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Biology, life table and efficacy of predatory mite, *Cydnoseius negevi* (Acari: Phytoseiidae) for controlling some pests on *Solanum melongena* in Egypt

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ABSTRACT

Biology, life table parameters and predation efficacy of phytoseiide mite, *Cydnoseius negevi* for controlling eriophyid mite, *Aculus lycopersici* and *Bemisia tabaci* on eggplant, *Solanum melongena* under laboratory and open field in Egypt was studied. The shorter female developmental time and longevity occurred when fed on *A. lycopersici* (8.16 and 21.08 days, respectively). The longer was on *B. tabaci* (9.20 and 26.90 days, respectively). Fecundity and daily oviposition rates were the higher on *A. lycopersici* as 34.15 eggs/female and 2.32 eggs/female/day. The lower were 25.30 eggs/female and 1.2 eggs/female/day on *B. tabaci*. The higher intrinsic rate of increase (r_m) and net reproductive rate (R_0) were 0.182 females/female/day and 15.87 females/female on *A. lycopersici*. Total predation of *C. negevi* male and female was 187.0, 249.5 prey for *A. lycopersici*, and 174.73 and 227.3 prey for *B. tabaci*, respectively. The efficiency of *C. negevi* was investigated at three rates of predator: prey release (1:3, 1:5 and 1:10) under open field on the two pests. The higher mean reduction percentage of *A. lycopersici* after six weeks of release was 85.71, 86.13 and 69.63; and 84.16, 77.36 and 63.31% for *B. tabaci*, respectively. The results suggested that *C. negevi* can be considered a good predator of eggplant piercing and sucking pests.

Keywords: Biological aspects, biological control, predation, tomato rust mite, whitefly, eggplant.

INTRODUCTION

The eggplant, *Solanum melongena* L. (Solanaceae) is frequently used for both domestic and global trade. It is grown in Egypt nearly at all agricultural areas. In 2019, 90% of the world's eggplant production, according to FAO, came from six countries. Egypt produced about 1.3 million tons, or 2.94% of the world's total production. It is one of the major summer crops in Egypt. The fruits of the eggplant vegetable are rich in vitamins, protein, and carbs (Mahamoud 2000).

The tomato rust mite, *Aculus lycopersici* (Tryon) (= *Aculops lycopersicae* (Massee)) is the main pest of tomato and infests most solanaceous plants (e.g., potato, tobacco, eggplant, pepper, datura, and black nightshade plants) (Vacante 2016). *Bemisia tabaci* (Gennadius) is highly polyphagous and known to feed on several vegetable field crops and weeds. The direct damage is caused by the piercing and sucking sap from the foliage of plants. The feeding causes reduce the plant growth rate and yield. Additionally, it could result in foliage chlorosis, leaf withering, premature leaf drop, and plant death. The indirect damage causes is accumulation of honeydew (Alemandri et al. 1998).

The predatory mite, *Cydnoseius negevi* (Swirski & Amitai) (Phytoseiidae) completed life cycle when fed on the tetranychid mites, *Eutetranychus orientalis* (Klein), *Tetranychus urticae* Koch and pollen grains of *Ricinus communis* (L.) as an alternative food substance in the laboratory (Abou-Awad et al. 1989). Biology of *C. negevi* is affected by feeding on individuals of either eriophyid fig mite, *Aceria ficus* Cotte or eggs of *T. urticae*. Feeding on of eriophyids promoted immature stages to develop faster compared with *T. urticae* eggs. The longer longevity was on eriophyid (36.23 days) and shorter on *T. urticae* (29.37 days). Female predator consumed daily 108 individuals of *A. ficus* and 73 eggs of *T. urticae* (Abou-Awad et al. 1998). *Cydnoseius negevi* developed and reproduced when fed on immatures of *B. tabaci* and *Thrips tabaci* Linderman (Momen et al. 2009). It is a general predator a member of life style type III (McMurtry et al. 2013).

Therefore, the aim of the current work is to determine the biology, life table parameters and predation of the predatory mite, *C. negevi* on *A. lycopersici* and *B. tabaci* feeding on Long Type eggplant cultivar under laboratory condition, as well as release *C. negevi* at three rates for control the two pests in open field.

MATERIALS AND METHODS

Sources of predatory mite and prey diets

The predatory mite, *C. negevi* and two prey species, *A. lycopersici* and *B. tabaci* were collected from eggplant leaves, in Shebeen El-Kom, Monufia governorate, Egypt, during spring season (2021). Pollen grain of castor bean was added as an additional food for the predator.

Development of *C. negevi* on two prey types

Eggs were put singly in an arena (2.5 cm in diameter) used for each prey diets, with 50 replicate each. The inspection was carried out twice daily under a stereoscopic microscope of 40 magnification force, until the mites reached adulthood. The changes were recorded until the death of the last female. When a female nymph emerged at each prey type, an adult male obtained from the mite culture was offered onto the leaf disc to increase the probability of sufficient insemination of females. The number of laid eggs by each female was recorded and the sex ratio of progeny was determined. The survival rate of females was recorded.

Mass rearing of the predatory mite

The stock colony of the predator was maintained on rearing units made of *Phaseolus vulgaris* L., under laboratory condition at 26±1°C and 60±5% RH. Predators were transferred to new units every four days. Mulberry leaves were placed underside facing up on a wet cotton wool layer in plastic trays (20 cm in diameter). Cotton wool was provided with water when necessary to prevent mites from escaping and to maintain leaf freshness. The two prey types were directly brushed from infested eggplant strands to the predator in the stock colonies. The predatory mite was continuously fed a mixture of motile stages of eriophyid mite and nymphs of whitefly. When over-population of predator was encountered, the old bean leaves were cut into several small pieces and then placed on a new stock culture. Adult females were left for 24 h to lay eggs. Eggs were then collected for different biological tests.

Biological control study

The present study was carried out on Long Type eggplant cultivar at Shebeen El-Kom, Monufia governorate, Egypt, during the summer season of 2021. An area of about 700 m^2 was cultivated with eggplant 175 m^2 for each treatment (three plots for release and one plot for check with three replicate). Seedlings were sowing on 03 May for summer plantation. Normal agricultural practices were followed except for keeping, the whole area free from any pesticide treatment. The predatory mite was release at three predators' prey levels (1:3, 1:5 and 1:10) for *A. lycopersici* and *B. tabaci* after 45 days of plantation. Weekly samples of 20 eggplant leaves per treatment were collected for pest inspection. Motile stages of eriophyid mite and nymphs of whitefly on eggplant leaves were counted. Reduction percentages of motile stages of pests were calculated according to equation by Henderson and Tilton (1955).

Statistical analysis:

Life table parameters were estimated according to Birch (1948) using the Life 48, BASIC Computer programmed (Abou-Setta et al. 1986). Mean number of two prey diets and predatory mite were analyzed using two-way ANOVA. Means were compared by LSD test at 0.05 level using SAS statistical software (Anonymous 2003).

RESULTS AND DISCUSSION

Development of *C. negevi* on two prey types

The results showed that, *C. negevi* male and females successfully developed on Long Type eggplant cultivar when fed on *A. lycopersici* and *B. tabaci*. All immature stages developed faster when predatory mite fed on motile stages of *A. lycopersici* than *B. tabaci* nymphs. Life cycle was the longer on *B. tabaci* nymphs (9.20 and 8.39 days) and the shorter on *A. lycopersici* (5.88 and 5.57 days) female and male, for respectively. The shorter generation period was recorded on *A. lycopersici* (11.35 days) and the longer on *B. tabaci* nymphs (12.63 days). The longer female pre-ovipostion, oviposition and post-ovipostion periods were 3.44, 19.95, and 3.51 days when the predatory mite fed on *B. tabaci* nymphs, and the shorter ones 3.19, 14.80, and 3.09 days on *A. lycopersici* (Table 1).

The maximum fecundity rate was 34.15 eggs/female and the daily rate was 2.32 eggs/female/day on *A. lycopersici*, while the lower ones were 25.30 eggs/female and 1.27 eggs/female/day on *B. tabaci* nymphs. The longer female and male life span when fed on *A. lycopersici* was 36.09 and 31.8 days, whereas the shorter periods were 29.24 and 26.57 days on *B. tabaci* nymphs. These results are in agreement with that of Farahat (2020) who indicated the life cycle lasted 6.65 and 5.70 days for female and male at 31°C, respectively. This period was 8.39 day (Abou-Awad et al. 1998) and 7.13 days (Hussein et al. 2016). Adult female longevity of *C. negevi* is similar to the finding of Abou-Awad et al. (1998) on *A. ficus*, *T. urticae* eggs, *B. tabaci* eggs, and castor pollen. Farahat (2020) reported that *C. negevi* developed successfully on the eggplant rust mite *Aceria melongena* (Zaher & Abou-Awad). The female of the predator deposited 38.19 eggs during oviposition period and continued 18.70 prey. Also, Hussein et al. (2016) showed that the eriophyid mite, *Aceria dioscoridis* (Soliman & Abou-Awad) was favorable than pollen grains of both date palm and corn for *C. negevi*. The higher fecundity (41.27 eggs/female) when the predator fed on *A. dioscoridis* and the lower (9.00 eggs/female) on both pollen of date palm. The higher female longevity was 61.47 days when fed on *A. dioscoridis*.

Life table parameters

The most important parameters, T, r_m, and R_0 differed between the two prey types. The mean generation time (T) on *A. lycopersici* was 15.12 days, and the longer one (17.24 days) was on *B. tabaci* nymphs. The gross reproductive rate (GRR) increased from 17.58 offspring/individuals on *B. tabaci* nymphs to 25.7 offspring/individuals on *A. lycopersici*. The intrinsic rate of increase (r_m) value was the lower on *B. tabaci* nymphs (0.133 ♀/♀/day), and the higher (0.182 ♀/♀/day) on *A. lycopersici*. Similarly, net reproductive rate (R_0) value was the lower (9.97 ♀/♀) on *B. tabaci* nymphs and the higher (15.87 ♀/♀) on *A. lycopersici*. The shorter doubling time (DT) was shorter (3.8 days) on *A. lycopersici* and longer (5.21 days) on *B. tabaci* nymphs (Table 2).

These results agree with finding by Farahat (2020) who showed eriophyid eggplant mite is thought to be a profitable prey species to *C. negevi*. The intrinsic rate of increase (r_m) was 0.102, 0.159, and 0.210 individuals/female/day at 18, 23, and 31°C, respectively. The population multiplied (R_O) was 22.83, 27.55, and 35.93 times in a generation time of 30.64, 20.81, and 17.04 days of predator, respectively. Fouly et al. (2021) showed that food sources affected all life tables where spider mite eggs and pollen grains were the most favorable foods increased R_O, r_m, and GRR values. Insect eggs prolonged generation and doubling times of *C. negevi*.

Predation of *C. negevi*

Immature females of *C. negevi* significantly consumed a higher number of prey (23.5 on *B. tabaci* nymphs and 13.72 on *A. lycopersici*) than male immature stages (19.15 and 10.55, respectively). However, *C. negevi* significantly consumed more prey (180.2) on *A. lycopersici* than on *B. tabaci* nymphs (166.4) during the oviposition period (Table 3). The higher number of prey consumed during the adult longevity was reported for *C. negevi* females on *A. lycopersici* (23.8 prey) while the lowest was 164.18 prey for male when fed on *B. tabaci* nymphs (Table 3).

Release of *C. negevi* for controlling *A. lycopersici* and *B. tabaci* nymphs

The predatory mite, *C. negevi* was released against the eriophyid mite, *A. lycopersici* and *B. tabaci* nymphs under three predator: prey rates (1:3, 1:5, and 1:10) on eggplant under field condition. The predator mite was released in June 2021 after six weeks of plantation. The mean numbers of rust mite, *A. lycopersici* were 4.2, 5.8, and 5.1 individuals/eggplant leaf for three levels, respectively and 4.7 individuals/eggplant leaf in the check. After releasing the predator, the rust mite gradually decreased in the released plots. The higher mean percentage reduction recorded after six weeks was 86.13 and 85.71% at 1:5 and 1:3, respectively, while lowest mean reduction was 69.63% at 1: 10. No significant difference in the reduction percentage between the two level 1:3 and 1:5 predator: prey (Table 4).

Table 1. Developmental time and life span of *Cydnoseius negevi* fed on *Aculus lycopersici* and *Bemisia tabaci* at 26±1°C and 60±5% RH.

Stages	Mean duration in day (±SD)				LSD at 0.05
	Aculus lycopersici		*Bemisia tabaci*		
	Female	Male	Female	Male	
Egg	2.29±0.28 a	1.91±0.24 b	2.36±0.34 a	2.15±0.13 a	0.21
Larva	1.07±0.17 b	1.07±0.13 b	1.61±0.42 a	1.14±0.14 b	0.19
Protonymph	2.19±0.21 c	2.26±0.23 bc	2.47±0.39 ab	2.52±0.25 a	0.21
Deutonymph	2.62±0.26 a	2.24±0.21 b	2.77±0.25 a	2.62±0.44 a	0.19
Immature stages	5.88±0.45 bc	5.57±0.29 c	6.84±0.68 a	6.18±0.52 b	0.37
Life cycle	8.16±0.61 b	7.48±0.42 c	9.20±0.73 a	8.39±0.60 b	0.43
Generation	11.35±0.80 b	-	12.63±0.91 a	-	0.53
Pre-oviposition	3.19±0.39 b	-	3.44±0.26 a	-	0.20
Oviposition	14.80±0.95 b	-	19.95±1.1 a	-	0.64
Post-oviposition	3.09±0.24 b	-	3.51±0.38 a	-	0.19
Longevity	21.08±0.96 c	19.09±0.83 d	26.90±1.0 a	23.54±1.02 b	0.74
Fecundity	34.15±2.5 a	-	25.30±1.59 b	-	1.30
Daily rate	2.32±0.24 a	-	1.27±0.08 b	-	0.11
Life span	29.24±1.26 c	26.57±1.05 d	36.09±1.19 a	31.80±0.91 b	0.80

Means within rows followed by the same letter were not significantly different at 5%.

Table 2. Life table parameters of *Cydnoseius negevi* fed on *Aculus lycopersici* and *Bemisia tabaci* at 26±1°C and 60±5% RH.

Parameter	***Aculus lycopersici***	***Bemisia tabaci***
Gross reproductive rate (GRR)[d]	25.7	17.58
Sex ratio (♀♀/total)	0.7	0.7
Net reproductive rate (R_0)b	15.87	9.97
Survival rate %	0.66	0.6
50% mortality a	21.6	28.7
Mean generation time (T)a	15.12	17.24
Intrinsic rate of increase (r_m)c	0.182	0.133
Finite rate of increase (λ)[C]	1.2	1.14
Doubling time (DT)a	3.8	5.21

[a]Days, [b]♀/♀,[c]♀/♀/day, d offspring/individual, $R_0 = \Sigma(lx \times m_x)$; $T_c = \Sigma(x \times l_x \times m_x) / \Sigma(l_x \times m_x)$; $r_m = Ln(R_0)/T$; $DT = Ln(2)/r_m$, $\lambda = exp(r_m)$ and GRR= Σmx.

The mean numbers of *B. tabaci* nymphs were 8.9, 8.3, 8.8, and 9.1/eggplant leaf for the check and three levels of release, respectively. After release the predator mite, individuals of *B. tabaci* nymphs gradually decreased in the released plots. The mean percentage reduction recorded after six week was 84.16, 77.36, and 63.31% at 1:3, 1:5 and 1:10, respectively, with a significant difference. The rate 1:3 gave the higher reduction (Table 5).

The same was obtained by Elhalawany et al. (2019) who released the two predatory mites, *Neoseiulus californicus* (McGregor) and *Neoseiulus arundonaxi* Metwally & Sanad for *T. tabaci* on onion in open field.

Table 3. Prey consumption of *Cydnoseius negevi* fed on *Aculus lycopersici* and *Bemisia tabaci* at 26±1°C and 60±5% RH.

Stages	Mean number of prey diets (±SD)				LSD at 0.05
	Aculus lycopersici		*Bemisia tabaci*		
	Female	Male	Female	Male	
Larva	6.04±0.86 b	5.85±0.80 c	7.5±1.19 a	4.91±0.83 b	0.61
Protonymph	3.27±0.89 c	2.73±0.79 c	8.05±0.94 a	6.38±0.87 b	0.61
Deutonymph	4.4±1.27 c	2.91±0.70 d	7.95±0.76	6.92±1.26 b	0.64
Immature	13.72±1.73 c	10.55±1.44 d	23.5±1.73 a	19.15±2.03 b	1.14
Preoviposition	41.3±2.68 a	-	22.65±2.08 b	-	1.49
Oviposition	180.2±4.74 a	-	166.4±7.24 b	-	3.78
Postoviposition	14.2±1.41 a	-	14.75±1.45 a	-	0.89
Longevity	235.8±5.12 a	167.85±4.7 c	203.8±8.0 b	164.18±3.97 c	3.78
Life span	249.5±5.31 a	187.00±4.83d	227.3±8.29 b	174.73±3.64 c	3.89

Means within rows followed by the same letter were not significantly different at 5%.

Table 4. Mean number and reduction percentage of *Aculus lycopersici* per 20 eggplant leaves after release of *Cydnoseius negevi* on eggplant in open field.

Sampling date	Control	Release rate						Max. Temp.	Mini Temp.	R.H.
		1:3		1:5		1:10				
		Number	R%	Number	R%	Number	R%			
Pre-count 24-Jun-21	4.7	4.2	-	5.8	-	5.1	-	40.8	21.3	44.8
1-Jul-21	12.6	3.1	72.47	4.6	70.42	8.9	34.91	41.76	22.63	44.59
8-Jul-21	20.5	4	78.16	3.6	85.77	6.4	71.23	40.43	21.97	44.41
15-Jul-21	28.4	3.2	87.39	4.3	87.73	7.7	75.01	40.16	22.54	46.83
22-Jul-21	36.7	3.7	88.72	4.9	89.18	8.6	78.40	40.94	23.86	43.47
29-Jul-21	45.8	2.9	92.91	5.1	90.98	9.5	80.88	39.19	22.99	48.50
5-Aug-21	52.1	2.5	94.63	4.7	92.69	12.8	77.36	42.69	23.37	39.06
Mean			**85.71 a**		**86.13a**		**69.63b**			
F-value				14.06						
P-value				0.0012						
LSD at 0.05				7.90						

Means within rows followed by the same letter are not significantly different (P<0.05)

Table 5. Mean number and reduction percentage of *Bemisia tabaci* nymphs per 20 eggplant leaves after release of *Cydnoseius negevi* on eggplant in open field.

Sampling date	Control	Release rate						Max. Temp.	Mini Temp.	R.H.
		1:3		1:5		1:10				
		Number	R%	Number	R%	Number	R%			
Pre-count 24-Jun-21	8.9	8.3	-	8.8	-	9.1	-	40.8	21.3	44.8
1-Jul-21	17.5	6.9	57.72	8.4	51.45	11.5	35.73	41.76	22.63	44.59
8-Jul-21	28.7	5.4	79.82	6.5	77.09	10.4	64.56	40.43	21.97	44.41
15-Jul-21	36.4	3.7	89.10	6.2	82.77	13.3	64.26	40.16	22.54	46.83
22-Jul-21	50.2	3	93.59	7.4	85.09	15.8	69.22	40.94	23.86	43.47
29-Jul-21	63.7	4.1	93.10	9.5	84.92	17.6	72.98	39.19	22.99	48.50
5-Aug-21	70.2	5.5	91.60	11.9	82.86	19.3	73.11	42.69	23.37	39.06
Mean			**84.16a**		**77.36b**		**63.31c**			
F-value				141.45						
P-value				0.0001						
LSD at 0.05				2.81						

Means within rows followed by the same letter are not significantly different (P<0.05)

The maximum reduction in thrips population was 73.42% for the predatory mite *N. californicus* followed by *N. arundonaxi* at rate 3000 predators/20m^2. El-Laithy et al. (2021) showed the higher efficacy of *C. negevi* against *B. tabaci* and *T. tabaci* when releases on sweet pepper in greenhouse. The reduction percentage averaged 73.8% for *B. tabaci* and 66.9% for *T. tabaci* after 29 weeks of application. Fouly et al. (2021) indicated that *C. negevi* was successfully reared on date palm pollen and eggs of *T. urticae.*

CONCLUSION

The predatory mite, *C. negevi* complete its life cycle satisfactorily on *A. lycopersici* and *B. tabaci* nymphs. The results also suggest that *C. negevi* is a good predator of eggplant pests and can be successfully considered in the biological pest control programs.

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