

PREDATORY POTENTIAL AND DEVELOPMENTAL RATE OF ELEVEN SPOTTED BEETLE, *COCCINELLA UNDECIMPUNCTATA* L. (COLEOPTERA: COCCINELLIDAE) REARED ON SOME INSECT PESTS OF TOMATO PLANT

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ABSTRACT

The ladybird beetle, *Coccinella undecimpunctata* is a polyphagous predator established in Egypt that used in a wide range in integrated pest management (IPM). In this research consumption rate and developmental periods besides adult longevity of *C. undecimpunctata* reared on some tomato pests were investigated. Our results showed that *C. undecimpunctata* was successfully preyed upon various immature stages of *T. absoluta*, egg stage of *S. littoralis* and nymphal stage of *A. gossypii*. There are no significant differences in the total developmental period of female immature stages of *C. undecimpunctata* when fed on the eggs or 1st larval instar of *T. absoluta* or eggs of *S. littoralis* while this period decreased by approximately two days when fed on 3rd larval instar of *T. absoluta* and increased by approximately two days when fed on aphid nymphs. Consumption rate of *C. undecimpunctata* towards tested insect pests revealed that female immature stages of the *C. undecimpunctata* have a higher consumption rate on different immature stages of *T. absoluta* than that on *S. littoralis* eggs or aphid nymphs while female adult of the beetle showed less preference towards immature stages of *T. absoluta*. Inversely, female adult of *C. undecimpunctata* consume more number of *S. littoralis* eggs and aphid nymphs than its immature stages.

Key words: Consumption rate, Developmental period, *Coccinella undecimpunctata*, Tomato pest

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INTRODUCTION

Tomato, *Lycopersicon esculentum* Miller (Solanaceae), is considered to be one of the most economically important crop, between 100 and 200 pest species are reported to attack tomatoes worldwide (Lange and Bronson, 1981). Insecticidal control of these pests is not only expensive but also the indiscriminate use of pesticides caused phytotoxicity and destruction of beneficial organisms such as predators, parasitoids, and micro-organisms in the area under control (Nikam et. al., 2010; Mahmood et. al., 2011).

Biological control of tomato pests considered a good alternative for insecticides and also an important tactic because it is safe, economic and environmental friendly (Hameed et. al., 2013). The ladybird beetle, *Coccinella undecimpunctata* come in the first order as a biological agent and predator of most tomato pests at different stages of their life cycle (Raimundo and Alves, 1986; Hodek and Honek, 1996).

So, the aim of present work is to determine the predatory potential and developmental rate of the ladybird beetle, *Coccinella undecimpunctata* to chalk out its role for area wide control of tomato pests in pest management programs when reared on three pests of tomato plant, *Spodoptera littoralis*, *Aphis gossypii* and *Tuta absoluta*.

MATERIALS AND METHODS

Rearing of *Tuta absoluta*:

For establishment a laboratory colony of *T. absoluta* infested leaves with larvae besides samples of soil under tomato plants were collected from tomato plantation located at Bernecht, Giza province, Egypt. The leaves and soil were transferred to the laboratory for inspection. Infested leaves were kept till pupation and the soil was sieved for separation of the pupae. The collected pupae from leaves and soil were housed in a wooden cage measured 60x40x40cm with all sides made of wire mesh contain a piece of cotton saturated with sugar solution for adult feeding and small pots with tomato plants for eggs laying. Infested tomato leaves from rearing cage were cut and the eggs were collected with fine brush under a stereoscopic binocular microscope and placed on tomato leaflets to use in the experiment.

Rearing of *Spodoptera littoralis*:

This pest has obtained from the permanent colony at Pests and Plant Protection laboratory, NRC. The culture was maintained at temperature of 25 ± 2 °C, 65 ± 5 % RH and photoperiod of 16:8 h (L: D). Adults were kept in 30x30x30 cm cages and fed with diluted honey solution. After emergence, female lays 1000-2000 eggs in egg masses of 100-500 /each on the lower leaf surface of the cotton plant (Hassan and Moawed, 1974). The infested plants were taken out of the cages and eggs collected with a small brush and placed on tomato leaflets to use in experiment.

Rearing of *Aphis gossypii*:

Apterous individuals of *A. gossypii* used in this study were collected from tomato plants sown at the field of Bernecht, Giza province, Egypt. Nymphs were obtained by putting apterous females on tomato leaf disks (5 cm diameter) placed upside down on wet cotton wool in Petri dishes (8.5 cm diameter). The cotton wool in the Petri dishes was soaked daily with water and the aphids were transferred on new leaf disks every week. Aphid rearing was done in the laboratory at 27 ± 1 °C, 70 ± 5 % RH and 12 : 12 h(L: D) photoperiod (Shannag et. al., 2007; Liu et al., 2008) and the newly emerged nymphs were collected to use in the experiment.

Rearing of *Coccinella undecimpunctata*:

The parental stocks of *C. undecimpunctata* were collected from clover fields at the Experimental Research Station, Faculty of Agriculture, Cairo University. The adults were maintained on aphids in an air conditioned rearing room at 28 ± 2 °C and $75.0 \pm 5\%$ RH and photo period of 14 h light: 10 h dark.

Freshly emerged adult beetles were reared on aphid in pairs in petri dishes (90mm diameter and 10mm height). A blotting paper was spread over its inner surface for egg laying. The eggs laid by females were counted and transferred in other petri dishes, with help of fine brush, for hatching. After hatching, twenty newly hatched grubs of predator were reared individually in plastic vials (4cm diameter and 6cm height) with respective prey species. Each experiment was replicated thrice. For newly born grubs, 30-40 individuals of respective tested prey species with the twig of respective plants were provided as food. This procedure was followed till pupation. The exuvae were removed and the period of each instar was recorded. Total numbers of prey species consumed by each instar of the grub, dead and unconsumed prey were counted daily and were replaced by fresh preys. After the emergence of adults (male and female), they were again provided with respected number of each tested prey daily, till their death. In this way, mean consumption by each instar of the grub, male and female adults in addition to longevity of *C. undecimpunctata* on different tested prey species was recorded.

Statistical analysis:

Development and predation at different life stage of *C. undecimpunctata* was recorded with respect to tested prey species. To determine statistical difference, ANOVA was computed and the mean values were compared using Duncan's multiple range test ($p \leq 0.05$).

RESULTS

TABLE 1
MEAN DEVELOPMENTAL PERIODS AND LONGEVITY OF *COCCINELLA UNDECIMPUNCTATA* FEMALE REARED ON VARIOUS STAGES OF *TUTA ABSOLUTA*, *SPODOPTERA LITTORALIS* AND *APHIS GOSSYPHII*

prey	Developmental stages				Total Immature	Adult Stage
	1 st Larval Instar	2 nd Larval Instar	3 rd Larval Instar	4 th Larval Instar		
<i>T. absoluta</i> Eggs	3.6 ± 0.16 a	4.2 ± 0.17 a	5.2 ± 0.18 a	6.5 ± 0.16 a	19.6 ± 0.3 a	22.8 ± 0.85 a
1 st Larval Instar	3.6 ± 0.12 a	4.2 ± 0.17a	5.2 ± 0.18 a	6.5 ± 0.16a	19.66 ± 0.3 a	23.0 ± 0.5 a b
2 nd Larval Instar	3.6 ± 0.12a	3.6 ± 0.18 b	4.4 ± 0.23 c	5.4 ± 0.16 c	17.2 ± 0.36 b	22.6 ± 0.6 a
<i>S. littoralis</i> Eggs	4.0 ± 0.19	3.3 ± 0.28	5.3 ± 0.15	6.4 ± 0.16	19 ± 0.33	30.4 ± 0.57
<i>A. gossypii</i> 1 st Nymphal Instar	4.1 ± 0.17	4.9 ± 0.17	5.7 ± 0.33	6.5 ± 0.26	21.2 ± 0.76	29.5 ± 0.3

Means followed by the same letter are not significantly different

Data in table (1) show the developmental periods of immature stages and female longevity of Coccinellid beetle fed on different preys. The period of 1st, 2nd, 3rd and 4th larval instars of the beetle were 3.6, 4.2, 5.2 and 6.5 days, respectively, when fed on *T. absoluta* eggs. These periods approximately did not when fed on the larval instars of *T. absoluta*. Also these periods did not much differ when fed on *S. littoralis* eggs; they were 4.0, 3.3, 5.3 and 6.4 days, respectively, and 4.1, 4.9, 5.7 and 5.6 days, respectively, when fed on aphid nymphs

for the same previous female larval instars of the beetle. The data also show that female longevity ranged from 22.8 to 30.4 days when fed on the eggs of both *T. absoluta* and *S. littoralis*, respectively.

TABLE 2
MEAN CONSUMPTION RATE OF FEMALE IMMATURES AND ADULT STAGE OF *COCCINELLA UNDECIMPUNCTATA* REARED ON VARIOUS STAGES OF *TUTA ABSOLUTA*, *SPODOPTERA LITTORALIS* AND *APHIS GOSSYPHII*

Developmental stages						
prey	1 st Larval Instar	2 nd Larval Instar	3 rd Larval Instar	4 th Larval Instar	Total Immature	Adult Stage
<i>T. absoluta</i>						
Egg	65.0 ± 1.33a	92.4 ± 1.4 b	115.6 ± 3.17 c	159.0 ± 5.0 d	432.1 ± 6.9 a	42.18 ± 1.0 a
1 st Larval Instar	54.9 ± 1.5ab	77.7 ± 3.2 ab	93.9 ± 1.61 c	115.0 ± 2.3 d	341.6 ± 4.3 b	8.37 ± 0.54 a
2 nd Larval Instar	54.4 ± 0.5 b	56.5 ± 0.5 b	72.2 ± 1.7 c	94.3 ± 1.3 d	277.4 ± 2.5 c	6.66 ± 0.47 a
<i>S. littoralis</i> Egg	41.0 ± 1.3	52.9 ± 0.86	62.3 ± 1.3	64.0 ± 0.78	220.2 ± 0.9	428.4 ± 7.2
<i>A. gossypii</i>						
1 st Nymphal Instar	31.3 ± 0.7	48.6 ± 0.7	59.5 ± 1.5	53.3 ± 1.06	192.7 ± 5.3	355.0 ± 5.7

Means followed by the same letter are not significantly different

The data about consumption rate of different stages of female *C. undecimpunctata* towards different preys are showed in table (2) where the higher consumption rate was recorded by the forth larval instar which consume 159 eggs of *T. absoluta* while the lower was recorded by the first larval instar which consume the minimum number of aphid nymphs. It is observed that consumption rate of female adult of *C. undecimpunctata* was less than that of its immature stages towards *T. absoluta* while the opposite was observed when fed on *S. littoralis* eggs (428.4 eggs) and aphid nymphs (355.0 individuals).

TABLE 3
MEAN DEVELOPMENTAL PERIODS AND LONGEVITY OF *COCCINELLA UNDECIMPUNCTATA* MALE REARED ON VARIOUS STAGES OF *TUTA ABSOLUTA*, *SPODOPTERA LITTORALIS* AND *APHIS GOSSYPHII*

Developmental stages						
prey	1 st Larval Instar	2 nd Larval Instar	3 rd Larval Instar	4 th Larval Instar	Total Immature	Adult Stage
<i>T. absoluta</i>						
Egg	3.8 ± 0.2 a	4.6 ± 0.13 a	5.5 ± 0.2 a	6.9 ± 0.2 ab	20.86 ± 0.42 a	17.0 ± 0.3 b
1 st Larval Instar	3.3 ± 0.12 a	3.8 ± 0.21 a	4.5 ± 0.27a	6.9 ± 0.2 ab	18.66 ± 0.47 b	17.0 ± 0.3b
2 nd Larval Instar	3.3 ± 0.12 a	4.6 ± 0.27 a	4.7 ± 0.3 a	6.9 ± 0.3 ab	19.60 ± 0.4 ab	18.9 ± 0.5 b
<i>S. littoralis</i> Egg	4.0 ± 0.16	5.0 ± 0.18	6.2 ± 0.17	7 ± 0.2	22.2 ± 0.9	21.0 ± 0.55
<i>A. gossypii</i>						
1 st Nymphal Instar	3.6 ± 0.16	4.4 ± 0.2	5.8 ± 0.24	7.5 ± 0.16	21.3 ± 1.2	22.2 ± 0.57

Means followed by the same letter are not significantly different

The developmental periods of male immature stages of *C. undecimpunctata* did not much differ from that of female when fed on the same preys (Table 3). It ranged from 3.8 to 6.9 days and from 3.3 to 6.9 days for 1st and 4th larval instar of the predator when fed on the eggs and 1st larval instar of *T. absoluta*, respectively. Also these periods ranged from 4 to 7 days with *S. littoralis* eggs as a food and from 3.6 to 7.5 days with aphid nymphs as a food for 1st and 4th larval instar of the predator, respectively. On the other hand, the longest male longevity was recorded with aphid nymphs as a food (22.2 days) while the shortest was recorded with eggs and 1st larval instar of *T. absoluta* as a food (17 days for both) (Table 3).

TABLE 4.
MEAN CONSUMPTION RATE OF MALE IMMATURES AND ADULT STAGE OF COCCINELLA UNDECIMPUNCTATA
REARED ON VARIOUS STAGES OF TUTA ABSOLUTA, SPODOPTERA LITTORALIS AND
APHIS GOSSYPHII

prey	Developmental stages					
	1 st Larval Instar	2 nd Larval Instar	3 rd Larval Instar	4 th Larval Instar	Total Immature	Adult Stage
<i>T. absoluta</i> Egg	59.2 ± 1.39 a	84.2 ± 1.7 a	115 ± 2.3 a b	136.8 ± 3.3 a b	395.33 ± 4.7 a	1277.8 ± 71 b
1 st Larval Instar	54.9 ± 1.5 a	77.7 ± 3.2 a	93.9 ± 1.6 a b	115 ± 2.3 a b	341.6 ± 4.3 b	909.7 ± 9.4 b
2 nd Larval Instar	454.4 ± 0.5 b	56.5 ± 0.58 a	72.2 ± 1.7 a	94.3 ± 1.3 a b	277.46 ± 2.5 c	940.7 ± 21.8 c
<i>S. littoralis</i> Egg	35.2 ± 1.11	48.8 ± 0.87	56.2 ± 1.43	57.3 ± 1.3	197.5 ± 2.3	360.2 ± 5.9
<i>A. gossypii</i> 1 st Nymphal Instar	33.6 ± 1.01	40.1 ± 1.87	51.2 ± 1.69	56.8 ± 1.81	181.7 ± 3.25	336.5 ± 9.6

Means followed by the same letter are not significantly different

Data in table (4) revealed that consumption rate of male immatures of *C. undecimpunctata* behave the same trend of female when fed on the same preys with an exception of adult stage which showed an opposite behavior of predation. The consumption rate ranged from 59.2 to 136.8 eggs of *T. absoluta* for 1st and 4th larval instar of male predator, respectively, while the same instars consumed 35.2 and 57.3 eggs of *S. littoralis*, respectively. When the 1st larval instar of *T. absoluta* was the food the consumption rates were 54.9 and 115 larvae for 1st and 4th larval instars of the predator, respectively, compared to 33.6 and 56.8 individuals of aphid nymphs for the same instars, respectively. Inversely, adult male of *C. undecimpunctata* showed higher predation rate towards all immature stages of *T. absoluta* where the consumption rate was 1277.8 eggs compared to 360.2 eggs of *S. littoralis*.

DISCUSSION

The ladybird beetle, *Coccinella undecimpunctata* is a polyphagous predator it feed on several insect species at different stages of their life cycle (Raimundo and Alves, 1986; Hodek and Honek, 2009). The species of the prey can be control the predation behavior of the beetle besides effect on some biological aspects of the predator. From this point, the predator can prefers and consume more prey species than others, so the consumption rate of the predator towards prey species may be taken as an index for prey preference of the predator (Mealzer, 1978; Hussein, 1991; Elliot et al., 2000; Khan and Khan, 2002). In this work the consumption rates of *C. undecimpunctata* towards some prey species in addition to effect of these preys on the developmental periods of the predator were studied.

Our results showed that *C. undecimpunctata* was successfully preyed upon various immature stages of *T. absoluta*, egg stage of *S. littoralis* and nymphal stage of *A. gossypii*. There are no significant differences in the total developmental period of female immature stages of *C. undecimpunctata* when fed on the eggs or 1st larval instar of *T. absoluta* or eggs of *S. littoralis* while this period decreased by approximately two days when fed on 3rd larval instar of *T. absoluta* and increased by approximately two days when fed on aphid nymphs. On the other hand, the longest female longevity was recorded when the beetle reared on the eggs of *S. littoralis* and aphid nymphs while there are no significant differences in the female longevity when the beetle reared on eggs or larval stages of *T. absoluta*.

The developmental period of male immature stages of *C. undecimpunctata* behave the same trend of the female immature stages where rearing of the beetle on eggs or larval stages

of *T. absoluta* causes slight differences in the developmental period of the beetle. An elongation in the developmental period ranged from two to three days was observed when the beetle reared on *S. littoralis* eggs or aphid nymphs and also caused increase in the male longevity by two to three day than other preys. The longest male longevity was recorded when the beetle reared on aphid nymph while the shortest was recorded when reared on larval stages of *T. absoluta*. This result agrees with that of Omkar and Sirvastava (2003) who reported that the developmental periods and adult longevity of *Coccinella septempunctata* affected directly by species of the prey.

Consumption rate (prey preferences) of *C. undecimpunctata* towards specific prey considered a very important factor for using this beetle in controlling insect pests. The data about consumption rate of *C. undecimpunctata* towards tested insect pests revealed that female immature stages of the *C. undecimpunctata* have a higher consumption rate on different immature stages of *T. absoluta* than that on *S. littoralis* eggs or aphid nymphs while female adult of the beetle showed less preference towards immature stages of *T. absoluta*. Inversely, female adult of *C. undecimpunctata* consume more number of *S. littoralis* eggs and aphid nymphs than its immature stages. This result coincided with that of Xue et. al. (2009) who reported that third instars and adult females of both species of coccinellids, *Coccinella septempunctata* and *H. axyridis* consumed significantly more aphids than did adult males. This result may be attributed to higher nutritional requirements for development of the larval stage and for reproduction by female adults (Omkar and Srivastava, 2003).

Our results indicate that voracity of female immature stages of *C. undecimpunctata* towards immature stages of *T. absoluta* make us an excellent chance for biological control of *T. absoluta* while female adult considered an effective biological agent against both *S. littoralis* and *A. gossypii*. The previous results are in agreement in case of *Tuta absoluta* and disagreement in case of *aphis gossypii*, as preys, with that about feeding capacity of *C. septempunctata* recorded by Mani and Krishnamoorthy (1999) and Pandey and Khan (2002) who has reported that grubs of *Coccinella septempunctata* consumed more aphids than adults. Also, Hamed and Hassanein (1984) reported that *Coccinella septempunctata* prefer aphids as prey over eggs of *S. littoralis*.

Important results were obtained with *C. undecimpunctata* male where immature or adult stages showed vigorous predatory behavior towards all immature stages of *T. absoluta* than *S. littoralis* eggs or aphid nymphs. This result assured the previous result obtained with female beetle and also assured the possibility of using *C. undecimpunctata* for controlling *T. absoluta*. The higher voracity female immature and male adult stages of *C. undecimpunctata* towards eggs of *T. absoluta* than eggs of *S. littoralis* may be attributed to the quality of the egg where the egg shell of *T. absoluta* may be softer than that of *S. littoralis* egg made the predator (*C. undecimpunctata*) some facilities for feeding on *T. absoluta* eggs or the color of *T. absoluta* eggs which more greener than that of *S. littoralis* may be attract the beetle.

CONCLUSION

The results of the current work agreed and disagreed with that of several researches about using *C. undecimpunctata* for controlling both *A. gossypii* and *S. littoralis*, but considered the first attempt and make up the first step in controlling *T. absoluta* by using *C. undecimpunctata*. Our results showed that *C. undecimpunctata* was successfully preyed upon various immature stages of *T. absoluta*. The higher voracity of female immature stages, male

and female adults of *C. undecimpunctata* towards all immature stages of *T. absoluta*, makes us an excellent chance for biological control of this new invasive serious pest.

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