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Functional response of *Chrysoperla carnea* (Stephens) and *Coccinella undecimpunctata* (Linnaeas) on some pests attack cotton plant under laboratory conditions

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Abstract
Understanding the interactions between predator and prey is the basis for bio-control strategy. In this study, the host preference of *Chrysoperla carnea* (Stephens) larvae and both larvae and adult females of *Coccinella undecimpunctata* (Linnaeus) between *Aphis gossypii* (nymph), *Phenacoccus solenopsis* (2nd nymph), *Spodoptera littoralis* (newly hatched) and *Tetranychus urticae* (nymph) were evaluated. Results showed that *A. gossypii* was the most preferred host under optional feeding conditions of both predators comparing with other hosts. Although, the predation efficiency of both predators were conducted for *Aphis gossypii* and *Phenacoccus solenopsis*, as the average consumption ratio reach to 19.73% and 27.12% insects of aphid for larval stage of *C. undecimpunctata* and *C. carnea* respectively. Adult stage of *C. undecimpunctata* had more consumption than its larval stages reach to 27.47% insects of aphid. In forced feeding conditions the average of consumption ratio for larval stages of *C. undecimpunctata* was 31.10% and 28.59% for *A. gossypii* and *P. solenopsis* respectively. While larvae of *C. carnea* feeds on 30.77% and 27.46% of *A. gossypii* and *P. solenopsis*, respectively. Adult stage of *C. undecimpunctata* was consumed on 83% and 80.98% of *A. gossypii* and *P. solenopsis*, respectively. The present work indicated that *C. undecimpunctata* (larvae & adults) and *C. carnea* (larvae) are an effective bio-control agents of *P. solenopsis* as well as *A. gossypii*.

Keywords: preferences, predation efficiency, *Chrysoperla carnea*, *Coccinella undecimpunctata*, *Aphis gossypii*, *Phenacoccus solenopsis*, *Spodoptera littoralis*, *Tetranychus urticae*

Introduction

Cotton plant represented one of the most important economic fiber crops throughout the world (Ramzan *et al.*, 2019) [15]. Its products are used in many branches like food, oil and lint (Ozyigit *et al*., 2007) [14]. This crop is attacked by many pests (depended on cotton variety, place of grow and ecological conditions) which effect on cotton quality and productivity such as aphids, thrips, mites, white flies, jassids, cotton leafworm, bollworms and cotton mealybugs (Hormchan *et al.*, 2001 and Dhaka and Pareek 2007) [9, 5]. For controlling this large number of pests, many control methods have been applied under the integrated pest management strategy.

Aphids attracted attention by causing losses for wide host range (Hany and Amal 2009) [8]. Cotton mealybugs, *Phenacoccus solenopsis* recently has been the topic of most research because its rapidly spread, wide range of host plants and covered with waxy layer so it makes pest control difficult also, it causes a significant damage to leaves, stem and fruits (Asifa *et al.*, 2013; Tong *et al.*, 2019; Abd El-Wareth 2016 and Nadia *et al.*, 2016) [4, 23, 1, 12]. Both of aphids and cotton mealybugs caused honeydew (sugary exudates) resulting from their feeding. In cotton crops, honeydew reduced quality of final products (Richard *et al.*, 2020) [17]. Bio-control has been classified as one of the methods used in Integrated Pest Management because it has less harmful to the environment than chemical control (Mahzoum *et al.*, 2020) [11]. Functional response is the most effective way to estimate the relationship between prey and predator in bio-control (Timms *et al.*, 2008; Osman and Bayoumy, 2011) [22, 13]. The green lacewing, *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) and the eleven-spotted ladybird, *Coccinella undecimpunctata* Linnaeus (Coleoptera: Coccinellidae) are an important generalist predator and a key specialist bio-control agents and its had ability to predate aphids and many soft bodied insects (Shafique *et al*., 2015, Arshad *et al*., 2017 and Rehab *et al*., 2020) [20, 3].

This research aims to assess the host preference under optional conditions of *C. undecimpunctata* and *C. carnea* between *A. gossypii*, *P. solenopsis*, *S. littoralis* and *T. urticae*. Although evaluated the predatory potential under forced feeding conditions of the same predators on *A. gossypii* and *P. solenopsis* under laboratory conditions.

Materials and Methods

1-Preparing Predators culture

The Adult females of *Chrysoperla carnea* were collected from unsprayed cotton fields then transferred to the laboratory of pesticides testing department and put in glass jars covered with a black cloth as site for oviposition. Larval (first instar) were collected and transferred into petri dishes and transfused individually to petri dish (9 cm). While, the eggs of the *Coccinella undecimpunctata* (Linnaeus) were collected from cotton fields and transferred to laboratory. After hatching only one of the first instar larvae put on a petri dish. and made vallary openings were established in plastic petri dish, the leaves were placed individually inside the dishes and filter paper was put under each leaf to absorb any water steam, while their petioles passed through the openings and immersed in 2% sucrose solution to retains the leaves alive (fig. 1). All insects (larval stages) were placed in Petri dishes on leaves.

Fig 1: preparation of Petri dishes and submerged the petioles of the cotton leaves in 2% sucrose solution to remain the leaves a live along pried with placed insects into dishes.

- **Providing preys (*A. gossypii, P. solenopsis, S. littoralis* and *T. urticae*):**

To get a suitable numbers of *Aphis gossypii, Phenacoccus solenopsis,* and *Tetranychus urticae,* the infested leaves were collected from unsprayed cotton fields and transferred to cotton plants potted under laboratory conditions of 32±2ºc, 65±5RH and 13:11 (L:D) photoperiod. After the preys multiplied, the experiment was performed on the adult stages for *A. gossypii* and *T. urticae* but adult females of *P. solenopsis* and aphid cotton plants infested were collected from unsprayed cotton plants and transferred to laboratory on cotton plants. While of *S. littoralis* were obtained from mass rearing laboratory, Agricultural Research Center, Plant Production Research Institute, Sakha branch. After days, all insects started sexual reproduction and parthenogenesis under laboratory conditions and increased in the number for the next experiments.

Preference (0ptional feeding conditions) of *C. carnea* and *C. undecimpunctata* between *A. gossypii, P. solenopsis, S. littoralis* and *T. urticae*:

To evaluated the host preference of *C. carnea* and *C. undecimpunctata* a fixed number of *A. gossypii, P. solenopsis, S. littoralis* and *T. urticae* was distributed in the petri dishes started with 50 prey and increased with the development of larval instar to predator (50, 70, 100, 150 prey, respectfully). The percentage of consumption is calculated within 24 hrs. The examination had done daily until molting skin for the next Predators larval age appearance. While, of *C. undecimpunctata* (adult) there was (1:100) (predator: prey) for 10 days.

The percentage of consumption= No / Na X 100 which:

No. is number of prey devoured ، Na. is initial prey provided

- **Predatory potential (Forced feeding conditions) of *C. carnea* and *C. undecimpunctata* on *A. gossypii* and *P. solenopsis***

Feeding capacity of *C. carnea* and *C. undecimpunctata* was evaluated after 24 hours by using a fixed number of *A. gossypii* and *P. solenopsis* in Petri dishes and take results every day until pupa stage for the next Predators larval age appearance of the predator. Every prey put in separate Petri dish, the number of pest were gradually increased till the fine each larval stage of *C. carnea* and *C. undecimpunctata* and the consumed individual of pest per each stage of the lacewing and ladybird were evaluated daily.

- **Statistical analysis**

Data were collected after 24 hours for host preference and predatory potential. Data were statistically analyzed using one-way analysis of variance (ANOVA) with SAS statistics 9.1 software.

Results and Discussion

Host preference activity (optional feeding)

Data in Table (1) illustrated that *A. gossypii* was the most preferred prey to the two predators. Also mean feeding increased as well as development of larval stages of predators. It was obviously cleared in results where the 1st instar larvae of *C. undecimpunctata* feeds on 19.50 ±2.12 aphis and the gradually increased to reach 137.0 ±43.1 prey of aphid by the 4th instar larvae, while the adult stage feeds on 274.75 ±38.2 *A. gossypii*. Arshad *et al*., 2017 [3] found that adults of *Coccinella septempunctata* consumed more aphids than grubs while El-Zahi, 2017 [6] found that the same result on *Coccinella undecimpunctata* adults consumed more aphids than mealybug. The 1st instar larvae of *C. undecimpunctata* fed only on *A. gossypii* while the 2nd instar larvae had consumed 6.50 ±5.66, 5.00 ±4.24 and 5.00 ±6.36 of *P. solenopsis*, *T. urticae* and *S. littoralis* respectively. Also the 3rd instar larvae had consumed on 11.25 ±7.07, 8.00 and 5.75 ±2.12 *S. littoralis*, *P. solenopsis* and *T. urticae* respectively. The 4th instar larvae had consumed on 33.75 ±2.12, 12.50 ±2.83 and 11.00 ±3.54 *S. littoralis*, *T. urticae* and *P. solenopsis*, respectively. Shera *et. al*. (2010) [21] indicated that *A. gossypii* were more preferred than mealybug when both were exposed to *C septeimpunctata***,** Ali and Risvi (2007), indicated that of *C septeimpunctata* feeding more of *A. gossypii* than insects other.

Data in Fig. (2) showed that the average of consumption ratio of adult stage of *C. undecimpunctata* was higher than larval period (from 1st to 4th larval instar). It was 27.47, 3.08, 2.08, 1. 56% for *A. gossypii*, *S. littoralis*, *T. urticae* and *P. solnopsis* respectively for the adult stage while it was 19.73, 2.95, 1.95, 1.62% for *A. gossypii*, *S. littoralis*, *P. solenopsis* and *T. urticae* respectively for the larval period. Feeding larvae or adult stages of *C. undecimpunctata* on aphids or many other species because of their capacity to survive (Habeck *et al*., 1990) [7]. While the larval instars of *C. carnea* also showed the same results where the 1st instar larvae feeds on 23.25 ±5.66 of aphids reached to 91.50 ±9.19 were eaten by the 3rd instar larvae. To the other preys it was consumed 3.25 ±4.24 and 1.25 ±0.71 of *T. urticae* and *S. littoralis* respectively by the 1st instar larvae, while the 2nd instar larvae recorded 9, 4.50 ±1.41 and 3.00 ±2.12 for *T. urticae, S. littoralis* and *P. solenopsis* respectively. At finely, the 3rd instar larvae of *C. carnea* had consumed 11.75

±2.83, 8.50 ±1.41 and 6.00 ±2.12 of *T. urticae*, *S. littoralis* and *P. solenopsis* respectively. Also the average of consumption ratio of larval period (from 1st to 3rd larval instar) of *C. carnea* were 27.12, 3.82, 2. 1.14% for *A. gossypii*, *T. urticae*, *S. littoralis* and *P. solenopsis* respectively.

Table 1: Preference of *C. undecimpunctata* and *C. carnea* on *A. gossypii*, *T. urticae*, *S. littoralis* and *P. solenopsis*

predators		**preys**			
		A. gossypii	***T. urticae***	***S. littoralis***	***P. solenopsis***
C. undecimpunctata	1st larval instar	19.50 ±2.12 c	0 c	0 c	0 b
	2nd larval instar	35.00 ±2.12 c	5.00 ±4.24 b	5.00 ±6.36 bc	6.50 ±5.66 a
	3rd larval instar	59.75 ±4.95 b	5.75 ±2.12 b	11.25 ±7.07 b	8.00 ±0 a
	4th larval instar	137.0 ±43.1 a	12.50 ±2.83 a	33.75 ±2.12 a	11.00 ±3.54 a
Adult stage of C. undecimpunctata		274.75 ±38.2 a	20.75 ±0 b	30.75 ±0.71 b	15.75 ±1.41 b
C. carnea	1st larval instar	23.25 ±5.66 c	3.25 ±4.24 b	1.25 ±0.71 c	0 a
	2nd larval instar	58.00 ±2.83 b	9.00 ±0 ab	4.50 ±1.41 b	3.00 ±2.12 b
	3rd larval instar	91.50 ±9.19 a	11.75 ±2.83 a	8.50 ±1.41 a	6.00 ±2.12 c

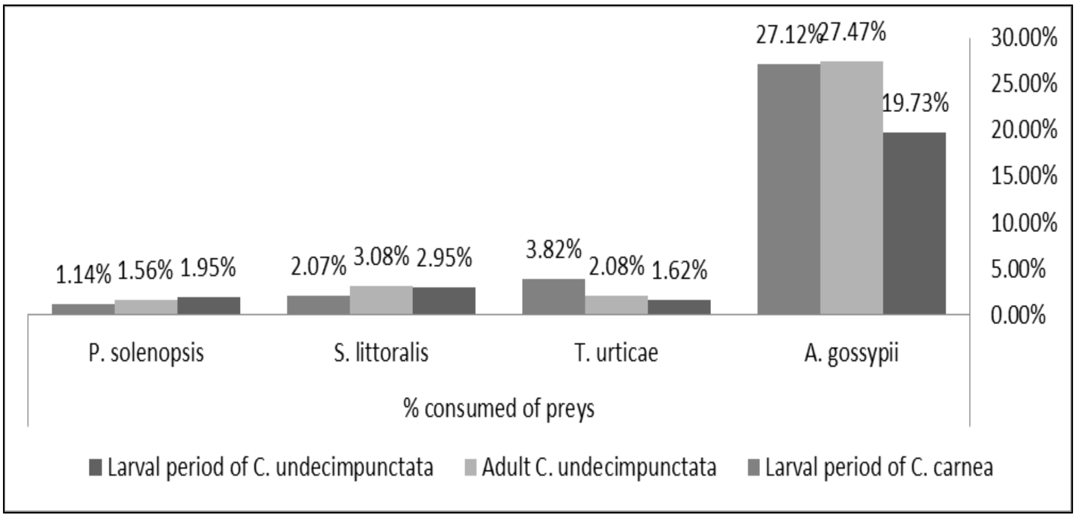

Fig 2: Percentage consumption of *C. undecimpunctata* and *C. carnea* on *A. gossypii*, *T. urticae*, *S. littoralis* and *P. solenopsis*

- **Predatory potential activity (feeding)**

Under forced feeding conditions of *C. undecimpunctata* and *C. carnea* on *A. gossypii* or *P. solenopsis*, there was no significant differences. The obtained results in Table (2) revealed that the 1st instar larvae of *C. undecimpunctata* devoured 31.25 ±4.24 of *A. gossypii* and 23.50 ±3.54 from *P. solpsisneo*. While, the 2nd, 3rd and 4th had consumed 84.00 ±12.02, 128.75 ±16.97 and 246.50 ±1.41 of *A. gossypii* but had 89.50 ±6.36, 171.75 ±0.71 and 208.25 ±31.82 of *P. solenopsis*, respectively. The adult stage of *C. undecimpunctata* had 830.00 ±25.46 (83, 00 %) of *A. gossypii* and 809.75 ±38.18 (80,98 %) of *P. solenopsis*. The larval instars of *C. carnea* had similar consumption ratio, the 1st, 2nd and 3rd instars larvae had 30.50 ±5.66, 98.50 ±9.19 and 146.25 ±0.71 of *A. gossypii* respectively and 24.75 ±2.83, 85.75 ±9.19 and 187.75 ±7.78 of *P. solenopsis*. As far as nymph of the aphid and mealybugs were consumed by *C. carnea*, the percentage of predation efficiency for aphid and *P. solpsisneo* were 30.77 and 27.48 %of the total number of consumed nymph, respectively (fig. 2). Mahzoum *et al*., 2020 [11] indicated that the 3rd stage was the most efficient of *Saissetia oleae* (Olivier). Huang and enkegaard (2010) [10] indicated that the high predation efficiency of *C. carnea* on the first instar nymph of the mealybug compering to second and third instar nymphs of ones *P. solenopsis*, where lacewing prefers consumed on the fast transition pest than slow

From Tables (1 and 2) and fig. (2and 3) it is concluded that *C. undecimpunctata* (larvae and adult) is more generalist predator than *C. carnea*.

Table 2: Means numbers of *A. gossypii* or *P. solenopsis* consumed by *C. undecimpunctata* and *C. carnea*

predators		**preys**	
		A. gossypii	***P. solenopsis***
C. undecimpunctata	1st larval instar	31.25 ±4.24 d	23.50 ±3.54 d
	2nd larval instar	84.00 ±12.02 c	89.50 ±6.36 c
	3rd larval instar	128.75 ±16.97 b	171.75 ±0.71 b
	4th larval instar	246.50 ±1.41 a	208.25 ±31.82 a
Adult stage of C. undecimpunctata		830.00 ±25.46 a	809.75 ±38.18 b
C. carnea	1st larval instar	30.50 ±5.66 c	24.75 ±2.83 c
	2nd larval instar	98.50 ±9.19 b	85.75 ±9.19 b
	3rd larval instar	146.25 ±0.71 a	187.75 ±7.78 a

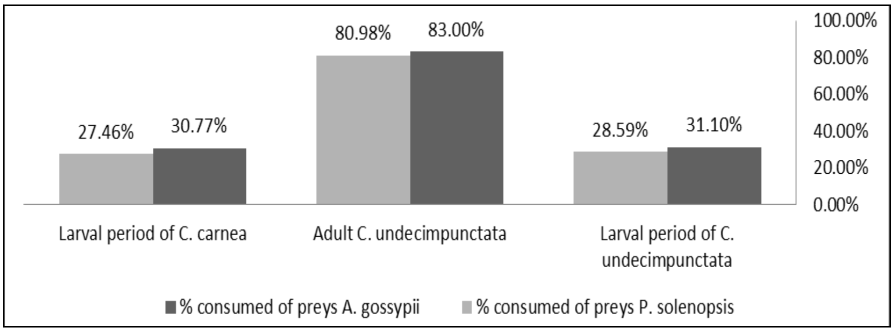

Fig 3: Predation efficiency of *C. undecimpunctata* and *C. carnea* on *A. gossypii* or *P. solenopsis*

Conclusion

By analyzing results of present experiments it was demonstrated that predators. are an effective bio-control agents of *P. solenopsis* as well as *A. gossypii*. It was showed that *C. undecimpunctata* (larvae & adults) consumed more numbers of prey than *C. carnea* (larvae) in all experiments. The preferences of *C. undecimpunctata* and *C. carnea* to aphids high than pests other. Moreover, the obtained findings showed that of ladybird and lacewing could be successfully used as biological control programs with aphids. Mealybug, leaf worm and the two spotted spider mite.

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