activity in the 2nd week of August and 3rd week of July and with values (10 and 14 individuals/30 leaves) during 2018-2019 seasons, respectively
- ***Orius* spp.:** Table 2 and 3 showed that *Orius* spp. was recorded 1 peak of activity in the 3rd week of July and 2nd week of August with values (13 and 7 individuals/30 leaves) during 2018-2019 seasons, respectively
- ***C. vicinaisis* and *P. alfierii*:** Two predators were 1 peak of activity in the 3rd week of July during 2018-2019 seasons with values (7 and 6 individuals/30 leaves) for *C. vicinaisis* and (5 individuals/30 leaves), respectively Table 2 and 3

Occurrence (%) of predators species associated with *A. craccivora* on cowpea: The occurrence of these predators in the 1st season 2018 could be descendingly arranged as follow:

Coccinella undecimpunctata was the dominant predator species with a rate of occurrence reached, 30.92%. *C. carnea* represented the second one with a percent of 18.44% from the total numbers of predators found in the 1st season, whereas the rest predator arranged dissentingly as follow, *Metasyrphus corollae* 17.72%, *Scymnus* sp., 11.03%, *Orius* sp., 11.93%, *C. Vicinaisis* 6.51% and *P. alfierii* 3.44% in 2018 (Fig. 1).

In 2018 season, the total number of predators was fluctuated and increased gradually to reach its maximum (107 individuals/30 plants) in the 3rd week of July (Table 2). The correspondent calculated average mean temperature and relative humidity during these periods were 30.0°C, 60.0% RH

In 2019 season, the population density of whole predators started with low densities till reached its maximum (110 individuals/30 plants) on the 3rd week of July. One additional

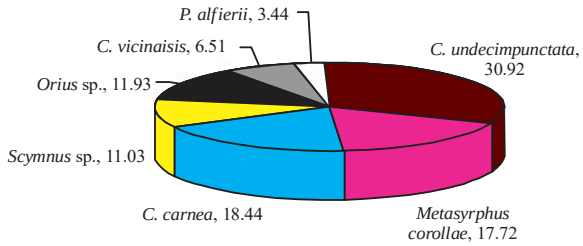

Fig. 1: Occurrence (%) of predators species on cowpea aphid *A. craccivora* during season 2018

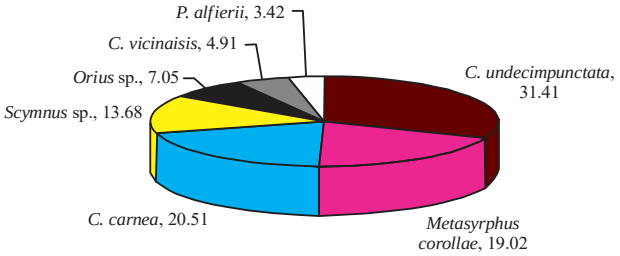

Fig. 2: Occurrence (%) of predators species on cowpea aphid *A. craccivora* during season 2019

peak (67 individuals/30 plants) was found in the 2nd week of August. The occurrence of the same predators in the 2nd season 2019 could be descending arranged as follow: *C. undecimpunctata* was the dominant predator species with a rate of occurrence reached (31.41%) from the total number of predators. *C. carnea* (20.51%), *Metasyrphus corollae* (19.02). *Scymnus* sp., (13.68%), *Orius* sp., (7.05%), *C. vicinaisis* (4.91%) and *P. alfierii* (3.42%) (Fig. 2).

In 2019 season, the total number of predators was fluctuated and increased gradually to reach its maximum (99 individuals/30 plants) in the 3rd week of July (Table 3). The correspondent calculated average mean temperature and relative humidity during these periods were 40.0°C, 63.0% RH.

Biological studies on the predator *C. undecimpunctata* on *A. craccivora*: The predator *C. undecimpunctata* which is native and efficient was chosen for rearing on *A. craccivora*. The experiment was conducted to study certain biological characters of this predator when reared on natural preys' *A. craccivora* under laboratory conditions.

Larval and pupal periods and feeding capacity of larvae: Table 4 and 5 show the results of studying certain biological characters of the predator *C. undecimpunctata* on *A. craccivora*, the eggs are laid in batches of various sizes on the underside of leaves and other locations near potential

Table 4: Duration of larval's instars of *C. undecimpuncatata* and feeding capacity when fed on *A. craccivora* under laboratory conditions (26.0±1°C and RH 65±5%)

Larval instar	Duration in days (Mean±SD)	Daily consumption	Total consumption/instar (Mean±SD)	Consumption (%)
1st	3.27±0.10	13.58	48.20±2.15	10.85
2nd	3.35±0.11	11.52	76.45±3.71	17.20
3rd	3.65±0.12	11.66	115.10±3.98	25.89
4th	4.45±0.14	16.64	204.70±4.01	46.06
Total	14.72±0.18	53.40	444.45±6.13	100.00

Table 5: Longevity and fecundity of predator *C. undecimpuncatata* reared on *A. craccivora* under laboratory conditions (26.0±1°C and RH 65±5%)

Adults stages	Periods in days (Mean±SD)	Daily consumption	Total consumption/ adult stage (Mean±SD)	Average number of eggs	
				Daily	Total
Female preoviposition	5.30±0.89	67.47	357.60±10.98	8.55	256.6±11.69
Oviposition	30.00±2.48	77.13	2313.90±30.11		
Postoviposition	6.90±1.91	67.19	463.60±11.32		
Longevity	42.20±3.87	74.29	3135.10±39.12		
Male longevity	33.90±3.10	64.71	2193.50±47.09	-	-

food sources for the larvae. Larvae emerge from eggs by rupturing one end of the egg. Shortly before eclosion the chorion becomes thin and semitransparent and the stemmata, mandibles and hatching spines (egg bursters) on the head of the embryo become clearly visible. The developmental period of the first instar larvae of *C. undecimpunctata* was 3.27±0.10 days when the larvae were fed on *A. craccivora*. The duration of the second instar larvae was 3.35±0.11 days. The developmental period of the third instar larvae was 3.35±0.11days.

It can be seen from these tables that the average duration of the predator larval instars was 14.72±0.18 days when fed on this aphid species. The averages of the total consumption during the four larval instars of the predator were 48.2±2.15, 76.45.±3.71, 115.1±3.98 and 204.7±4.01 aphid individuals, respectively with a general average of 444.45±6.13 aphid individuals' larva (Table 4). It is clear from this table that the 3rd and 4th larva instar formed 25.89 and 46.06%, respectively of the total consumption. Meanwhile, the 1st and 2nd instars consumptions were 10.85 and 17.20%. The fully grown fourth instar larva stops feeding and attaches itself to the substrate using its anal pad. There it remains during a quiescent prepupal stage of several h until it moults to transform into a pupa. The average development of the pupal stage was 5.80±0.14 days.

Longevity, feeding capacity and fecundity of adults: The predator male adult stage during its longevity period which lasted an average of 33.90±3.10 days as in Table 5 which consumed a total average of 2193.5±47.09 aphid individuals with a daily rate of 64.71 individuals. Preoviposition period of the females was 5.30±0.89 days, oviposition period lasted 30.0 days female consumed of 2313.90±30.11*A. craccivora* individuals, while, postoviposition was 6.90±1.91 days. The predator female consumed a total average of 3135.1±39.12 *A. craccivora* individuals, with a daily rate of 74.29 during its longevity which lasted 42.20±3.87 days. The average number of deposited eggs per predator's female was 256.60±11.69 during the oviposition period which reached an average of 30.0±2.48 days.

DISCUSSION

Aphis craccivora Koch., is considered one of the most injurious pests in cowpea and other leguminous crop. In the present study the population density of the cowpea aphid, *Aphis craccivora* and its associated predators on cowpea fields. Two peaks in third week of July and fourth week of August which were means of number *A. craccivora* were (3903 and 951 individuals/30 plants) in the 1st season. While in the 2nd season one peak was noticed in the 4th week in July (2994 individuals/30 plants). The obtained results was similar to those of Saleh *et al.*[27] and Saleh[28] in Egypt who stated that *A. craccivora* was the most injurious pest attacking broad bean and cowpea in upper Egypt owing to the favorable weather conditions.

The present results are in agreement with the findings that *A. craccivora* had two main periods of activity with maximum counts[8]. On the other hand, Ali *et al.*[29] mentioned that *A. craccivora* had one peak only on cowpea in the third and 4th week of July (130.1 and99.91 individuals/40 plants) in 2011 and 2012, respectively.

The present study that concluded predators are a major component of natural control and integrated pest management programs of certain sap-sucking pests. The obtained data revealed that predators recorded as following, *C. undecimpunctata, Metasyrphu scorollae*., *C. carnea, Scymnus* sp., *Orius* sp., *Cydonia vicinaisis* and *P. alfierii*. The

composition of the arthropod predator complex varied among the orchards and *Coccinella undecimpunctata*, *Chrysoperla carnea* and *Metasyrphus corollae* were the dominant species in the field. The present results are in agreement with the findings mentioned that the common predators observed in faba bean and cowpea fields were: *C. undecimpunctata*, *C. carnea*, *P. alfierii* (Koch.), *Orius* sp., *M. corollae scymnus* sp. and *C. vicinaisis*[29].

In the present study insect predators associated with insect pests recorded as following: *Coccinella undecimpunctata* was the dominant predator species with a rate of occurrence reached, 30.92%. *C. carnea* represented the second one with a percent of 18.44% from the total numbers of predators found in the first season, whereas the rest predator arranged dissentingly as follow, *Metasyrphus corollae* 17.72%, *Scymnus* sp., 11.03%, *Orius* sp., 11.93%, *C. Vicinaisis* 6.51% and *P. Alfierii* 3.44% in 2018. Meanwhile; *C. undecimpunctata* was the dominant predator species with a rate of occurrence reached (31.41%) from the total number of predators. *C. carnea* (20.51%), *Metasyrphus corolla* (19.02). *Scymnus* sp., (13.68%), *Orius* sp., (7.05%), *C. vicina*isis (4.91%) and *P. alfierii* (3.42%) in 2019.

The present results agree with those of Metwally[30], who stated that, *C. undecimpunctata, S. interuptus* and *O. albidipennis* were associating with *A. craccivora* on cowpea plants. It is stated that *C. undecimpunctata* was represented by 16.88 and 23.96%, *C. vicinaisis*, 7.14 and 5.73%, *C. vicinanilotica* 4.11 and 3.65%, *M. corollae* 3.25 and 2.86%, *C. carnea* 3.68 and 3.13% on *A. craccivora* infested cowpea during 2009 and 2010 seasons, respectively in Egypt[31]. On the other hand, it is reported that the efficiency was a function of the predator\prey ratio and the initial aphid density at the time of release of the predator prey density had a large influence on the fecundity and establishment of this coccinellid in the greenhouse[32].

Moura *et al*.[33] and Cabral *et al*.[34] evaluations on predating efficiency of *C. undecimpunctata* on aphids. Low consumption of *P. solenopsis* than mustard aphid might be due to fact that mealy bugs are covered with waxy layer, which makes the prey unpalatable for consumption by predators. The predator *C. septempunctata* consumed less *B. brassicae* than other species due to waxy coating on *B. brassicae*[35]. It is Stated that aphidophagous coccinellids play an important natural role in regulating and suppressing the population of their potential preys principally aphid *A. craccivora*[23].

These results are in accordance with the findings of Saleh[28] and Abdel-Samad *et al*.[36], who reported the *C. undecimpunctata*, *C. carnea* and *Metasyrphus corollae* were the most important predators attacking *A. craccivora.*

The results of studying certain biological characters of the predator *C. undecimpunctata* on *A. craccivora*. The developmental period of the first instar larvae of *C. undecimpunctata* was 3.27±0.10 days when the larvae were fed on *A. craccivora*. The duration of the second instar larvae was 3.35±0.11 days. The developmental period of the third instar larvae was 3.35±0.11 days. The average duration of the predator larval instars was 14.72±0.18 days when fed on this aphid species. The averages of the total consumption during the four larval instars of the predator were 48.2±2.15, 76.45.±3.71, 115.1±3.98 and 204.7±4.01 aphid individuals, respectively with a general average of 444.45±6.13 aphid individuals' larva.

These findings agree with that of previous reports that the incubation period of *C. undecimpuncatata* was 2.7 days at 26-28°C[37]. It was also reported that the period for the same predator was 2.0 days at 30°C[38]. While Elhag and Zaitoon[39] found the period was 3.5 days at 25.0±2.0°C.

Ghanim and El-Adl[40] found that larvae of *C. undecimpuncatata* and *C. vicinaisis* took 10.0 and 9.0 days when reared on both aphids, *Rhopalosiphum maidis* (Fitch) and *S. avenae*. When *C. undecimpuncatata* reared on *R. padi* L., the larvae, pupae and complete immature stages averaged 7.0, 2.5 and 12.0 days at 30°C [39]. On the other hand, it was found that when *C. undecimpuncatata* reared on *Macrosiphum pisi* (Harris) the larvae and pupae averaged 9.2 and 2.9 days at 26°C[41].

Meanwhile, Barakat[42] reported that the incubation period, larva, pupa and total developmental period was lasted 2.7, 11.0 and 7.6 and 24.3 days at 26.8°C when predator *C. undecimpuncatata* reared on *H. pruni*, the 4 larval instars consumed 15.7, 50.4, 48.2 and 157.9 individuals, respectively.

On the other hand, Mohammed[41] found that the average of the total consumption during the four larval stages of the predator *C. undecimpuncatata* when reared on *M. pisi* was 27.7, 68.4, 123.9 and 144.0 individuals, respectively. Also, Imam[43] revealed that mean consumption of aphids *A. craccivora* per *C. undecimpunctata* adult was 80.8, whereas, 21.76, 55.67, 107.86 and 231.03 aphids were consumed by a single larva during 1st, 2nd, 3rd and 4th instars, respectively. A single female laid 195.0±13.10 eggs during entire life period. The egg hatching was 96.3 while 82.0% larvae survived up to pupal stage. Total larval and pupal duration was 23.4±0.35.

The study of Ali and Rizvi[44] on 5 aphid preys revealed that the developmental period of *Coccinella septempunctata* varied significantly with respect to aphid species under

controlled conditions. The development of the immature stages were significantly shorter when fed on *A. craccivora* and *M. rosae*.

In the present study preoviposition period of the females was 5.30±0.89 days, oviposition period lasted 30.0 days female consumed of 2313.90±30.11 *A. craccivora* individuals, while, postoviposition was 6.90±1.91days. The predator female consumed a total average of 3135.1±39.12 *A. craccivora* individuals, with a daily rate of 74.29 during its longevity which lasted 42.20±3.87 days. The average number of deposited eggs per predator's female was 256.60±11.69 during the oviposition period which reached an average of 30.0±2.48 days. Whereas Elhag and Zaitoon[39] mentioned that oviposition and longevity periods for *C. undecimpuncatata* females were 29.8 and 70.0 days. They found that number of eggs laid per female and daily mean of eggs were 370.5 and 142 eggs when reared on *B. brassicae* and *R. padi*, while it was reported that oviposition and longevity period for the same predator females was 56.6 days with (481 eggs). The female consumed an average 4599.2 *M. pisi* individuals during this period[40].

On the other hand, Barakat[42] found that oviposition and longevity period for these predator females was 43.5 days with (343.5 eggs) during this period. The female consumed average 2531.7 *H. pruni* individuals, while male consumed average 2017.6 *H. pruni* individuals. The difference in the fitness parameters (development, survival and fecundity) of *E. nigromaculatus* could be explained as a direct result of the quality and quantity differences in prey and as an indirect effect of the host plant. The protein content of broad bean ranges from 22-36%[45]. In addition, this study might provide useful information for the utilization of this ladybird predator in IPM programs in broad bean and cowpea. Finally, predators could be recommended as biological control agents against this aphid *A. craccivora* under Egyptian conditions.

CONCLUSION

This article explores the predatory species potential and biology of *C. undecimpunctata* fed on cowpea aphid, *Aphis craccivora. Coccinella undecimpunctata* was the dominant predator species with a rate of occurrence reached, 30.92%. *C. carnea* represented the second one with a percent of 18.44% from the total numbers of predators. The predator female consumed a total average of 3135.1±39.12 individuals. *Coccinella undecimpunctata* is one of the common species in Egypt, it is considered as an important predator of the eggs and the newly hatched larvae of cotton leaf worm and aphids. The average number of eggs deposited per female was 256.6±11.69 eggs. Experiment demonstrated that predators are an effective bio control agents of *A. craccivora* which can be used in integrated pest management program successfully for the management of aphid, *Aphis craccivora* on cowpea crops.

SIGNIFICANCE STATEMENT

This study discovers potential and biology of aphidophagous insects to control cowpea aphid, *Aphis craccivora*. Studying the relationship between cowpea aphid, *Aphis craccivora* as favorable preys and their predators enable to know how these predators cold share in this natural balance. Moreover, this study will help the researcher to uncover the opportunity for determining the best timing for releasing of more effective predatory species in the fields, suffering from pests attack, in the frame of Integrated Pest Management (IPM) strategies, side by side with safe alternative control methods.

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