

## LIFE TABLE ATTRIBUTES AND FEEDING EFFICIENCY OF *OENOPIA SAUZETI* (MULSANT) (COLEOPTERA: COCCINELLIDAE) FED ON APHID (*APHIS GOSSYPHII*)

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**ABSTRACT:** ladybird beetles are play vital role in agroecosystem due to successful and efficient feeding behavior against aphids, the present research experiment was carried to find out the life history and feeding efficacy of *oenopiasauzetif* on *Aphis gossypii*, at the laboratory of Biological Control, integrated pest management programme (IPMP), National Agriculture Research Centre (NARC), Islamabad. The results of the experiment revealed that the mean developmental time of immature stage 3<sup>rd</sup> and 4<sup>th</sup> instar have a significant difference with  $3.72 \pm 0.11$  and  $3.87 \pm 0.036$  days, while the egg to adult emergence was  $39 \pm 0.35$  days. The longevity has significant difference in male and female with the higher values at female 34.0 days. Similarly, the feeding efficiency was maximum in *O. sauzeti* females which feeds on 2227.1 mean number of *Aphis gossypii*, while the  $(409.25 \pm 1.42)$  mean numbers of aphids were consumed by larva. The maximum aphid consumption was observed at 4<sup>th</sup> instar larva ( $198.98 \pm 0.51$  aphid) followed by 3<sup>rd</sup> instar larva ( $128.57 \pm 0.59$  aphid). The mean oviposition time of *O. sauzeti* on *A. gossypii* was recorded as 21.36 days and average eggs laid female<sup>-1</sup> day<sup>-1</sup> was 20.53, while the total laid eggs given by a female were 253.60. The apparent mortality (100qx) was maximum at egg stage (24) and the mortality survival ratio (MSR) was highest at pupal stage (0.53), similarly, the indispensable mortality (IM) was also observed high at pupal stage. The maximum survival fraction (Sx) was observed at the 4<sup>th</sup> larval stage (0.91) and the maximum life expectancy (ex) was observed at 1<sup>st</sup> larval instar (4.51) days. The total killer power (k-value) of the *O. sauzeti* for the complete generation was 0.49. This will help to develop an ecofriendly managing approach for the minimizing the aphids infestation in economical important crops.

**Key words:** Life table, feeding efficiency, *Oenopiasauzeti* and aphid (*aphis gossypii*).

(Received 13.04.2023

Accepted 16.06.2023)

## INTRODUCTION

Aphids (Aphididae: Homoptera) are soft body insects with sucking type mouth parts. These are a huge group of insects which feed on a different kind of hosts. They have a maximum biological prospective with few species existing more than ten generations annually (Kos *et al.*, 2008). These are destructive insect pests that cause production losses in important cereal crops such as wheat, barley, and maize, as well as cotton and cause severe damage throughout the seedling and blooming stages (Freier *et al.*, 2007). In Pakistan, several aphid species including *Aphis gossypii*, *Sitobionavenae*, *Rhopalosiphum maidis* and *Schizophusgraminum*, *Sitobionmiscanthi* and *Rhopalosiphumpadiare* causing significant economic losses in agriculture crops (Khan *et al.*, 2007).

Among the aphids species, *Aphis gossypii* (Glover) is a serious pest of cotton, for its high

ability to decline production by feeding affect and extend plant diseases like blue disease and cotton bunchy top disease (Correa *et al.*, 2005; Reddallet *et al.*, 2004). The negative effect of the aphids is direct feeding which may kill the host, also and indirectly by secreting honeydew and through vectoring necessary pathogens (Blackman and Eastop, 2000). In the earlier period, cotton aphid has been restricted through a broad range of synthetic insecticides. The rising apprehension above the consumption of insecticides is a main theme, in lot of agriculture due to green uncleanness and the financial effects of pesticides conflict Ebert (1997). There are two main causes demanding for bio-control agents are that insecticides pressure has lead with a high level of resistance in numerous species of cotton aphid (Hines and Furk, 1993) and the growing usage of bio-control agents beside other insect pests increase the demand for suitable control methods against cotton aphids. The significance of coccinellidae predation of aphids in

various cropping systems has newly been reviewed by Emden and Richard Harrington (2007), which comprise research of aphid pest management systems Deguineet *al.* (2007). Since pesticides have more negative environmental effects, biological control programmes and biologically based IPM against aphids must be implemented employing insect predators and egg parasitoids such as Asins and Pons, (2001).

Coccinellids are the top valuable predatory insects in biological control and usually known as ladybird beetle or lady bugs. The lady bird beetles related to the Coccinellidae family and order Coleoptera. The reported species of ladybird beetles are 6000 which are reported from different parts of the globe, in which 71 predatory ladybird beetles exist and reported from Pakistan (Vandenberg, 2000; Irshad, 2001). Ladybird beetles are generally thought of as beneficial insects since they feed soft-bodied insects such as aphids, whiteflies, mealybugs, jassids, scale insects, psyllids, small larvae insect eggs, and phytophagous mites. All these insect pests caused significant damage to our agricultural crops and forest farms.

Among the coccinellids beetles *Oenopiasauzeti* Mulsant (Coleoptera: Coccinellidae) are the most known beneficial predatory insects, native to Thailand, Southern China, India, Burma and Pakistan. In Pakistan these beetles were collected from Peshawar, Islamabad, Northern areas of Pakistan and Azad Jammu Kashmir. Its hosts consist of *Aphis gossypii* Glover, *Aphis craccivora* Koch, *Shizaphisgraminum* (Rondani) *Rhopalosiphummaidis* (Fitch), *Aleurolobusbarodensis* Maskell, *Neomaskellia* spp. *Evacanthus* spp. (Homoptera: Cicadellidae) and *Tetranychus* spp. (Acarina: Tetranychidae) (Rafi *et al.*, 2005). Although some species of genus *Oenopia* is reported fed on aphid pests.

The novelty of the current experiment is to study the life table attributes and feeding efficiency of *Oenopiasauzeti* fed on *A. gossypii* aphids under controlled conditions for the first in the Pakistan.

## MATERIALS AND METHODS

Experiment was conducted at the laboratory of biological control in Insectary of Insect pest management program (IPMP), Department of Plant and Environmental Protection, National Agriculture Research Center (NARC) Islamabad to study the biological characteristics of both, the predator *Oenopiasauzeti* and its host *Aphis gossypii*, during the year 2019. In order to conduct the experiment, the main necessities were the existing materials of destructive predator species (ladybird beetles) and their associated host species (aphid). For the culture maintenance of the insect the host plants were planted.

**Plantation of host plants:** Cotton plants were planted under glass houses and also in various sizes of pots to maintain the culture of *Aphis gossypii*. The seeds were sown at different time intervals to maintain the continuous supply of aphids. Typical methods were used to help the plants mature. The pots containing of cotton plants were placed in the wooden crates (4×2 sq. feet).

**Culture maintenance of the aphids:** The aphids were collected from the cotton plants at the field area of NARC and brought to laboratory. The aphids were relocated to growing host plants under glasshouses and ample shade. To establish a full-fledge colony, the pest-ridden leaves were simply to be separate from source plants and placed into the terminal portion of the new growing plant. Aphid's colony were monitored and maintained throughout the entire experimental duration.

**Culture maintenance of ladybird beetle (*Oenopiasauzeti*):** The predacious Coccinellid beetle, *Oenopiasauzeti* was collected from NARC field. The adults and pupae were collected and brought to the laboratory for further propagation of culture. After sprouting the adults were kept in a plastic boxes size of (20×40cm) plate 3 (d) under organized condition of 25±2°C in insects holding room. Aphids were transfer to the leaves of the cotton plants inside the plastic holders. The upper side of the jars were covered with a muslin cloth and preserved under controlled environment of 25±2°C and complemented by 60±5% RH. The stock culture of ladybird beetle was maintained in plastic holders as well. The monitoring of the rearing room and the rearing cabinet in particular was done uninterruptedly throughout the whole process. The jars were observed every 12 hours for the laying of eggs. To avoid cannibalism, the entirety of the newly laid eggs was shifted to petri dishes immediately. Every 24 hours, the beetles were provided a fresh diet was replaced with the old diet in the jars. A total was taken daily on the number of collected eggs under electric microscope and kept for hatching in plastic box. After hatching, the larvae were transported into clean containers measuring (10 × 6) cm in size, and covered in muslin cloth for ventilation. The larvae were offered aphids within the rearing vials. The adults which sprout from the pupae were transported to the plastic cages to extent further oviposition and maintain the cultural under same controlled environment

**Feeding efficiency and developmental period of *Oenopiasauzeti* fed on *A. gossypii* aphids:** To discover the efficiency of feeding and developmental time of different stages of *Oenopiasauzeti*, a total of 40 freshly emerged 1<sup>st</sup> instar larvae were collected from the stock culture and each larva was transferred into transparent vials separately, which were then covered the top of the jars with muslin cloth. Primarily, the first instar larvae were providing 20 (1<sup>st</sup> to 3<sup>rd</sup>) instars nymphs of aphids.

The number of aphids was increased when the larvae enter into the next instar. After every 24 hr, the consumed aphids and un-consumed aphids were tallied and exchanged with a new food. This procedure was continued till the all larvae has entered into the pupal stage. If at any stage the larvae is found dead, then were replaced with fresh larvae from stock culture maintained on the identical aphid species.

Similarly, to discover the adult feeding efficiency of *Oenopiasauzeti*, the total numbers of 20 adults consisting of 10 female and 10 male ladybird beetles were collected from stock culture. The beetles were then kept independently in rearing vials and the counted number of aphids were introduced inside the vials on infested leaves of cotton plants.

The data were recorded on the following parameters

- Developmental time of different stages
- Survival and mortality during each stage
- Feeding efficiency of larval instars
- Feeding efficiency of larval instars per day
- Pre pupa and pupal duration
- Duration from egg to adult emergence
- Pre-Oviposition, Oviposition and post-Oviposition period
- Numbers of aphid consumed per larval instar and total larvae
- Numbers of aphid consumed per larval instars and larvae per day
- Numbers of aphid consumed per male and female adult lady bird beetles
- Feeding efficiency per adult beetles per day

## EXPERIMENTS No. 2

(1) **Age specific life-Table:** To construct a life table attributes, the total numbers of 100 eggs of identical age, which were collected from the maintained standard culture on *A. gossypii* aphids. Living and dead insects emerged from 100 eggs were calculated daily. The given supposition was used s used for life table parameters of *Oenopiasauzeti* construction.

$100 q_x$  = Age intervals during mortality x and calculated by the given formula  $100 q_x = (d_x/l_x) \times 100$

X = Insect ages in days

$l_x$  = Survival rates of insect at the start for each interval

$dx$  = Insect dead insects at individually intervals

$ex$  = Average lifecycle time remaining for individuals of age x, and were calculated by this formula  $e_x = T_x / l_x$

Where,  $T_x$  and  $l_x$  were calculated as under

$l_x$  = Age between active individual's x, while x+1 was determined by  $T_x = l_x + (l_x + 2) \dots + l_w$ , Whereas  $l_w$  is the last age intervals.

**Stage Specific Lifetable:** The data were recorded on the specific stage of life table and calculated by the given method which follow by (Ali and Rizvi, 2008b)

x = insects age in days (days).

$L_x$  = Numbers of survivals insects at the starting age intervals (x).

$D_x$  = intervals of age mortality (x)

The life table parameters were calculated based on the above statements.

**Apparent Mortality (100  $q_x$ ):** The percent (%) mortality rate of the insects was calculated by the given formula.

$$\text{Mortality apperance} = \frac{dx}{l_x} \times 100$$

**Survival Fraction ( $S_x$ ):** The data achieved in mortality apparent which were tested for assessment of particular survival fraction stage of individually stage calculating by the given equation.

$$\text{Particular stage } S_x = \frac{\text{subsequent stage of } l_x}{\text{particular stage of } l_x}$$

**Survivals ratio of mortality (SRM):** The survivals ratio of mortality was determine by the given equation

$SRM = (\text{Mortality in particular stages}) / (l_x \text{ of subsequent stages})$

$$SRM = \frac{\text{particular stage in mortality}}{\text{subsequent stages of } l}$$

## Indispensable Mortality (IM)

**The indispensable mortality was calculated by the given equation.**

$IM = (\text{Total numbers of adults emerged} \times \text{mortality survival ratio of insect at specific stages})$

**K-values:** K-values are calculated from changes in "log  $l_x$ " consecutive value. This important element determines reduction/ multiplication from parent to offspring. The overall mortality rate of a generation was determined by summing these values calculated from in insect's various growth stages and as denoted as "K".

$K = kE$  (incubation stages) +  $kL1$  (1<sup>st</sup> larval instar) +  $kL2$  (2<sup>nd</sup> larval instar) +  $kL3$  (3<sup>rd</sup> larval instar) +  $kL4$  (4<sup>th</sup> larval instar) +  $kPP$  (pre-pupa) +  $kP$  (pupal stage), all immature stages of *Oenopiasauzeti*(Mulsant).

**Data analysis:** The data gathered were analyzed through one way ANOVA Completely randomized design (CRD) and were subjected analysis of variance by using Statistics software version 8.1 Means compared with the help of LSD test at 5% level of significance (Steel and Torrie, 1984).

## RESULTS

**Developmental time of immature stages of *O. sauzeti* reared on *Aphis gossypii* under controlled environment:** The developmental time of different stages of *O. sauzeti* from egg to adult are presented in table 1. Table shows that the incubation period of *O. sauzeti* takes  $3.55 \pm 0.10$  days. Maximum duration for the incubation period was recorded to be 3.9 days while minimum days

were found to be 2.7 days. First, second, third, and fourth larval instar takes  $2.58 \pm 0.05$ ,  $1.95 \pm 0.03$ ,  $3.71 \pm 0.11$  and  $3.87 \pm 0.036$  days, respectively. The maximum duration for the first, second, third and fourth larva was found to be 2.8, 2.1, 4.0 and 10.0 days while the minimum duration were found to be 2.30, 1.8, 2.7 and 8.5 days, respectively the total larval duration were recorded  $15.66 \pm 0.15$  days, while the maximum and minimum were recorded 16.2 and 14.4 days respectively. Pre-pupa takes  $0.91 \pm 0.03$  days while  $7.01 \pm 0.05$  days were recorded for pupa. For the Pre-pupa and pupal stages, maximum duration was observed to be 1.10 and 7.73 days respectively however, 0.70 and 6.8 days was the minimum duration for pre-pupa and pupa stages. Overall total  $39 \pm 0.35$  days were taken by *O. sauzeti* from hatching time to adult emergence. The total time took from egg to adult emergence ranged from 36.60 to 40.20 days.

**Adult mean longevity in days of *O. sauzeti* raised on *Aphis gossypii* in controlled environment:** The longevity of *O. sauzeti* female and male fed on *A. gossypii* were shown in figure 1. The result indicates that the longevity of both male and female adults of *O. sauzeti* are significantly different from each other. Figure shows that the adult females have comparatively high longevity value ( $34.0 \pm 0.11$ ) than the males ( $27.96 \pm 0.19$ ) days. However, the maximum and minimum longevity of female was 45.0 and 41.0 days, respectively.

The maximum and minimum longevity of male was 35.0 and 34.4 days, respectively.

**Average feeding efficiency of different larval instars and adults of *O. sauzeti* reared on *Aphis gossypii* under controlled conditions:** The mean feeding efficiency of different larval stage of *O. sauzeti* on *Aphis gossypii* is given in table 2. The larval feeding efficiency of *O. sauzeti* on *Aphis gossypii* is shown significantly high in the larval stage forth ( $198.98 \pm 0.51$ ) followed by third larval stage ( $128.57 \pm 0.59$ ) while the least feeding efficiency was observed at first larval stage ( $28.44 \pm 0.32$ ). However, the mean feeding efficiency of total larval consumption was ( $409.25 \pm 1.42$ ) on *A. gossypii*, while there is a significant difference present in male and female feeding efficiency as adult female mean value is  $2227.1 \pm 4.44$  and the male consumption values is  $1744 \pm 12.78$  which is comparative less than the female showed in figure 2.

**Mean pre-oviposition, oviposition, post oviposition period, number of eggs female<sup>-1</sup> and number of eggs female<sup>-1</sup> day<sup>-1</sup> of *O. sauzeti* feed on *Aphis gossypii* under laboratory conditions:** The result of ovi-position periods of *O. sauzeti* on *Aphis gossypii* were indicates that the pre-oviposition was 5.96 days, oviposition was 21.36 days and post oviposition time was 4.91 days table 4. However, the total average numbers of eggs were recorded 253.60 laid female<sup>-1</sup>, while the average eggs laid female<sup>-1</sup> days<sup>-1</sup> was recorded 20.53.

**Table 1: Developmental time  $\pm$  SE of immatures stages of *Onepiasauzeti* reared on *Aphis gossypii* under controlled conditions.**

Developmental Stages	Developmental time (days) $\pm$ S.E	Maximum durations	Minimum durations
Incubation Periods	$3.55 \pm 0.10$	3.9	2.7
1 <sup>st</sup> larva instar	$2.58 \pm 0.05$	2.8	2.30
2 <sup>nd</sup> larva instar	$1.95 \pm 0.03$	2.1	1.8
3 <sup>rd</sup> larva instar	$3.71 \pm 0.11$	4.0	2.7
4 <sup>th</sup> larva instar	$3.87 \pm 0.036$	10.0	8.5
Larvae	$15.66 \pm 0.15$	16.2	14.4
Pre-pupa	$0.91 \pm 0.03$	1.10	0.70
Pupa	$7.01 \pm 0.05$	7.3	6.8
Egg to adult emergence	$39 \pm 0.35$	40.20	36.60

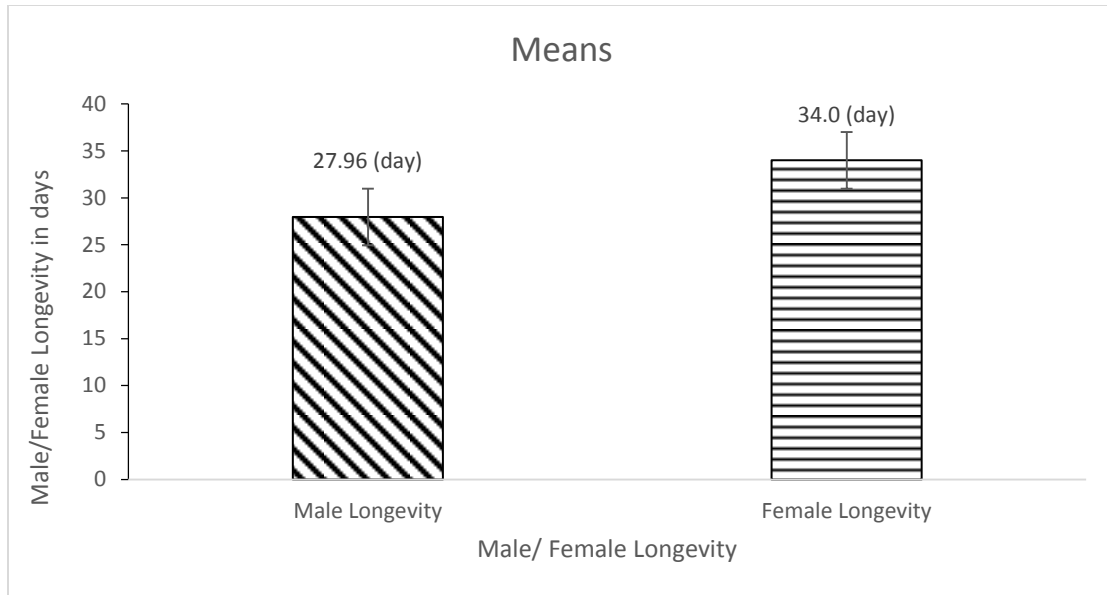


Figure 1: Adult longevity in days of *O. sauzeti* reared on *Aphis gossypii* in controlled environment.

Table 2: Average feeding efficiency  $\pm$  SE of different larval instars of *O. sauzeti* reared on *Aphis gossypii* under controlled conditions.

Immature Stages (Instars)	Mean feeding efficiency $\pm$ S.E
1 <sup>st</sup> larva instar	28.44 $\pm$ 0.32e
2 <sup>nd</sup> larva instar	52.54 $\pm$ 0.29d
3 <sup>rd</sup> larva instar	128.57 $\pm$ 0.59c
4 <sup>th</sup> larva instar	198.98 $\pm$ 0.51b
Larvae	409.25 $\pm$ 1.42a

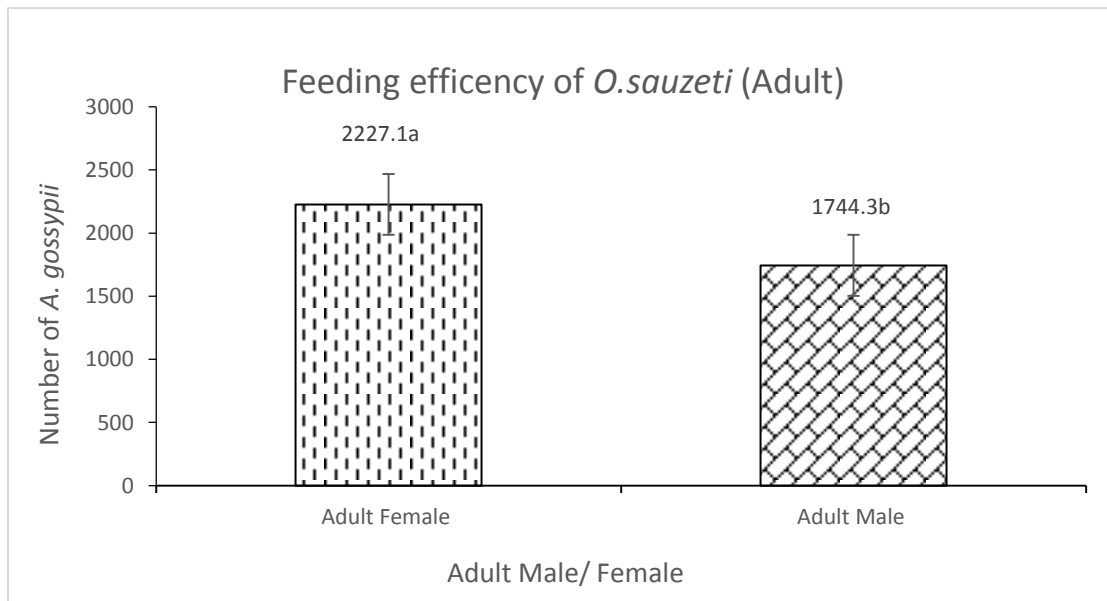


Fig. 2: Average feeding efficiency  $\pm$  SE of adults of *O. sauzeti* reared on *Aphis gossypii* under controlled conditions.

**Table 3: Mean pre-oviposition, oviposition, post oviposition period, number of Eggs female<sup>-1</sup> and number of eggs female<sup>-1</sup> day<sup>-1</sup> of *O. sauzeti* feed on *Aphis gossypii* under laboratory conditions.**

Oviposition Periods and Female Fecundity of <i>O. sauzeti</i>	
Pre-Oviposition	5.69 ±0.10
Oviposition	21.36 ±0.23
Post-Oviposition	4.91 ±0.12
Eggs Female <sup>-1</sup>	253.60 ±2.37
Eggs Female <sup>-1</sup> days <sup>-1</sup>	20.53 ±0.64

**Stage specific life table of *O. sauzeti* fed on *A. gossypii* under controlled condition. Apparent Mortality:** The apparent mortality at egg stage was highest (24) and lowest (8.33) at 4<sup>th</sup> larval instar stage. The apparent mortality at egg stage was higher and lower at the 4<sup>th</sup> larval instar stage. The second highest apparent mortality was in the 1<sup>st</sup> larval instar stage and then in pupae stage, respectively (Table 5).

**Survival Fraction (Sx):** The survival fraction (Sx) at 4<sup>th</sup> larval instar was highest (.91) and lowest at egg stage (.76). Survival fraction recorded at the 4<sup>th</sup> larval instar was maximum and minimum at egg stage. After the 4<sup>th</sup> larval instar, the pre-pupa stage had the second highest survival fraction, however, the 1<sup>st</sup> instar, 2<sup>nd</sup> instar and pupae stage had the lowest survival fraction (Table 5).

**Mortality Survivor Ratio (MSR):** Mortality Survivor Ratio (MSR) at the pupal stage was highest (0.53) and lowest at 4<sup>th</sup> larval instar stage (0.18). After pupal stage the egg stage had the second highest MSR and then the

1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> larval instars and pre-pupal stage had the lowest mortality survivor ratios, respectively (Table 5).

**Indispensable Mortality:** The highest (17.49) rate of indispensable mortality (IM) was recorded in the pupal stage followed by the egg stage (10.23). The lowest (5.94) indispensable mortality was recorded in the 4<sup>th</sup> larval instar followed by 3<sup>rd</sup>, 2<sup>nd</sup> and 1<sup>st</sup> instars which were 6.27, 8.91 and 9.57, respectively (Table 5).

**Life Expectancy (ex):** The life expectancy (ex) for 1<sup>st</sup> larval instar was highest (4.51) and lowest at the pupal stage (1.96). After the 1<sup>st</sup> larval instar, the highest life expectancy was recorded in 2<sup>nd</sup>, egg stage and 3<sup>rd</sup> instar which was 4.42, 4.31 and 4.09, respectively (Table 5)

**K-Value:** K-value for the egg stage was the highest (0.12) and lowest for the 3<sup>rd</sup>, 4<sup>th</sup> and pre-pupae stages. K-value for 3<sup>rd</sup>, 4<sup>th</sup> and pre-pupae were statistically different from each other and were recorded as 0.04. The second highest k-values were recorded for the 1<sup>st</sup> and 2<sup>nd</sup> instars which were 0.09 and 0.07, respectively (Table 5).

**Table 4: Age specific life table of *O. sauzeti* fed on *A. gossypii* under controlled condition.**

Stage X	lx	Dx	Lx	100qx	SX	TX	MSR	IM	Log lx	Ex	K- values
Egg	100	24	88	24	0.76	431.5	0.31	10.23	2	4.31	0.12
1 <sup>st</sup> instar	76	14	69	18.42	0.81	343.5	0.29	9.57	1.88	4.51	0.09
2 <sup>nd</sup> instar	62	9	57.5	14.51	0.85	274.5	0.27	8.91	1.79	4.42	0.07
3 <sup>rd</sup> instar	53	5	50.5	9.43	0.90	217	0.19	6.27	1.72	4.09	0.04
4 <sup>th</sup> instar	48	4	46	8.33	0.91	166.5	0.18	5.94	1.68	3.44	0.04
Pre-pupa	44	4	42	9.00	0.90	120.5	0.22	7.26	1.64	2.73	0.04
Pupa	40	7	42	17.5	0.82	78.5	0.53	17.49	1.60	1.96	0.09
Adult	33	33	36.5						1.51		K=0.49

Where, lx = No. surviving at the start of the stage, dx= No. mortality in each stages, LX= No. of alive between age x+1, 100qx= Apparent mortality, SX= Survival fraction, MSR= Death/Survivor ratio, IM= indispensable mortality, ex= Life expectancy and K= killing power.

## DISCUSSION

The ladybird beetles are potential predators of soft bodied insects (Iftikhar *et al.* 2018). Among them, aphid species are the most suitable prey of coccinellid predators (Bouvet *et al.* 2019; Tang *et al.* 2013). Keeping in view the economic importance of ladybird beetle as predators, it is pivotal to understand the life table parameters and feeding efficacy of these predatory

beetles on the target pests i.e., aphids. The ladybird beetles, *O. sauzeti* are widely distributed aphid predators.

The current experiment was performed to explore the developmental duration and immature stages of *Oenopiasauzeti* reared on *Aphis gossypii*. Our finding showed that incubation period of *O. sauzeti* was 3.55 days reared on *A. gossypii*. The mean developmental time immature stages of 3<sup>rd</sup> and 4<sup>th</sup> larval instar have a significant difference. The maximum duration immature

stages of *O. sauzeti* was recorded on 4<sup>th</sup> larval instar followed by 3<sup>rd</sup> larval instar, while the minimum duration of immature stages was recorded on 2<sup>nd</sup> followed by 1<sup>st</sup> larval instar. Our conclusion are in line with the Aziz *et al.* (2020) who study on *O. sauzeti* against *Tinocalliskahawaluokalani* aphid. Who reported that incubation period of *O. sauzeti* was recorded 3 days and the immature stages of *O. sauzeti* 3<sup>rd</sup> and 4<sup>th</sup> larval instar have significant difference. The highest mean duration were recorded in 4<sup>th</sup> larval instar followed by 3<sup>rd</sup> instar, while the minimum mean duration of *O. sauzeti* was recorded in 2<sup>nd</sup> larval instar. Farooq *et al.* (2018) recorded the same resulted although they used *Coccinellaseptempunctata* against *L. erysimi* and *M. persicae* other than *O. sauzeti* and *A. gossypii*. Who reported that the highest mean duration of incubation was noted on *L. erysimis*, while the lowest on *M. persicae*. The developmental duration of *C. septempunctata* have significant difference when fed on *L. erysimis* and *M. persicae*. The maximum developmental duration larval stages of *C. septempunctata* was recorded on 4<sup>th</sup> larval instar, and the minimum larval instar was observed on 2<sup>nd</sup> instar of *C. sptmpunctat*. Pervious worker Ghadamet *al.* (2009) also conducted the same experiment but slightly different from the current studies. Who study on the same genus *Oenopia* different species *conglobata* in Laboratory condition.

Furthermore, significant differences were found in longevity of male and female *O. sauzeti* when were feed with *A. gossypii*. *Oenopiasauzeti* female lived longer i.e., 34 days and its male lived for 27.96 days when were feed with *A. gossypii*. The longevity of this species here in this study seems to be associated with oviposition and fecundity, and these parameters are higher for *O. sauzeti*. The differences in egg laying ability of predators could be a reason for various oviposition capacities (Atlihan and Kaydan 2002). The results of this study also support the results of Zhang *et al.* (2012) which reported positive interaction of fecundity and longevity of coccinellid beetles. Generally, high longevity of females resulted in large amount of egg production. Khan *et al.* (2015) conducted experiment on *Harmoniadimidiata* who reported that the longevity of male and female was 36.4 and 39.8 days, respectively.

Furthermore, significant difference was found in feeding of male and female of *O. sauzeti* when fed with *A. gossypii*. Our finding are also in line with Hsieh. (2012) who studied on *O. sauzeti* against *Myzuspersicae*. They reported that the mean consumption rate of *O. sauzeti* male and female were significant difference from one another. The maximum mean number of consumption was recorded on female, while the minimum mean feeding potential was recorded on male of *O. sauzeti*. Pervez and Omkar (2004) also conduct experiment on same pest Aphid (*Aphis gossypii*) but have different beetle *Propyleadissecta*. Who reported that the

feeding efficacy of male and female was significantly different form each other. The highest consumption rate was recorded on female, while lowest on male of *O. sauzeti*.

The result regarding total mean feeding efficacy of different larval instar of *O. sauzeti* reared on *A. gossypii*. The current finding showed that the feeding efficacy of immature stages of *O. sauzeti* was significantly different. The highest feeding potential rate was recorded on 4<sup>th</sup> larval instar followed by 3<sup>rd</sup> larval instar, while the lowest feeding potential of *O. sauzeti* was recorded on 1<sup>st</sup> and 2<sup>nd</sup> larval instar of *O. sauzeti*. A similar experiment was also reported by Pervez and Omkar (2004) recorded the same finding although they used *Propyleadissecta* on *Aphis gossypii*. Who reported that the feeding efficacy of immature stages (1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup>) of *P. dissecta* was significantly different. The maximum consumption rate was recorded on 4<sup>th</sup> larval instar and lowest on 1<sup>st</sup> larval instar. Similar experiment was also conducted by Khan *et al.* (2015) on *Harmoniadimidiata* against *Schizaphusgraminum*.

In the current study finding regarding the biological attribute of *O. sauzeti* against *A. gossypii* indicate that mean oviposition, pre-oviposition and post-oviposition times were examined. The total oviposition period of *O. sauzeti* was recorded 21.36 days. While the average no. eggs female<sup>-1</sup> was recorded 253.60 eggs and the average number of eggs per female per day was recorded 20.53 eggs.

Our finding as line with Aziz *et al* (2020) who study on *O. sauzeti* fed on *T. kahawalukalani*, who reported that the oviposition period of *O. sauzeti* was recorded 23.38 days. Ghadam (2009) conducted same experiment on another species *conglobata* of the genus *Oenopia*. Reported that oviposition period was recorded 30.28 days. Khan *et al.* (2015) also conducted experiment recorded the same result although they used *Harmoniadimidiata* against *Scizaphusgraminum* other than *O. sauzeti* and *A. gissypii*.

The life table parameter of the current study revealed that the apparent mortality was highest at egg stage (24) for the first larval instar, the results of apparent mortality reported in *Hyperaspis notate* showed that the higher mortality at first instar stage than last instars (Dreyer *et al.*, 2015). The survival fraction (Sx) was maximum at 4<sup>th</sup> larval instar (0.91) and life expectancy (ex) was highest (4.51). However, the mortality survivor ratio (MSR) and indispensable mortality (IM) were recorded highest in the pupal stage (0.53) and (17.49), respectively, the trends mortality survivor ratio (MSR) and indispensable mortality (IM) similar as reported in *Coccinellaseptempunctata* and *C. transversalis* (Rizvi *et al.*, 2009; Ali and Rizvi, 2010). The k-value was maximum at the egg stage was (0.12) and the k-value per generation was 0.49 to complete one generation. According to Khan *et al.* (2017), the life probability (ex)



was highest (5.24) egg phase and least (1.89) at the pupal stage, however, the current results showed that the highest value at the first larval instar, while the pupal stage collaborates with the Khan *et al.* (2017), when feeds on the *Aphis gossypii*.

**Conclusion and Recommendations:** The study concludes that immature and adult stage of *O. sauzetii* had an exponential increase rate feeding on the aphid species *Aphis gossypii*, which help adult females in quantitative eggs production and reproduction responses as show in the k-value (0.12). However, the developmental time, longevity of adult (female and male), biological parameters pre-oviposition, oviposition and post oviposition time in immature and adult stages of *O. sauzetii* predates on the *Aphis gossypii* have significantly different and showed that *O. sauzetii* can be reared and further be used in the biological control programs against many other species of aphids. The feeding efficacy in the *O. sauzetii* increases from the immature to adult stages. This study shows that the ladybird species *O. sauzetii* has promising future in the biological control of aphid species *Aphis gossypii*, which will help the scientist to develop mass rearing technique of this species against this aphid species. Further, studies will need to be develop on the field implementation strategies of this ladybird species for the natural control of aphid species.

## REFERENCES

- Asin, L. and Pons, X., Effect of high temperature on the growth and reproduction of corn aphids (Homoptera: Aphididae) and implications for their population dynamics on the Northeastern Iberian Peninsula. *Environ. Entomol.* 30: 1127-1134 (2001).
- Atlihan, R. and Kaydan, M. B., Development, survival and reproduction of three coccinellids feeding on *Hyalopterus pruni* (Geoffroy) (Homoptera: Aphididae). *Turk J Agric For* 26:119-124 (2002).
- Aziz, M. A., Sadaf, H., Iftikhar, A. and Hafeez, F., Influence of *Crapemyrtle* aphid, *Tinocallis kahawaluokalani* (Homoptera: Aphididae) on population characteristics of three aphidophagous ladybird beetles. *International Journal of Tropical Insect Science*, 40(2): 361-371 (2020).
- Blackman, R. L. and Eastop, V. F., Aphids on the world's crops: an identification and information guide. 2nd edition. John Wiley and Sons, UK. 466 (2000).
- Bouvet, J., Urbaneja, A. and Monzó, C., Life history traits of the coccinellids *Scymnus subvillosus* and *S. interruptus* on their prey *Aphis spiraecola* and *A. gossypii*: implications for biological control of aphids in clementine citrus. *Biol Control* 132:49-56 (2019).
- Correa, R. L., Silva, T. F., Arraujo, J. S., Barroso, P., Vidal, M. and Vaslin, M., Molecular characterization of virus from the family of Luteoviridae associated with cotton blue disease. *Archives of Virology* 150: 1357-1367 (2005).
- Deguine, J. P., Vaissayren, M. and Leclant, F., IPM case studies: cotton. In: van Emden, H.F., Harrington, R. (Eds.), Aphids as Crop Pests. CAB International, Cambridge, Massachusetts, USA. 573-585 (2007).
- Dreyer, B. S., Neuenschwander, P., Bouyjoy, B., Baumgartner, J. and Dom, S., The influence of temperature on the life table of *Hyperaspis notata*. *Entomologia Experimentalis Applicata*, 84(1): 85-92 (2015).
- Ebert, T. A. and B. Cartwright, B., Biology and ecology of *Aphis gossypii* Glover (Homoptera: aphididae). *Southwestern Entomologist*, 22(1), 116-153 (1997).
- Emden, V., Harrington, R., Aphids as Crop Pests. CAB International, Cambridge, Massachusetts, USA (2007).
- Farooq, M., Shakeel, M., Iftikhar, A., Shahid, M. R., and Zhu, X., Age-stage, two-sex life tables of the lady beetle (Coleoptera: Coccinellidae) feeding on different aphid species. *Journal of Economic Entomology*, 111(2): 575-585 (2018).
- Freier, B., Triltsch, H., Mowes, M. and Moll, E., The potential of predators in natural control of aphids in wheat: results of a ten-year field study in two German landscapes. *Bio Cont.* 52: 775-78 (2007).
- Furk, C. and Hines, C. M., Aspects of insecticide resistance in the melon and cotton aphid, *Aphis gossypii* (Homoptera: Aphididae). *Ann. Appl. Biol.* 123(1): 9-17 (1993).
- Hsieh, B. Y., Using life table to explore the relationship between predator and prey of ladybug and *Myzus persicae*. Dissertation of the Department of Entomology, Chung Hsing University, pp.1-23 (2012).
- Iftikhar, A., Aziz, M. A., Naeem, M., Ahmad, M. and Mukhtar, T., Effect of temperature on demography and predation rate of *Menochilus sexmaculatus* (Coleoptera: Coccinellidae) reared on *Phenacoccus solenopsis* (Homoptera: Pseudococcidae). *Pak J Zool* 50:1885-1893 (2018).
- Irshad, M., 2001. Distribution, hosts, ecology and biotic potential of Coccinellids of Pakistan. *Pak. J. Biologic. Sci.* 4(10): 1259-1263 (2001).
- Khan, J., Haq, E. U. and Rehman, A., Effect of temperature on the biology of



- Harmoniadimidiata (Coleoptera: Coccinellidae) reared on *Scizaphusgraminum*(Rond.) Aphid. Journal of Biodiversity and Environmental Science. 7(5): 42-49 (2015).
- Khan, S. A., Farmanullah, N., Saljoki, A. U. R., Hayat Y. and Shahid, S., Natural enemies of cereal aphids in NWFP, Pakistan. Sarhad. J. Agri. 23(2): 435-439 (2007).
- Kos. K., Tomanovic, Z., Petrovic-Obradovic, O., Laznik, Z., Vidrih, M., and Trdan, S., Aphids (Aphididae) and their parasitoids in selected vegetable ecosystems in Slovenia. Acta Agric. Slovenica. 91(1): 15–22 92 (2008).
- Pervez, A., and Omarkar., Prey- Dependent Life Attributes of an Aphidophagous Ladybird Beetle, *Propyleadissecta* (Coleoptea: Coccinellidae). Biocontrol Science and Technology. 14(4): 385-396 (2004).
- Rafi, M. A., Irshad M. and Inayatullah, M., Predatory Ladybird beetles of Pakistan. National Insect Museum & Insect Pest Informatics (2005).
- Reddall A., Ali, A. and Able, J., Cotton bunchy top (CBT): an aphid and graft transmitted cotton disease. Australasian Plant Pathology 33: 197–202 (2004).
- Tang L, Wu, J., Ali, S., Ren, S., The influence of different aphid prey species on the biology and life table parameters of *Propylaea japonica*. BiocontrolSci Tech. 23(3):624–636 (2013).
- Zhang, S-Z., Li, J-J., Shan, H-W., Zhang, F., Liu, T-X., Influence of five aphid species on development and reproduction of *Propylaea japonica* (Coleoptera: Coccinellidae). Biol Control 62(4):135–13 (2012).