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# Life Table and Reproductive Parameters of Ladybird Beetle, *Coccinella undecimpunctata* (Linnaeus) (Coleoptera: Coccinellidae) on Aphids, *Myzus persicae* (Sulzer) and *Brevicoryne brassicae* (Linnaeus) (Hemiptera: Aphididae)

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## ABSTRACT

The study aimed to determine the effect of two aphid species; *Myzus persicae* (Sulzer) and *Brevicoryne brassicae* (Linnaeus) (Hemiptera: Aphididae) on the life table and reproductive parameters of ladybird beetle, *Coccinella undecimpunctata* (Linnaeus) (Coleoptera: Coccinellidae). The results revealed that the total developmental period from egg to adult emergence was significantly shorter on *Myzus persicae* (18.6 ± 0.42 days) and longer on *Brevicoryne brassicae* (27.4±0.50 days). The adult longevity of males and females was noted significantly higher on *M. persicae* than *B. brassicae*. The reproductive parameters such as oviposition period (37±1.00 days), post-oviposition period (4.4±0.41 days), and fecundity (315.09±0.34 eggs) were found higher on *M. persicae* than *B. brassicae* (31.2±1.09 days, 3.3±0.35 days, 189.54±0.43 eggs, respectively). Among the life table parameters, net reproductive rate and intrinsic rate of increase were significantly higher on *M. persicae* (132.18 females/female and 0.19/day, respectively) and lower on *B. brassicae* (80.77 females/female and 0.12 /day, respectively). Our results showed that *C. undecimpunctata* can be easily reared on *M. persicae* and is a more efficient biological control agent for *M. persicae* than *B. brassicae*.

*Keywords:* aphids, population, coccinellids, biology, performance.

## INTRODUCTION

Insect pests are the prime reason for biotic stresses that cause significant damage to crops worldwide. Among the insect pests, aphids are the major global group of pests causing serious economic damage to almost all crops. There are about 4000 aphid species described feeding over 250 agricultural and horticultural crops throughout the world (Ali & Rizvi, 2007). For the last few years, the population of aphids has been increasing and attaining the status of the alarming pest in Kashmir. The aphids cause damage both directly and indirectly to almost all cultivated crops. In direct damage, aphids suck the cell sap which results in the drying of shoots, wilting, and distortion of the plants, and secrete honeydew which results in sooty mold formation on leaves and shoots. While in indirect damage aphids serve as vectors of various viral plant diseases (Elwaki & Mossler, 2016). For instance, cabbage aphid is a vector of 20 plant viral diseases in a wide range of plants (Lashkari, Sahragard, & Ghadamyari, 2007). Similarly, green peach aphid, *Myzus persicae* (Hemiptera: Aphididae) spreads more than 100 viruses (Umina, Edwards, Carson, Van Rooyen, & Anderson, 2014) & is the most economically important aphid pest worldwide (van Emden & Harrington, 2007). There are several factors that have intensified the status of aphid species as a pest, including its distribution, host range, mechanisms of plant damage, life cycle, capacity to disperse, and ability to evolve resistance to insecticides. *M. persicae* is an extremely cosmopolitan species with a worldwide distribution and is highly polyphagous, with a host range of more than 400 species in 40 different plant families, including many economically important crop plants (Blackman & Eastop, 2000). Synthetic pesticides have made important impacts on aphid control, but it has limitations due to the negative impacts on the environment and the development of resistance in aphids (Peris & Kiptoo, 2017). The exhibition of frequent resistance to insecticides has made aphids serious global pests in agriculture. For instance, green peach aphid has developed resistance to at least 70 different chemical compounds and different insecticide resistance mechanisms have been reported worldwide (Silva et al, 2012).

Biological control of aphids is an environmentally friendly alternative to very hazardous and toxic insecticides that are frequently applied to protect plants (Bellows, 2001). Among the natural enemies of aphids, the ladybird beetles are the best known beneficial predatory insects. There are about 6000 ladybird beetle species in the Coccinellidae family described in the world (Che et al, 2021; Szawaryn & Czerwinski, 2022). The majorities of coccinellid species are beneficial predators and have played a significant role in the development of biological control strategies (Berthiaume, Hebert, & Cloutier, 2007). Ladybird beetles are of great economic importance in agricultural production and have been used successfully for the biological control of spider mites, aphids, coccids, and other soft-bodied insects (Ullah, Haq, Ahmad, Inayatullah, & Saeed, 2012).

*Coccinella undecimpunctata* L. (Coleoptera: Coccinellidae) is an old-world aphid predator that is native to central Asia, North Africa, Iceland, and much of Europe (Smyth, Allee, & Losey, 2013). It is a euriphagous predator, which prefers to feed on aphids (Hodek & Honek, 1996). It is now a widespread predator of sucking pests that have been established successfully in many countries. It has also been considered to be an important and successful predator of many sucking pests attacking cotton, sunflower, citrus (Naveed, Salam, & Saleem, 2007), wheat, and vegetable crops (El-Heneidy, Rezk, Abdel-Megeed, Salwa, & Abdel-Samad, 2004). The existence of *C. undecimpunctata* has been observed in various agroecosystems of Kashmir valley (Khursheed et al, 2021).

Life parameters of any biological control agent such as development rate and reproductive parameters depend on various biotic and abiotic factors (Jervis, Copland, & Harvey, 2005). Among the biotic factors, the quality and abundance of food are very important, influencing directly the growth and development of the predator (Dixon, 2005). Life tables are used to measure mortality, survivorship, and the life expectancy of a population at varying ages. There are several types of life tables. A generation or cohort life table is a life history of the mortality experiences of an actual cohort of individuals. Life table parameters are an important tool used by researchers for the selection of the most suitable biocontrol agent (Messenger, 1964). The intrinsic rate of increase is of great importance among other parameters for selecting candidate species as biocontrol agents. The intrinsic rate of population increase of the predator should be equal to, or greater than, that of its prey. A life table analysis provides the basis for elucidating the fitness components of an organism and how they fluctuate with abiotic and biotic factors. Tabulating the survivorship and fecundity schedules of individuals from birth to death is fundamental for cohort life tables. This enables the calculation of several parameters that allow the prediction of an insect's performance, as well as an investigation of mortality and reproduction patterns. A common estimate of population fitness is the intrinsic rate of increase, assuming a closed population that displays constant birth and death rates. In addition, the generation time ratio of prey to predator is often used as an indicator of prey population regulation (Borges, Soares, & Hemptinne, 2006). The successful mass rearing of the coccinellids in a biological control program, and assessment of their reproductive characteristics such as growth rate, fecundity, and predation rate are very important for the development of an efficient biological control strategy (Yu, Chi, & Chen, 2013). Further, the provision of an ample and nutritional diet is a major concern in the predation potential and biology of coccinellids (De Clercq, Bonte, Van Speybroeck, Bolckmans, & Deforce, 2005) and food quality can influence the development, survival, and reproduction of predators (Omkar, Kumar, & Sahu, 2009). The present investigation is undertaken to compare the population dynamics including development, survival rate and fecundity of the *C. undecimpunctata* reared on two major aphids, *M. persicae,* and *B. brassicae*. The results provided basic information for biological control programs by using *C. undecimpunctata*.

## MATERIALS AND METHODS

### Maintenance of stock culture

### Aphid cultures

The seedlings of kale and capsicum were obtained from field populations and transplanted to plastic pots containing a mixture of soil and FYM and were grown under polyhouse conditions. The nymphs and adults of cabbage aphid, *B. brassicae* from kale plants and green peach aphids, *M. persicae* from capsicum plants were collected directly from the field, released on the respective host plants, and the cultures were maintained for further use. The aphids were identified on the basis of available key (Opfer & McGrath, 2013). *B. brassicae* siphunculi short and dark, cauda broad and triangularand body colour green covered with white-greyish waxy powder. Whereas, *M. persicae* has siphunculi and cauda light green, long convergent, siphunculi with dark tip, body colour light green, sometimes pink or red and sometimes with dark green longitudinal bands.

### Ladybird beetle cultures

The initial culture of *C. undecimpunctata* was initiated by collecting adults from the field and maintained in plastic jars (20 cm length and 15 cm diameter) with a sufficient supply of aphid species. The culture was maintained pairly on each aphid species separately. The aphid supply was replenished every 24 h. The jars were monitored daily and eggs laid were collected, transferred with the help of a fine camel hair brush to clean Petri dishes lined with moistened filter paper, and allowed to hatch. Newly emerged larvae of *C. undecimpunctata* from the stock were used in the experiments. The culture was maintained under the laboratory as well as polyhouse conditions till the experiments were completed.

### Development and survival

To study the development and survival, one hundred eggs of *C. undecimpunctata* were obtained from the adults reared on the two different aphid species and were transferred separately in clean Petri plates. The incubation period and the number of eggs hatched were recorded at 12 h intervals. The first and second larval instars of *C. undecimpunctata* were provided by 1st and 2nd nymphal instars of each aphid species and later developmental instars were provided by all the instars of each host aphid species. The experiment was replicated ten times; the five larvae in each beaker constituted a replicate. The observations were recorded at 12 h intervals for the below mentioned biological parameters (Omkar et al, 2009; Arshad et al, 2020).

## Reproduction

Ten pairs of newly emerged adults of *C. undecimpunctata* (n = 10) fed on *B. brassicae* and *M. persicae* separately were isolated and kept in plastic jars containing 1-2 branches of each host plant. Each plastic jar represented one replication. Similarly, the adult pairs were supplied daily with *B. brassicae* and *M. persicae* separately. The laid eggs were collected daily for each couple. Data were recorded daily to determine the below mentioned reproductive parameters:

Pre-mating period and mating period

Pre-oviposition period

Oviposition period

Post-oviposition period

Reproductive rate

Life table parameters

Life table parameters for this ladybird when reared on each of the two aphid species were calculated by following Birch (1948) and Southwood (1978) methods:

Net reproductive rate (Ro) = ΣlxMx.

Mean generation time (Tc) = Σ lxMx/Ro (where, x = pivotal age).

Where lx = number of females surviving in a given population (n = 10).

Mx = net fecundity of emerging female.

The intrinsic rate of increase (rm) = ln Ro/Tc.

The finite rate of increase ($\lambda_m$) = antilog $e^{-rm}$ (where e = 2.718228).

Generation time (GT) = ln Ro/rm.

Doubling time (DT) = ln 2/rm.

## Individual female fitness

The measurement of individual fitness (R) was calculated from life history data by using the following equation given by McGraw and Caswell (1996):

R = {ln (mV)}/ D

Where, m = survival (1 or 0).

V = potential fecundity.

D = total development time.

## Statistical analyses

The bootstrap techniques were used for the estimation of population parameters (Efron & Tibshirani, 1993). Turkey-HSD test was performed to compare the differences among the treatments (Dunnett, 1980). All the statistical analysis was carried out using R, version 4.1.0 (R Core Team, 2021).

## RESULTS

### Developmental period

The data presented in Table 1 revealed that the duration of the incubation period of *C. undecimpunctata*, when fed on *M. persicae*, was shorter than those fed on *B. brassicae* ($t = 3.94$, $df = 18$, $p = 0.002$). Similarly, the 1st, 2nd, 3rd, and 4th larval instars showed significantly faster development when reared on *M. persicae* and slow development on *B. brassicae* ($t = 3.97$, $df = 18$, $p = 0.001$) ($t = 3.90$, $df = 18$, $p = 0.000$), ($t = 3.05$, $df = 18$, $p = 0.006$), ($t = 2.74$, $df = 18$, $p = 0.013$). The total larval developmental period was significantly shorter on *M. persicae* than on *B. brassicae* ($t = 8.70$, $df = 18$, $p = 0.000$). The duration of pre-pupal and pupal stages was also observed shorter on *M. persicae* than that of *B. brassicae* ($t = 3.85$, $df = 18$, $p = 0.001$; $t = 3.84$, $df = 18$, $p = 0.001$). The longevity of both females and males of *C. undecimpunctata* was recorded significantly longer when fed on *M. persicae* than *B. brassicae* ($t = 5.80$, $df = 18$, $p = 0.000$; $t = 2.90$, $df = 18$, $p = 0.009$). The longevity of females was higher than males on both *M. persicae* and *B. brassicae*. The results of the present investigation indicated that the aphid species *M. persicae* was a more suitable prey species for the development of *C. undecimpunctata*.

Table 1. Mean duration of different developmental stages of *Coccinella undecimpunctata* on *Myzus persicae* and *Brevicoryne brassicae.*

| Observations | Mean duration (Days ± S.E) | | t value | df | p value |
|---|---|---|---|---|---|
| | *Brevicoryne brassicae* | *Myzus persicae* | | | |
| Egg incubation | 3.73 ± 0.30 | 2.31 ± 1.63 | 3.94 | 18 | 0.002 |
| 1st instar | 3.61 ± 0.30 | 2.24 ± 0.20 | 3.97 | 18 | 0.001 |
| 2nd instar | 3.64 ± 0.22 | 2.56 ± 0.16 | 3.90 | 18 | 0.000 |
| 3rd instar | 4.25 ± 0.44 | 2.72 ± 0.21 | 3.05 | 18 | 0.006 |
| 4th instar | 3.74 ± 0.30 | 2.60 ± 0.26 | 2.74 | 18 | 0.013 |
| Total larval period | 15.24 ± 0.45 | 10.12 ± 0.36 | 8.70 | 18 | 0.000 |
| Pre pupa | 2.52 ± 0.24 | 1.60 ± 0.23 | 3.85 | 18 | 0.001 |
| Pupa | 5.84 ± 0.32 | 4.34 ± 0.21 | 3.84 | 18 | 0.001 |
| Total development period | 27.33 ± 0.50 | 18.37 ± 0.42 | 12.47 | 18 | 0.000 |
| Adult longevity (Female) | 41.43 ± 0.81 | 51.12 ± 0.63 | 5.80 | 18 | 0.000 |
| Adult longevity (Male) | 35.65 ± 0.73 | 39.35 ± 0.80 | 2.90 | 18 | 0.009 |

### Survival rate

The results presented in Table 2 indicated that the percent pupation was significantly higher when larvae fed on *M. persicae* than on *B. brassicae* ($t = 4.02$, $df = 18$, $p = 0.000$). A similar trend was recorded as far as the percent immature survival was concerned. The percent immature survival was also observed significantly higher on *M. persicae* than on *B. brassicae* ($t = 4.24$, $df = 18$, $p = 0.000$). Similarly, the growth index was significantly higher on *M. persicae* than on *B. brassicae* ($t = 9.0$, $df = 18$, $p = 0.000$). However, there was no significant difference in the sex ratio of

*C. undecimpunctata* when fed on *M. persicae* and *B. brassicae* separately (*t* = 2.5, *df* = 18, *p* = 0.017).

Table 2. Mean survival rate and sex ratio of *Coccinella undecimpunctata* on *Myzus persicae* and *Brevicoryne brassicae*.

| Observations | *Brevicoryne brassicae* | *Myzus persicae* | t value | df | p value |
|---|---|---|---|---|---|
| Percent pupation (No. of pupae/No. of 1st instars) | 73 ± 3.01 | 84 ± 3.20 | 4.02 | 18 | 0.000 |
| Percent immature survival (No. of adults emerged/No. of 1st instars*100) | 68 ± 2.32 | 81 ± 3.33 | 4.24 | 18 | 0.000 |
| Growth index (% pupation/mean larvel duration) | 3.3 ± 0.22 | 6.8 ± 0.32 | 9.0 | 18 | 0.000 |
| Sex ratio (No. of females/total adult emergence) | 0.58 ± 0.03 | 0.69 ± 0.02 | 2.5 | 18 | 0.017 |

## Reproduction

The data on reproductive parameters of *C. undecimpunctata* are enumerated in Table 3, which revealed that the duration of the pre-mating period was significantly found shorter in adults when fed on *M. persicae* than those that were fed on *B. brassicae* (*t* = 2.94, *df* = 18, *p* = 0.008). There was no significant difference in the mating period of *C. undecimpunctata* when fed on *M. persicae* and *B. brassicae* separately (*t* = 1.55, *df* = 18, *p* = 0.138). The predator showed a significantly longer pre-ovipositional period on *B. brassicae* and shorter on *M. persicae* (*t* = 5.6, *df* = 18, *p* = 0.000). The oviposition and post-oviposition periods were recorded significantly longer when fed on *M. persicae* than those fed on *B. brassicae* (*t* = 5.6, *df* = 18, *p* = 0.000; *t* = 3.5, *df* = 18, *p* = 0.002). Maximum egg-laying capacity was recorded in females that fed on *M. persicae*, which was significantly higher than those that fed on *B. brassicae* (*t* = 3.73, *df* = 18, *p* = 0.000). The reproductive rate of *C. undecimpunctata* was also significantly higher when females fed on *M. persicae* than that of *B. brassicae* (*t = 4.18*, *df* = 18, *p* = 0.000). Peak oviposition age of predator also differed, occurring significantly earlier on *M. persicae* and later on *B. brassicae ((t = 10.32*, *df* = 18, *p* = 0.000*)*.

Table 3. Mean duration of different reproductive parameters of *Coccinella undecimpunctata* on *Myzus persicae* and *Brevicoryne brassicae.*

| Observations | *Brevicoryne brassicae* | *Myzus persicae* | t value | df | p value |
|---|---|---|---|---|---|
| Pre-mating period (days) | 5 ± 0.32 | 3.61 ± 0.20 | 2.94 | 18 | 0.008 |
| Mating period (minutes) | 46.5 ± 0.41 | 38.58 ± 0.34 | 1.55 | 18 | 0.138 |
| Pre-ovipositional period (days) | 9.47 ± 0.33 | 6.53 ± 0.28 | 5.6 | 18 | 0.000 |
| Oviposition period (days) | 31.24 ± 1.09 | 37 ± 1.00 | 3.5 | 18 | 0.002 |
| Fecundity (eggs) | 189.54 ± 0.58 | 315.09 ± 0.76 | 3.73 | 18 | 0.000 |
| Post -oviposition period (days) | 3.34 ± 0.35 | 4.43 ± 0.41 | 3.52 | 18 | 0.000 |
| Reproductive rate (eggs/day) | 10.52 ± 0.09 | 17.31 ± 0.07 | 4.18 | 18 | 0.000 |
| Day of peak oviposition (days) | 29.67 ± 0.76 | 19.54 ± 0.89 | 10.32 | 18 | 0.000 |

## Life table parameters

The data pertaining to life table parameters of *C. undecimpunctata* in Table 4 revealed that net reproductive potential (Ro), intrinsic rate of increase, and finite rate of increase were higher when fed on *M. persicae* (132.18 females/female, 0.19/day and 1.18/day) than that those fed on *B. brassicae* (80.77 females/female, 0.12/day and 1.10/day). Mean generation time (T) varied from 42.06 days on *B. brassicae* to 35.11 on *M. persicae*. Doubling time was shorter on *M. persicae* (4.34 days) than on *B. brassicae* (5.93 days). Individual female fitness was higher for those females reared on *M. persicae* (0.54) than those reared on *B. brassicae* (0.22).

Table 4. Life table parameters of *Coccinella undecimpunctata* on *Brevicoryne brassicae* and *Myzus persicae*.

| Observations | *Brevicoryne brassicae* | *Myzus persicae* |
|---|---|---|
| Net reproductive potential (Ro) (Females/Female) | 80.77 | 132.18 |
| Intrinsic rate of increase (rm) (Individual/ Day) | 0.12 | 0.19 |
| The finite rate of increase (ʎm) (Individual/ Day) | 1.10 | 1.18 |
| Generation time (Days) | 42.06 | 35.11 |
| Doubling time (Days) | 5.93 | 4.34 |
| Individual female fitness | 0.22 | 0.54 |

## DISCUSSION

The egg incubation period was shorter in the females fed on *M. persicae* than those fed on *B. brassicae*. The findings are also similar to Arshad et al (2020) who reported that the incubation period of the coccinellid, *H. convergens* fluctuated when feeding on different aphid species. The nature and quality of prey have a significant influence on the duration of egg incubation and larval instars of *C. septempunctata* (Majerus et al, 1989). This perhaps indicates the role of the adult diet in the rate of development of embryos. Previous studies also revealed same results for *C. sexmaculata* (Fabricius) (Chaudhary, David, & Singh,1983) and *Brumoides suturalis* (Fabricius) (Gautam, 1990). The developmental period of all four larval instars was shorter when they fed on *M. persicae* than on *B. brassicae.* Our results are similar to Arshad et al (2020) who reported that the developmental period of all four larval instars of *H. convergens* was shorter when they fed on *L. erysimi* than *on A. gossypi*i. The increased growth and development of *C. undecimpunctata* when fed on *M*. *persicae* may be attributed to the presence of higher protein levels in this species, and their higher consumption, which could be due to higher palatability (Atwal & Sethi, 1963). In the present study, aphid species (*B. brassicae* ) that were consumed in lesser amounts resulted in a longer larval development period of *C. undecimpunctata*. The developmental rate of ladybird instars was thus found to be proportionate to the amount of food eaten by them. The reduction in consumption rate probably leads to reduced nutritional levels, thus having a substantial effect on larval development. Blackman (1967) also noticed the difference in larval development of *C. septempunctata* after being fed on different aphid species like *M. persicae*, *A. fabae* (Theobald), *A. pisum* (Harris), *Megoura viciae* (Buckton), *B. brassicae* and *A. sambuci* (Linnaeus). The less consumption of some aphids by predatory beetles has been ascribed to the presence of certain alkaloids or unsuitable chemicals, not suitable to the constitution and metabolism of the ladybirds (Okamoto, 1966). The toxicity of certain aphid species needs to be confirmed by chemical analysis of body contents.

The shortest pre-oviposition period of C. *undecimpunctata* was observed after feeding on *M. persicae*, and this suggests that the increased quantity of high quality food decreased the length of the pre-oviposition period. This is also supported by the findings of Rhamhalinghan (1985). The decreased consumption of less suitable foods and/or the presence of alkaloids probably affect pre-adult development, resulting in slower sexual maturation and a longer pre-oviposition period on less suitable aphids (*B. brassicae*). This view is supported by the findings for *H. axyridis* (Hukusima & Kamei 1970) and *Propylea japonica* (Thunberg) (Kawauchi, 1981). The quality of the host has been reported to influence the survival, fecundity, and longevity of predators (Moghaddam et al, 2016). The longer oviposition period of *C. undecimpunctata* when fed on *M. persicae* is due to the high consumption of suitable food (along with the suitable nutrients) helps in early ovariole maturation and provides energy to sustain a longer oviposition period, while the reduced consumption of less suitable food affects and probably slows down ovariole development. This lends support to the hypothesis that a certain amount of food is necessary for maturation of ovarioles in *C. undecimpunctata*. A similar finding, that quality and quantity of food affects the oviposition period, was also recorded for *M. sexmaculatus* (Agarwala & Choudhuri, 1995). Thus, when the ladybirds were fed on suitable aphids, the pre-reproductive period was shortened, while the consumption of less suitable food increased the non-reproductive phase. The effect of quality as well as quantity of food was also seen on fecundity and longevity. There was a linear relationship between food consumption with the longevity and fecundity of the ladybird. A linear relationship between longevity and fecundity suggested that longevity may be an important determinant of fecundity. These findings are in conformity with those recorded for *C. septempunctata* (Rhamhalinghan, 1987; Kawauchi, 1991). Maximum fecundity was recorded in females who fed on *M. persicae* and minimum fecundity in females who fed on *B. brassicae*, again reflecting the nutritive value and palatability of the former species. The low fecundity recorded when fed on *B. brassicae* is most likely due o the prey’s effect on egg maturation. Coccinellids fed on the prey of high quality have more ovarioles and mature them earlier than those fed on poor quality prey (Rhamalinghan, 1986). In the case of *Brachinus lateralis*, Juliano (1985) reported that the consumption of high quality prey resulted in faster development, larger food reserves, and larger body size.

Life table parameters are strongly influenced by many factors, including the nature of the prey species, the host plant, and laboratory conditions. We observed that the net reproductive rate (Ro) of *C. undecimpunctata* varied from 80.77 offspring on *B. brassicae* to 132.18 offspring on *M. persicae*. The mean generation time (T) was lower on *M. persicae* than on *B. brassicae*. The highest value of the intrinsic rate of increase (r) and finite rate of increase was recorded on *M. persicae* than *on B. brassicae*. Kontodimas et al (2008) estimated that the total fecundity, net reproductive rate, and intrinsic rate of increase of *C. septempunctata* on *A. fabae* increased with an increase in adult longevity. However, species with the highest fecundities are not necessarily the most successful in decreasing pest populations because individual longevity and fecundity may be correlated. Solano, Delgado, Morales, & Vasquez (2016) reported that *Cycloneda sanguinea* (Linnaeus) reared on *A. craccivora* had very high values of reproductive rate (Ro), intrinsic rate of increase (r), and finite rate of increase (λ) which are consistent with the present study. The intrinsic rate of increase (r) is the most valuable life table factor for comparing population growth potential under different treatments (Southwood, 1966). Lewontin (1965) reported that predators with short pre-ovipositional periods are expected to have high intrinsic rates of increase. Ali and Rizvi (2010) calculated values of R0, T, r, λ, and doubling time (DT) for *C. septempunctata* reared on *L. erysimi*, which are comparable with our results. The highest R0 and rm values were recorded on a diet of *M. persicae*, suggesting this aphid is suitable for mass rearing of *C. undecimpunctata*.

## CONCLUSION

It can be concluded from the results of this study that the ladybird, *C. undecimpunctata* could complete its development on both aphid species (*M. persicae* and *B. brassicae*). However, larval development was faster and reproductive potential was maximum on *M. persicae* than on *B. brassicae*. *M. persicae* can be used as a natural host for the mass rearing of *C. undecimpunctata* and the development of a biological control strategy.

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