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Biological parameters of ladybird *Oenopia conglobata contaminata* (Col: Coccinellidae), fed on *Brevicoryne brassicae* in laboratory conditions

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Abstract
Oenopia conglobata contaminata Menetries (Coleoptera: Coccinellidae) is known as one of the most important predators of pests in Iranian gardens and farms. In this research, some of the biological parameters of this Ladybird were investigated by feeding *Brevicoryne brassicae* at 26 ± 1 °C, (60 ± 1% RH and 16L: 8D). To this end, different growth stages, derived from several breeding generations in the laboratory, were selected, and kept individually, inside Petri, in the growth chamber. In a demographic study, 100 eggs with a life span of less than 24 hours were selected and larvae were fed individually with the host daily. The hatching time of the eggs, and the length of the growth and development of each of the different stages of growth, was visited on a daily basis. Data from Ladybird demography were analyzed using age-stage and bisexual life tables. Mean and error estimates were calculated based on the bootstrap method, with 100,000 replicates. Based on the results obtained, the intrinsic rate of increase in population (r_m) and the rate of increase in population (λ) (per day) were 0.136 ± 0.007 and 1.14± 0.008 Net reproductive rate (R_0), and average generation time (T), were calculated in *B. brassicae*, respectively, 190.91 eggs and 38.35 days respectively. Considering the demographic parameters, we can say that *O. conglobata*, by feeding on the host of *B. brassicae*, is able to complete the cycle of life and reproduction.

Keywords: Biological parameters, *Brevicoryne brassicae*, *Oenopia conglobata*

Introduction
The family Coccinellidae, colloquially known as the ladybirds is a well-known, abundant, and diverse family with about 6000 species in worldwide [1, 2]. The majority members of this family (about 90%) are predator of herbivorous pests such as aphids, adelgids, psyllids, mealy bugs, and scale insects and the rest are phytophagous or mycophagous, and consequently the predatory coccinellids play a significant role in development of biological control strategies [3, 4, 5]. Generally, the brightly coloured species feed on aphids, while the darker coloured and smaller species feed on scale insects, mealybugs, whiteflies or spiders and mites (Ipetri, 1999), also these insects have a wide range of species from stenotopic to eurytopic. Ladybirds are the hunter of several pests, and play a very important role in generating the equilibrium and natural control of aphids, whitefly, mealy bugs, scales, mites, butterflies, and various Insect larvae [4]. The availability of this insect predator is an important factor, which is effective in the effectiveness of these insects [6]. Regarding the frequency of Ladybirds, an effective factor is more than other factors, the quantity and quality of their host [7]. Ladybird *Oenopia conglobata contaminata* (1758) Menetries has been introduced as an important natural enemy of many aphids and Psyllids in Iran [8]. There are many reports in Iran regarding the domain of hosting this Ladybird, Which have been collected and reported from various regions of Iran.
Aphids of the upper Aphidoidea family are highly successful insects, found in temperate regions with the highest number of species, and most often have aphid-specific herbs [9]. Aphid The cabbage wax comes from Europe, but has now been scattered in many parts of the world. In one study, the major hosts are rapeseed, carrots, celery, Chinese broccoli, cabbage, radish, mustard, and many other species of Brassicae. These aphids cause direct damage through plant nutrition and indirect damage through the transfer of various plant viruses in the cabbages of the race, and the high levels of viruses in citrus. Demographic studies, and the table of life, have a special place to fight pests to determine the parameters of population growth and the effectiveness of natural enemies. An increase in population can be demonstrated by fertility of the living table, which states the potential of reproduction of female insects at different times.

It seems that, introducing the theory of age - the stage of two sexes of the living table, has resolved these bugs [10]. The table of life includes a full description of the growth, survival, and reproduction of a person or a population. This data simulates the population in a fundamental way. An analysis of the lifestyle table describes the changes in the rate of growth among individuals based on both sexes [10]. Becausee age - the two sexes stage of the life table gives a complete explanation for each period [11], simulations based on age - the two sexes stage of the life table, suggests a suitable method for the pre The most appropriate nasal time for pest control [12]. In support of this Ladybird, this research was conducted using the elaboration of the two-sexes of the life table, in order to assess biological parameters. These results provide a comprehensive description of survival and reproduction among a group of people of the same age.

Materials and methods

Create a colony of *Brevicoryne brassicae*

Canola plants were used to breed waxy aphid of cabbage. The colony of cabbage aphid (*Brevicoryne brassicae*) was reared on canola. The primary aphids were located on plants in the greenhouse of the Canola Farm of Shahid Bahonar University of Kerman, Iran. To create a colony in the greenhouse, with the amount of leaf that was active on it. Rapeseed plants were planted in plastic pots, 15 cm high, and 16 cm in diameter, and used to carry out experiments. Aphid infected pots were placed inside aluminum cages and kept in the greenhouse (26 ± 1°C, 60 ± 1%RH, and a photoperiod 16: 8 L: D). The aphids were bred for three generations. After a while, the population of aphids in the aluminum cages in the greenhouse increased, and they were used to conduct the experiment.

Collect and breed Ladybird

Adults of *O. conglobata* were originally collected from pistachio trees (*Pistacia vera*), infested by the common pistachio psyllid, *Agonoscena pistaciae* Burckhardt & Lauterer, in a pistachio garden at Shahid Bahonar University of Kerman, Iran, and a batting method was used. Fresh pistachio leaves infested by *A. pistaciae* were obtained daily from a pistachio garden and were transferred to the laboratory for the experiments on psyllids. In this way, several beats were tied to the branches uniformly, using sticks and a white rectangular dish was placed under the branches, and ladybirds were collected inside this container. Well-ventilated plastic containers were used to transfer entire insects to the laboratory, and the leaves were infected with aphids in containers for feeding ladybirds during transport. Three generations have been reared colony ladybirds in the growth chamber under controlled conditions (26 ± 1 °C, 60 ± 1%RH, and a photoperiod 16: 8 L:D) and fed *Brevicoryne brassicae*.

Ladybird Life Table Test

The study of life table began using 100 eggs. Leaves containing eggs were visited every 24 hours. Hatching eggs, one day of larvae, were placed separately in petri dishes, in diameter 9 cm, with stomata, 3 cm in diameter, covered with a tour. The growth of these larvae was studied on the *Brevicoryne brassicae* of cabbage on a daily basis, and the larvae of the period were studied at different ages. The mortality rate of different larval instars and pupils was also recorded. At the end of pupal, adults who had appeared in one day were transferred into the petri dish to mating the [13]. To form the lives of two sexes, daily events all people, from birth to death, Including the daily fertility of the females, as well as the stages of development, such as eggs, nymphs, pupae, full insects, and the sexes of each individual, such as male, female, and unknowns (F= female, M= male, and N = Which died before the complete insect stage), and recorded in Notepad software [10], so that it is known whether each insect is full of what the eggs were imported into. The method [14], Use It was dispatched to identify Ladybirds in each replica, as well as males and females. First, with a pin of nail polish, one was marked slowly, on the ends of the wing to the right of the Ladybirds that appeared on one day (for each a person has a different badge, based on the color and number of signs). The ladybirds that had been mating before, and their gender were marked, were used to ensure male and female per pet. Daily and occasionally a marked male and female separately placed at the disposal of the Young Ladybird Signed. This procedure was repeated until the mating, and sex determination of the complete insects that appeared recently, every day. Mating insects were transferred to separate patches, and the laying of each pair was recorded daily. This trend was followed until the death of the insect. In addition to the number of eggs, the mortality rate of the insect was recorded, and the survey continued until the end of the last insect's life. After collecting the necessary data, population growth indices were calculated.

Life Table Parameters

The life history data of all individuals were analyzed using the age stage, two-sex life table approaches [15]. The age-stage specific survival rate (S_{xj}), life expectancy for age and stage of life (e_{xj}), the value of reproduction for age and stage of life (v_{xj}) were calculated, which j and x are respectively represented the age and stage of life [10]. The intrinsic parameter of the population increase (r_m) was estimated, based on the Euler-Lautka equation $\sum_{x=0}^{\omega} e^{-rx} l_x m_x = 1$ and with the age-index of zero [16]. The Bootstrap method was used to repeat the parameters with one hundred thousand replicates, and the mean and standard error (SE) were calculated, using the coupled Bootstrap test.

Statistical analysis

Raw data obtained from life table experiments was analyzed based on the two sexes theory of age-life stage [10, 15], using the MsChart software (version 2015. 002) TWOSEX [17]. Curves and charts were drawn using Excel and Sigmaplot (Systat software Inc.).

Results

The age-stage specific survival rate (S_{xj}) presented in Fig 1 show that the probability that a survival egg will be found up to age x and stage j, and the survival rate as distinct from the various biological stages of Ladybird *O. conglobata* Shape. These curves indicate survival and difference in stages, overlapping stages, and changes in the rate of growth between individuals [17, 18]. Chi Showed that changes in the rate of growth among individuals lead to overlapping of steps in the survival curve. According to the average of each stage [19], If survival curves are made the collapse of the stages will not be observed, and it lead to create errors in the survival curves. The life expectancy of each group, Age-stage specific life expectancy (e_{xj}) Ladybird predator, is the expected duration, which one person hopes to survive at any age and stage (from age x to stage j). Life expectancy is calculated with the application of the age-stage specific survival rate (S_{xj}),

without assuming that the population gains, the age distribution of the distribution is stable, so we can predict the survival of a population under all circumstances. Life expectancy the basis for two sexes, the stage - the age of the living table, indicates the difference between the same age, or different stages or sexes [12]. The life expectancy for a newborn was 34.01 days (Fig. 2). Reproductive value Age (v_{xj}) *O. conglobata* is defined as the contribution of an individual, with age x and j, in the generation of the next generation [20]. (Fig. 3). This index is a special indicator that shows the relative participation of each age group, for future generations [21, 22]. The reproductive rate of a newborn (V_{01}) is precisely the rate of increase in the population. The reproduction rate increases significantly when reproduction begins. The peak was obtained in reproductive parameters of females on the thirty-fourth day, (218.88). The newborn was born 1.14 which accurately shows the rate of increase in population.

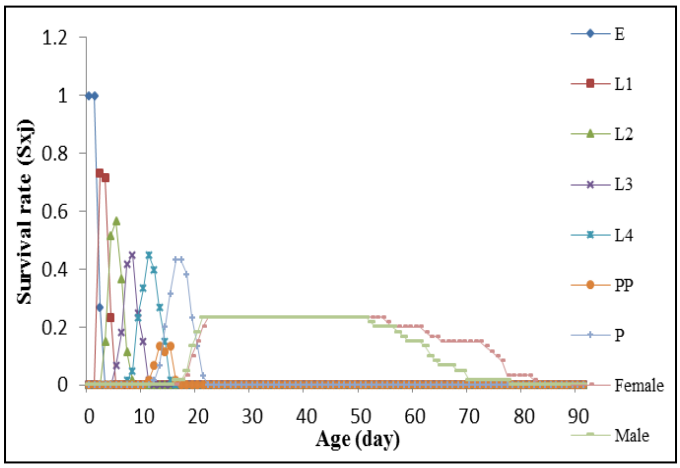

Fig 1: Age-stage specific survival rate (Sxj) of *Oenopia conglobata* on *Brevicoryne brassicae*

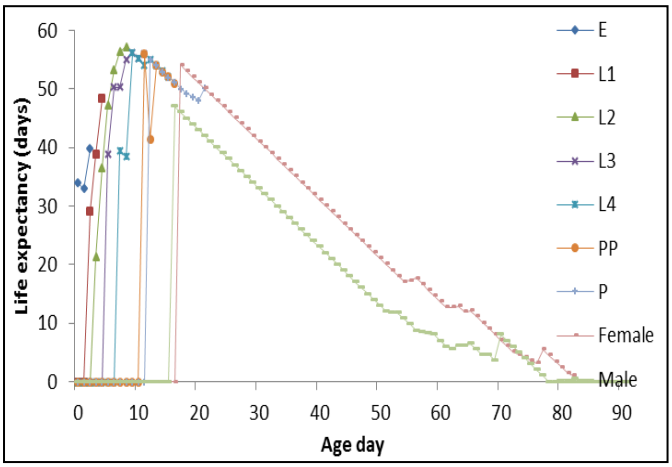

Fig 2: Age-stage specific life expectancy (e_{xj}) of *Oenopia conglobata* on *Brevicoryne brassicae*

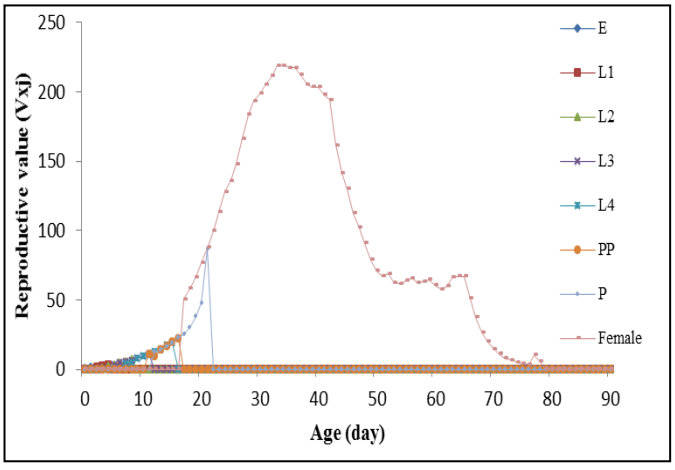

Fig 3: Age-stage specific reproductive value (V_{xj}) of *Oenopia conglobata* on *Brevicoryne brassicae*

Estimated values for the intrinsic rate of population increase (r_m), the finite rate of increase (λ), average generation duration (T), reproductive rate (R_0) and gross reproduction rate (GRR) are shown in Table 1. The results showed that the intrinsic rate of population increase (r_m), and the rate of increase in population (λ) (per day) were 0.136 ± 0.007 and 1.14± 0.001. The Ladybird population increase rate (λ) was 1.14 days. The intrinsic rate of population growth was the population growth rate, and it was used as a comparative parameter to determine the effect of different treatments, including the quality, and physical and chemical characteristics of the host plant on the reproductive capacity of the insect [23]. Net reproductive rate (R_0) (The average number of newborns produced by an insect, with the survival factor interfering with lifetime) was 190.91 (Table 1). Based on the results, the average generation time (T), or in other words, the time required for R0 to equalize the population, was reported to be 38.35 days.

Table 2: Comparison of Parameters of Ladybird *Oenopia conglobata* with *Brevicoryne brassicae*

Population parameters	Mean ± standard error
Intrinsic rate of population increase r_m	0.136± 0.007
Finite rate of population increase λ	1.14± 0.008
Gross reproduction rate GRR	471.49± 87.46
Net reproduction rate R_0	190.91± 45.72
The average duration of a generation T	38.35± 0.98

Discussion

The population parameters were calculated based on data of the entire cohort, i.e., both sexes and the variable developmental rates among individuals [24]. Calculated parameter and standard errors of the intrinsic rate of increase (r_m), net reproductive rate (R_0), mean generation time (T), and the finite rate of increase (λ) obtained by using the age-specific model and age-stage specific model are shown in Table 2.

In the review [25], two sexes are the age-stage *O. conglobata* table were nymphs of aphid of pomegranate green at 27.5 °C, indicating that the duration of each generation (T) was 30.5 ± 0.75 days and the net reproduction rate (R_0) was 251.65 eggs per insect. The intrinsic rate of increase (r_m) and the Finite rate of population increase (λ) and gross reproduction rate (GRR) were 0.18, 1.19 and 392.67 respectively, which does not match the results of the present study, *Brevicoryne brassicae* of cabbage, due to differences in type the host. In research [26], there is life table of *O. conglobata* on psyllid of pistachios showed at 27.5 °C that the net reproduction rate and the intrinsic rate of increase were 186.46 and 0.19, which at the above mentioned temperature, the intrinsic rate of increase this ladybird on psyllid was similar to our results, fed by Psyllid and the net rate was similar to that of *Brevicoryne brassicae* of cabbage. In the study on the table of life for *O. conglobata* is Psyllid of Pistachio [27], at 27.5 degrees Celsius, he showed that the net and gross reproduction rates, and the inherent rate of increase in native are 308.74, 202.81 and 0.16. According to the study [28], it was found that the aphid of peach green, aphid of pomegranate green, *B. brassicae* of cabbage and common pistachio psyllid are suitable for bait for this ladybird predator. The difference in the current study compared to other studies can be due to the difference in temperature, the method of data analysis, the accuracy of the test, and the host. Also, on comparing the parameters of the table of life, the present study with similar research, although it seems that comparing the parameters derived from the traditional and two sexes of the living table is not correct [29]. So far, various studies have been done. To determine the growth rate of ladybird *O. conglobata* on host other, or other predators with similar experimental conditions, or different from this research. Comparison of these studies with the present study helps to find the host and conditions to increase the efficiency of this ladybird. Our results of this study showed that ladybird *O. conglobata* is in a favorable position in terms of the ability and speed of population increase, and *O. conglobata* is considered as a natural enemy for *B. brassicae* and it could be used in an IPM program accompany of other psyllophagous agents.

Conclusion

O. conglobata contaminata could be valuable as a biocontrol agent for *Brevicoryne brassicae*. On the other hand, the two-sex life table provides the actual control efficiency of the entire population, i.e., both sexes are included. We can estimate the optimal conditions for their cultivation, with more accuracy and with better predictive power, which can be a topic for future studies.

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