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Influence of Prey Consumption on the Predatory Potential and Biological Parameters of *Exochomus nigripennis* (Erichson) Against *Phenacoccus solenopsis* Tinsley and *Icerya seychellarum* (Westwood)

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Abstract: *Phenacoccus solenopsis* Tinsley and *Icerya seychellarum* (Westwood) are recent invasive sap-sucking insects in Egypt. *Exochomus nigripennis* (Erichson) being a viable option for conventional biological control. In the laboratory of the Plant Protection Research Institute, Agricultural Research Centre, Egypt, the biological parameters and predatory potential of *E. nigripennis* were assessed using *P. solenopsis* and *I. seychellarum* as preys. Fourth instar *E. nigripennis* larvae was recorded the highest average total consumption of 455 individuals, with a feeding capacity of 43.10 when reared on *P. solenopsis*. While the third larval instar of *E. nigripennis* consumed the maximum number of *I. Seychellarum* 43.11 with a feeding capacity of 45.18 compared to other instars. *E. nigripennis* females had a lifespan of 30.9 ± 1.21 days, and consuming 3255 preys on *P. solenopsis*, while males had a feeding capacity of 2198.64. The immature stages of *E. nigripennis* varied significantly based on the prey species. Larvae developed faster on *I. Seychellarum*, while pupal periods were shortest on *I. Seychellarum* and longest on *P. solenopsis*. The shortest development time was on *I. Seychellarum* (22.8 days), while the longest was on *P. solenopsis* (30.37 days). The longevity and reproduction of *E. nigripennis* were significantly influenced by the preys they were reared on. Males and females fed on *P. solenopsis* exhibited longer survival and females had an extended oviposition period. The fecundity was highest when females were fed *P. solenopsis* supplemented with sugar solution. The study suggests that an integrated pest management program can effectively manage *P. solenopsis* and *I. seychellarum*, by utilizing *E. nigripennis* as a biological control agent, making it suitable for mass rearing in agricultural ecosystems.

Key words: *Exochomus nigripennis, Phenacoccus solenopsis. Icerya seychellarum.*

1. Introduction

One of the most recent invasive sap-sucking insects in Egypt is the cotton mealybug, *Phenacoccus sonopsis* Tinsley (Hemiptera: Pseudococcidae), which damages many economically important crops, including cotton, okra, vegetables, and others (**Ibrahim *et al*., 2015)**. It feeds every green portion of the attacked plants, which in severe infestations cause the plants to weaken, stunted, and have deformed, yellow leaves. In the coming years, *P. solenopsis* is predicted to rank among the most dangerous economic pests in Egypt due to its favourable agricultural habitat for development and spread **(Prasad *et al*., 2012 and Shehata, 2017)**. Under a variety of temperature and relative humidity conditions, *P. solenopsis* can reproduce quite well. Farmers primarily rely on synthetic pesticides to manage pests that infest their crops, but because the mealybug has a waxy secretion covering its body, chemical treatment of this pest is challenging. There is an urgent need to explore alternative strategies such as biocontrol agents for the control of *P. solenopsis*, as the widespread use of synthetic and chemical pesticides for pest control has led to many serious problems in terms of environment and biodiversity **(Joshi *et al*., 2010)**. Several mealybug species (Hemiptera: Margarodidae) also infest the guava, *Psidium gaujava* L. in Egypt, causing losses in crop quantity and quality **(Ata *et al.*, 2021 and Awadalla, 2013)**. One of the most destructive mealybug species that attacks guava trees in Egypt is the seychellarum mealybug, *Icerya seychellarum* (Westwood) **(El-Sherbenie, 2004)**. This highly polyphagous pests consume 123 different plant species from 49 different plant families **(Ben-Dov *et al.,* 2009)**. As pesticide use decreases, biological control can become a valuable pest management strategy **(Czaja *et al*., 2015)**. With over 6000 species, the Coccinellidae family is the best group of natural enemies due to its ability to act as a biocontrol agent against numerous types of soft-bodied insects, such as mealy bugs and aphids **(Dixon, 2000)**. Sucking pest populations in forestry and agriculture are likely to be naturally controlled by Exochomus in many areas, preventing them from becoming economically destructive **(Farooq-ahmad, 2012)**. *Exochomus nigripennis* (Erichson) (family: Coccinellidae) is a polyphagous, global predator commonly found in forestry and horticultural systems **(Mehrnejad *et al*., 2011)**. Due to its high rate of predatory behaviours and capacity for mass rearing, *E. nigripennis* is a viable choice for conventional biological control. The artificial rearing of predators has received more attention in recent years. Commercially produced predators and parasitoids are widely dispersed for biological control by inoculation and flooding. The use of Coccinellidae predators (Coleoptera) has shown positive results in managing sucking pests like *E. nigripennis* **(Govindasamy and Khursheed, 2018 and Qin *et al.*, 2019)**. This zoophage consumes various insect pests, including coccids, aphids, mites, and other soft-bodied insects **(Alrubeai, 2017)**.

In this study, the preferences and predatory potential of *E. nigripennis* toward *P. solenopsis*, and *I. seychellarum* were compared under laboratory conditions. Also examined the biological processes and life parameters of *E. nigripennis* on these two preys.

2. Materials and Methods

2.1. Insects

Cotton mealybug, *Phenacoccus solenopsis* Tinsley was collected from infected okra, *Abelmoschus esculentus (L.)* plants, while the seychellarum mealybug, *Icerya seychellarum* (Westwood), was collected from guava, *Psidium guajava* L trees. Wild adults of *Exochomus nigripennis* (Erichson) were collected from okra plants infested with *P. solenopsis* to establish a colony in Sakha, Kafr-El Sheikh Governorate, Egypt during the summer of 2023. The experiments were conducted under laboratory conditions of 28 ± 2 °C, 85 ± 5 RH and a 13:11 (L: D) photoperiod.

2.2. Rearing of test insect

In this study, *P. solenopsis* nymphs and adults were reared on okra plants in a wooden box of (100 x 50 x 50 cm), while *I. seychellarum* nymphs and adults were reared on guava leaves in a similar wooden box.

2.3. Durations of immature stages and larval feeding capacity of *Exochomus nigripennis* (Erichson)

Thirty eggs were collected from the lab colonies and preserved on wet filter paper in a Petri dish with a diameter of 12 cm. The eggs were monitored until they hatched. The freshly hatched larvae were carefully transferred into additional Petri dishes (12 cm in diameter) until pupation. The adult *E.*

nigripennis from each stock culture were maintained in a large Petri dish (200 mm in diameter by 9 mm in height) with filter paper for mating. Every mating couple was carefully moved to a new (100x9 mm) Petri dish. Each Petri dish with *P. solenopsis* and *I. seychellarum* nymphs and adults was supplemented with fresh prey daily for the *E. nigripennis* pair. Each pair was provided with one kind of prey per treatment group up until the time of egg laying. Eggs were gradually moved to a fresh Petri plate (100 × 9 mm) every day. The incubation period of female-deposited eggs was determined to estimate the development duration of *E. nigripennis*. Newly hatched larvae were placed in Petri dishes (100 × 9 mm). Twenty larvae from each culture were raised in duplicates on the same preys as their parental culture. A predetermined number of adults and nymphs of the prey were added daily. The growth, survival, and feeding capacity of the larvae in each treatment were recorded, and any dead larvae were removed.

2.4. The lifespan, prey consumption and fecundity of *Exochomus nigripennis* adults

Adults were divided into two groups based on their sex and individually arranged in a (100 × 9 mm) Petri plate. Every adult was fed the same prey as their larvae. Adult males and females were moved to a single (200 × 9 mm) Petri dish, where they were provided with prey nymphs and adults while waiting to mate. Ten pairs of successfully mated adults were carefully moved to ten Petri dishes (measuring 100 × 9 mm) where they were daily given prey. Each mated couple was split up after seven days. The adults were fed until they died. Daily records of prey consumed by males and females over their lifespans. The pre-ovipositional stage occurred between the day of emergence and oviposition. The total number of eggs laid by each female was calculated by counting the eggs each day while the females were in the ovipositional phases. From the conclusion of the ovipositional period till death, the post-ovipositional period was calculated.

Fig. (1). Images of *Phenacoccus solenopsis* getting infected on okra plants

Fig (2). Images of the okra plants with the predator *Exochomus nigripennis*

Fig (3). Images of the larvae of *Exochomus nigripennis* after consuming *Icerya seychellarum* nymph

2.5. Statistical Analysis

ANOVA was utilized for analysing the data, and Duncan's multiple range test was used to compare the means **(Duncan, 1955).**

3. Results

3.1. Durations of immature stages and larval feeding capacity of *Exochomus nigripennis* (Erichson) reared on *Phenacoccus solenopsis* Tinsley

The data presented in (Table 1) indicated significant variation in the duration of the immature stage as well as the average total consumption of *Exochomus nigripennis* when reared on *Phenacoccus solenopsis*. *E. nigripennis* incubation period was 6.60 ± 0.31 days. *E. nigripennis* consumed *P. solenopsis* as followed; first larval instar 2.50 ± 1.17 days, with average of total consumption 13.38 nymphs, second larval instar 4.60 ± 0.16 days, and represented by average of total consumption 293.25 nymphs, third larval instar was 3.50 ± 0.7 days, with average of total consumption 294 nymph and adult, and fourth larval instar was recorded 5.00 ± 0.30 days, and represented by average of total consumption 455 nymph and adult. The time of total development of immature stages was recorded 30.37 ± 0.61 days (Table 1).

The Average of total consumption of *E. nigripennis* larva was 1055.63 individuals. Results clearly depicted that 4^{th} larval instar of *E. nigripennis* consume the greatest number of cotton mealy bugs (455) with feeding capacity of (43.10) compared to other instars (Table 1).

3.2. The lifespan, prey consumption, and fecundity of adult *Exochomus nigripennis* reared on *Phenacoccus solenopsis*

Data arranged in (Table 2) showed the longevity, feeding capacity and fecundity of *E. nigripennis* reared on *P. solenopsis* under laboratory conditions. There was a significant difference in the duration of adult stages and their feeding capacity. After rearing *E. nigripennis* on *P. solenopsis*, the female average pre-ovipositional period was 3.63 ± 0.18 days. During this time, the predator female consumed 55.07 individuals with a daily consumption rate of 11.57 ± 1.84 and 3.6 ± 0.98 nymphs and adults, respectively. Females had an average ovipositional period of 28.25 ± 0.85 days which they consumed 1894.73 preys with a daily rate of 56.50 ± 14.71 and 10.57 ± 1.59 nymphs and adults, respectively (Table 2). The average number of deposited eggs per predator female was 241.02 ± 2.22 eggs, with a daily rate of 7.80 ± 0.92 eggs. Mated female fed on *P. solenopsis* had a total feeding capacity of 3255.00 individuals throughout lifespan, whereas male had a feeding capacity of 2198.64 (Table 2).

Table (1). Average (± SE) durations of immature stages and larval feeding capacity of *Exochomus nigripennis* reared on *Phenacoccus solenopsis* under laboratory conditions

Immature stages	**Duration (days)**	**Daily average consumption**		**Average of total consumption**	**% Feeding capacity**
		Nymph	**Adult**		
Incubation period (Eggs)	6.60 ± 0.31				
1st larval instar	2.50 ± 1.17	5.35 ± 0.82	00	13.38 c	1.27
2nd larval instar	4.60 ± 0.16	69 ± 2.36	00	293.25 b	27.78
3rd larval instar	3.50 ± 0.71	31.00 ± 0.75	53 ± 0.83	294 b	27.85
4th larval instar	5.00 ± 0.30	19.00 ± 1.02	72 ± 0.44	455 a	43.10
Total larval stage	22.20 ± 0.63	124.35 ± 13.68	125 ± 18.45	1055.63	100
Pupal stage	8.17 ± 1.01				
Total immature stages	30.37 ± 0.61				

Average followed by different letters in a column are significantly different

Table (2). Average (± SE) the lifespan, prey consumption, and fecundity of adult *Exochomus nigripennis* reared on *Phenacoccus solenopsis* under laboratory conditions

Adult stages	**Period (days)**	**Daily average consumption**		**Average total consumption**	**No. of eggs**	
		Nymph	**Adult**		**Daily**	**Total**
Female Pre-oviposition	3.63 ± 0.18	11.57 ± 1.84	3.6 ± .98	55.07 d		
Oviposition	28.25 ± 0.85	56.50 ± 14.71	10.57 ± 1.59	1894.73 c	7.80 ± 0.92	241.02 ± 2.22
Post-oviposition	2.65 ± 0.18	20.60 ± 8.76	2.50 ± 0.65	61.22 d		
Longevity	30.9 ± 1.21	88.67 ± 8.44	16.67 ± 1.07	3255.00 a		
Male Longevity	18.9 ± 1.70	95.66 ± 7.23	20.67 ± 1.06	2198.64 b		

Average followed by different letters in a column are significantly different

As conclusion the fourth instar *E. nigripennis* larvae was recorded the highest average of total consumption, with values 455 individuals and a feeding capacity percentage of 43.10 as compared to other instars. The female longevity period was 30.9 ± 1.21 days, which consumed overall this period 3255 preys when reared on the *P. solenopsis* under laboratory conditions.

3.3. Durations of immature stages and larval feeding capacity of *Exochomus nigripennis* reared on *Lcerya seychellarum*

Data arranged in (Table 3) cleared that the duration of the immature stages varied significantly and average of total consumption of *Exochomus nigripennis* when reared on *Lcerya seychellarum*. *E. nigripennis* incubation period was 6.90 ± 0.28 days. *E. nigripennis* consumed *I. Seychellarum* as followed, first larval instar 2.50 ± 0.50 days with average value of total consumption 4.58 nymphs, second larval instar 2.20 ± 0.20 days with average of total consumption 11.37 nymphs, third larval instar 3.17 ± 0.79 days with average of total consumption 43.11 nymph and adult, and fourth larval instar 3.17 ± 0.40 days with average of total consumption 36.36 nymph and adult. The developmental time of immature stages was 22.80 ± 1.36 days (Table 3), with average of total consumption 95.42 individuals. Results clearly depicted that the third larval instar of *E. nigripennis* consumed the maximum number of *I. seychellarum* 43.11 with a feeding capacity of 45.18 compared to other instars (Table 3). The total duration immature stages from egg hatching to adult emergence of *E. nigripennis* were 22.80 ± 1.36 days when reared on *I. seychellarum* under laboratory conditions.

Table (3). Average (± SE) durations of immature stages and larval feeding capacity of *Exochomus nigripennis* reared on *Icerya seychellarum* under laboratory conditions

Immature stages	Duration (days)	Daily average consumption		Average total consumption	% feeding capacity
		nymph	Adult		
Incubation period (Eggs)	6.90 ± 0.28				
1st larval instar	2.50 ± 0.50	1.83 ± 0.60	00	4.58 b	4.80
2nd larval instar	2.20 ± 0.20	5.17±2.43	00	11.37 b	11.92
3rd larval instar	3.17 ± 0.79	9.60 ± 1.80	4.00 ± 1.10	43.11 a	45.18
4th larval instar	3.17 ± 0.40	8.80 ± 1.90	2.67 ± 1.67	36.36 a	38.11
Total larval stage	17.94 ± 0.85	25.40 ± 1.79	6.67 ± 1.00	95.42	100
Pupal stage	4.86 ± 0.51				
Total of immature stages	22.80 ± 1.36				

Average followed by different letters in a column are significantly different

3.4. The lifespan, prey consumption, and fecundity of adult *Exochomus nigripennis* reared on *Icerya seychellarum*

Data presented in (Table 4) showed that the duration of adult stages and their feeding capacity of *E. nigripennis* reared on the *I. seychellarum* varied significantly. The female average pre-ovipositional period was 8.25 ± 0.85 days. During this time female predators consumed an average of 180.10 individuals, with a daily consumption rate of 10.33 ± 5.61 and 11.5 ± 5.92 nymphs and adults, respectively. The average ovipositional duration for females was 15.60 ± 0.65 days, and they consumed 187.2 preys with a daily rate of 12 ± 5.48 *P. solenopsis* nymphs (Table 4). The average number of deposited eggs per predator female was 78 eggs. Mated females fed *I. Seychellarum* had a feeding capacity of 803.46 individuals throughout their lifespan, whereas males had a feeding capacity of 166.46 (Table 4).

In conclusion the third larval instars of *E. nigripennis* recorded the highest average values of totalconsumption, with values of 43.11 and a feeding capacity of 45.18 compared to other instars (Table 3). The female longevity period was 23.75 ± 0.48 days, which they consumed 803.46 preys when reared on *I. Seychellarum* under laboratory conditions (Table 4).

Table (4). Average (± SE) The lifespan, preys' consumption, and fecundity of adult *Exochomus nigripennis* reared on *Icerya Seychellarum* under laboratory conditions

Adult stages	Period (days)	average consumption		Average of total consumption	Total no. of eggs
		Nymph	Adult		
Female Pre-oviposition	8.25 ± 0.85	10.33 ± 5.61	11.5 ± 5.92	180.10 ab	00
Oviposition	15.60 ± 0.65	12 ± 5.48	00	187.2 ab	78
Post-oviposition	2.65 ± 0.17	00	00	00 b	00
Longevity	23.75 ± 0.48	22.33 ± 3.70	11.5 ± 5.92	803.46 a	00
Male Longevity	14.5 ± 1.71	11.48 ± 5.65	00	166.46 ab	00

Average followed by different letters in a column are significantly different

3.5. Durations of immature stages and larval feeding capacity of *Exochomus nigripennis* reared on *Phenacoccus solenopsis* and *Icerya Seychellarum* under laboratory conditions

Figures illustrated (4 and 5) provide a summary of the effects of various prey on the development time of *E. nigripennis* immature stages (from egg to adult emergence). When this predator was reared on various prey, four larval instars were detected. The length of the egg, larval, and pupal stages varied significantly among the studied preys. On *I. Seychellarum*, larvae developed at fastest rate 17.94 days, which was considerably faster than the larval period on *P. solenopsis* 22.2 days. Additionally, the pupal duration was longest 8.17 days when consumed *P. solenopsis* and shortest 4.86 days when consumed *I. Seychellarum*. Furthermore, the development time of immature stages of *E. nigripennis* was varied significantly among preys. *I. seychellarum* had the quickest overall development period 22.8 days, whereas *P. solenopsis* had the longest 30.37 days (Fig 4). In summary, when reared on *P. solenopsis*, *E. nigripennis* fourth larval instar recorded the highest average of total consumption with values of 455 individuals and feeding capacity percentages of 43.10 compared to other instars. Similarly, when reared on *I. Seychellarum*, the third larval instar recorded the highest average of total consumption, with values of 43.11 individuals and feeding capacity percentages of 45.11 compared to other instars (Fig 5).

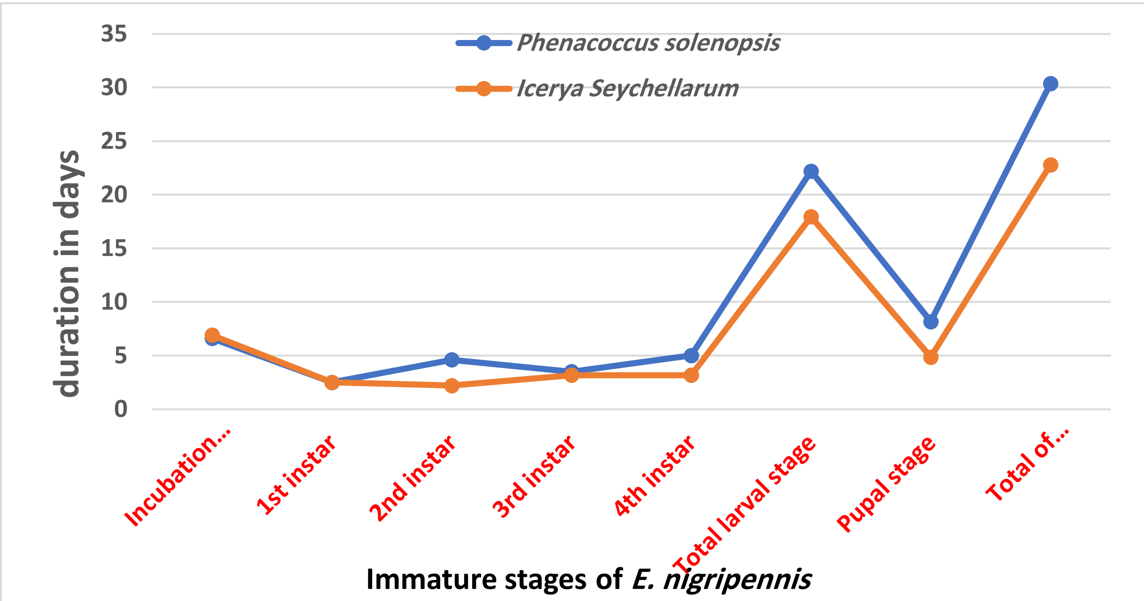

Fig (4). Average duration of immature stages of *Exochomus nigripennis* fed on *Phenacoccus solenopsis* and *Icerya Seychellarum* under laboratory conditions

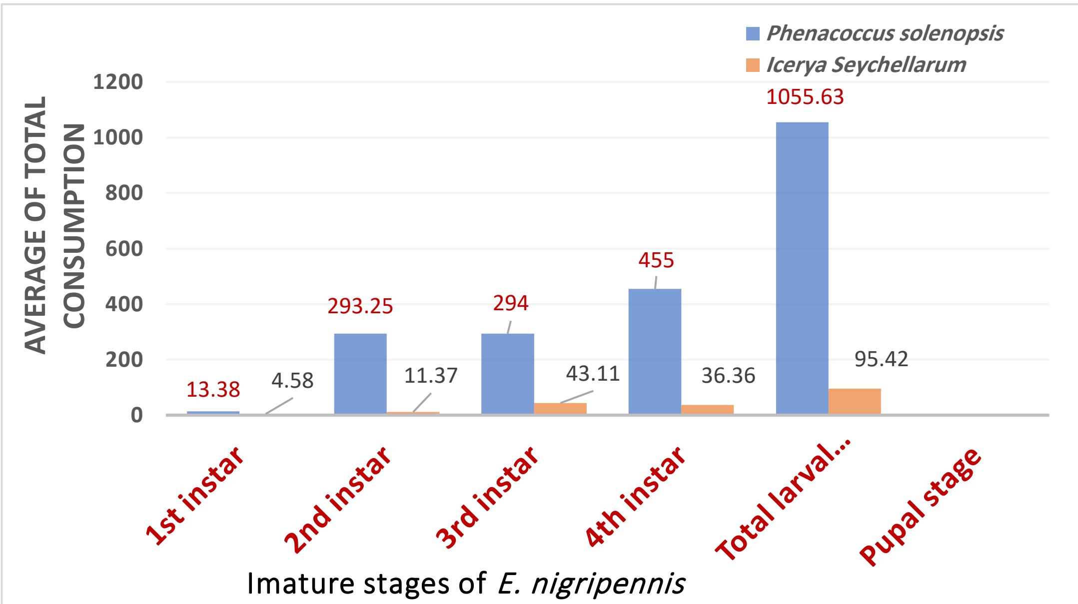

Fig (5). Average total consumption of immature stages of *Exochomus nigripennis* fed on *Phenacoccus solenopsis* and *Icerya Seychellarum* under laboratory conditions

Table (5). Average (± SE) The lifespan, prey consumption, and fecundity of adult *Exochomus nigripennis* reared on *Phenacoccus solenopsis*, *Phenacoccus solenopsis* provided with sugar solution and *Icerya Seychellarum*

Adult Stages	*Phenacoccus solenopsis*	*Phenacoccus solenopsis* with sugar solution	*Icerya Seychellarum*
Male longevity (days)	18.9 ± 1.70 a	11 ± 2.89 b	14.5 ± 1.71 b
Female longevity (days)	30.9 ± 1.21 a	28.5 ± 0.65 b	23.75 ± 0.48 c
Pre-oviposition period (days)	3.63 ± 0.18 b	3.75 ± 0.25 b	8.25 ± 0.85 a
Oviposition period (days)	28.25 ± 0.85 a	22 ± 0.65 b	15.60 ± 0.65 c
Fecundity (eggs per female)	220.35 ± 0.85 a	264.00 ± 1.47 a	78.00 ± 0.65 b

Average followed by different letters in a row are significantly different

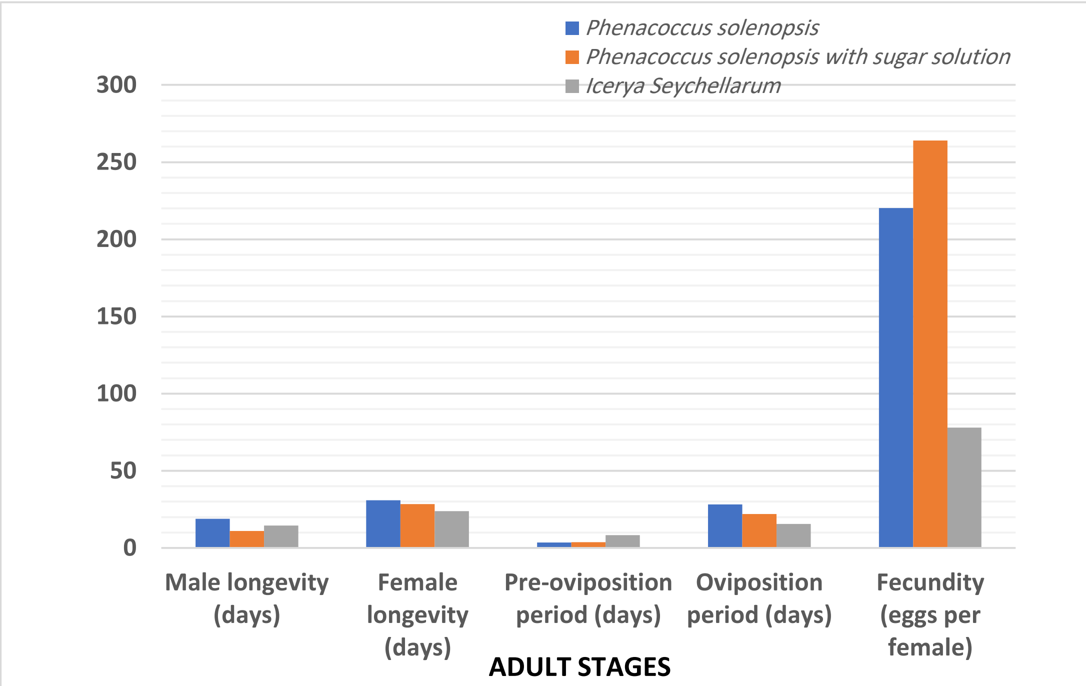

Fig (6). Average (± SE) lifespan, oviposition and fecundity of *Exochomus nigripennis* adult fed on *Phenacoccus solenopsis*, *Phenacoccus solenopsis* provided with sugar solution and *Icerya Seychellarum*

3.6. Lifespan, oviposition and fecundity of *Exochomus nigripennis* adult reared on the *Phenacoccus solenopsis*, *Phenacoccus solenopsis* provided with sugar solution and *Icerya Seychellarum* under laboratory conditions

Table 5 and Figure 6 summarize the effects of various preys on the lifespan and female reproduction of *E. nigripennis* adult. The lifespan and reproduction of *E. nigripennis* were significantly affected by these preys (Table 5). Males and females fed on *P. solenopsis* had longer survived times 30.9 ± 1.21 and 18.9 ± 1.70 days, respectively compared to those reared on other prey. For females consumed *P. solenopsis*, the oviposition period was noticeably prolonged 28.25 ± 0.85 days. *E. nigripennis* exhibited the highest average fecundity of 264.00 ± 1.47 eggs per female when provided with a sugar solution with *P. solenopsis*. In comparison, the fecundity was lower on *P. solenopsis* alone at 220.35 ± 0.85 eggs per female, and the lowest fecundity of 78.00 ± 0.65 eggs per female was observed on *I. Seychellarum* (Figure 6).

4. Dissection

The coccinellid predator *E. nigripennis* in this study showed distinct biological parameters when reared on *P. solenopsis* and *I. Seychellarum* under laboratory condition. Among the various larval instars of *E. nigripennis*, the fourth instar exhibited the highest average total consumption 455 individuals and the highest feeding capacity percentage 43.10%. Females reared on *P. solenopsis* had an average lifespan of 30.9 ± 1.21 days, which they consumed 3255 individuals.

These results align with findings by **Ali *et al*., 2014**, who reported that the fourth instars of *H. variegate* (47.94 ± 2.3) and *C. septumpuctata* (49.65 ± 2.3) had similar consumption patterns in Pakistan under laboratory conditions. **Arif *et al*., 2011** noted that the consumption rates of fourth instars among native predatory coccinellids ranged from 37 to 46 nymphs, with *H. convergens* consuming significantly more and *M. sexmaculatus* consuming less. In laboratory settings, the average intake of Coccinellid adults and larvae was generally higher than the previously reported. The highest mean number of mealybugs consumed by the fourth instar of *H. variegata* consumed was 55.11±1.38, although adult females consumed more mealybug nymphs per day (131.51±2.10) compared to males (129.57±314).

Furthermore, (**Shanab *et al*., 2010)** indicated that the developmental duration of the immature stages of *E. nigromaculatus*, reread on hibiscus mealybug, *Maconellicoccus hirsutus* (Green), lasted, on grape and potatoes, 30.70 ± 1.03 and 32.27 ± 1.2 days, respectively. When fed on *A. gossypii,* the *E. nigripennis* ingested 11–16% more prey throughout its larval phase **(Jalali *et al*. 2018).** This research investigated the impact of prey consumption on life characteristics and the predatory capability of *E. nigripennis* on *P. solenopsis* and *I. seychellarum*. In comparison to other instars, the third and fourth instars of *E. nigripennis* larvae consumed the greatest number of cotton mealy bugs *P. solenopsis* and *I. Seychellarum,* likely due to their larger size and higher consumption. This finding is consistent with studies by (**Gautam and Tesfaye, 2002, Sattar *et al*., 2007 and Ulhaq *et al*., 2006)**, which indicated that larger instars consumed more hosts than first and second instars. The results suggested that a higher reproduction rate corresponds to increase prey ingestion during immature stages. This may be attributed to the larger concentrations of lipids, carbohydrates, ashes, vitamins, caloric acid, and cholesterol, and proteins (amino acids) found in adults and forth larval instar **(Ulhaq *et al*., 2006)**. The acceptance of the artificial nutrition plays a crucial role in the mass rearing of natural enemies. Despite the fact that *E. nigripennis* developed and reproduced on all tested prey, the fitness varied, likely due to differences in the composition of proteins, glycogen, and lipids of each prey type **(Borzoui *et al*., 2016; Wang *et al*., 2018)**.

The range of *E. nigripennis* immature development duration (22.8 – 30.37 days) in our study was comparable to other studies on this predator with *P. citri* and *A. pistaciae* **(Mehrnejad *et al.,* 2000; Ardakani *et al.,* 2020)**. However, our findings conflict with those of **Mirhosseini *et al*., 2015**, who reported significant effects of various prey on the longevity and fecundity of *E. nigripennis*.

In our investigation, predators consuming *P. solenopsis* showed the longest adult lifespans and highest of fecundity, indicating that *P. solenopsis* nymphs and adults were the most favourable prey for *E. nigripennis* mass rearing. Both *P. solenopsis* and *P. solenopsis* provided with sugar solution increased the adult lifespan and fecundity of *E. nigripennis*. This illustrated how prey affects *E. nigripennis* survival and reproduction. The lower quality of *I. Seychellarum* likely contributed to negative impacts on the life cycle, including changes in reproductive periods and decreased fecundity **(Zhang *et al.,* 2012; Mohammadzadeh and Izadi, 2018)**. On the other hand, *P. solenopsis* supported the maximum rate of reproduction for *E. nigripennis*, offering the longest reproductive period 28.25 days, and the largest fecundity 264 eggs per female.

5. Conclusions

The current research shows that *E. nigripennis* can effectively control *P. solenopsis* and be useful for mass rearing in integrated pest management programs. To reduce production costs, further research is necessary to create artificial diets based on natural prey. The cotton mealybug serves as an excellent diet for the growth of *E. nigripennis* making it suitable for mass rearing in agricultural systems.

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