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Age-Stage, Two-Sex Life Tables of the 24 Spot Ladybird [(*Subcoccinella vigintiquatuorpunctata* (Coleoptera: Coccinellidae)]

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HIGHLIGHTS

- *Subcoccinella vigintiquatuorpunctata* is one of the main pest on alfalfa.
- Age-specific life table and survival rate for each life stage was calculated by using TWOSEX-MSChart.
- This study suggest the life table can be used for the biology and control of the alfalfa pest.

Abstract: The life cycle of *Subcoccinella vigintiquatuorpunctata* (L.) (Coleoptera: Coccinellidae), which is an important pest of alfalfa (*Medicago sativa* Linnaeus (Fabales: Fabaceae) has been studied in laboratory conditions with a constant temperature of 25±1 ºC, relative humidity of 65±2% and light period of 16:8 hours. TWOSEX-MSChart was used to determine the parameters of the life table. The development stages of the egg to adult were recorded separately according to sex (female/male). The development duration of female and male individuals was found to be respectively, egg, 6.61±0.18, 5.45±0.19 days; first instar larvae, 4.58±0.16, 4.21±0.20 days; second instar larvae, 3.61±0.14, 3.21±0.17 days; third instar larvae, 2.81±0.14, 2.48±0.14 days; fourth instar larvae, 6.32±0.17, 6.03±0.17 days; pupae stage, 5.84±0.14, 5.34±0.11 days; total development time, 29.77±0.44, 26.72±0.41 days. In addition, the adult preoviposition (Apop) of the pest was 310.95±0.19 days; total preoviposition (Tpop) 340.33±0.59 days, the average number of eggs laid was 343.23±43.3; oviposition period was 29.71±0.7 days; the number of eggs laid per day was determined as 12.31±0.37. Adult longevity was found 265.68±29.5 and 292.69±28.2 days in female and male individuals, respectively. Among the population parameters, the intrinsic rate of increase (*r*) was 1.39 d^{-1}. Net reproductive rate (*Ro*), 143.783 progeny/individual, the mean generation time (*T*) 355.547 days; Total reproductive rate (*GRR*) 249.764 females/females; finite rate of increase (λ) was calculated as 1.01 d^{-1}. It shows that the data from the life table created with the results obtained can be used for the biology and control of the pest.

Keywords: *Subcoccinella vigintiquatuorpunctata;* population parameters; alfalfa.

INTRODUCTION

Alfalfa (*Medicago sativa* Linnaeus) (Fabales: Fabaceae), which belongs to the legume family, is a perennial plant and is the most frequently farmed forage crop in our country with 6,628,887 da [1]. Alfalfa is high in feed value and protein, making it palatable and healthy for all types of livestock. It is reported that

alfalfa, which is very rich in vitamins, contains at least 10 vitamins [2]. Alfalfa is usually grown for hay production, grazing, or silage forage. It also creates good mixtures with gramineae forage crops.

Subcoccinella vigintiquatuorpunctata belongs to the subfamily Epilachninae. Beneficial insects are commonly found in this subfamily. The pest is a prevalent species around the world, such as in Europe, North Africa, Russia, Siberia, and Asia, according to reports [3].

Adults of *Subcoccinella vigintiquatuorpunctata* are hemispherical, 3-4 mm long, yellowish-red to brown-red in color, and normally have 24 black spots ladybird. It has been determined as a pest on over 70 host plants, including alfalfa [4]. It was detected for the first time in Turkey by Bodenheimer (1958), and he named the pest 24 black spots ladybird and stated that it caused significant crop losses, especially in legumes, and its biology was unknown [5]. The 24-spot ladybird's adults and larvae consume the host plants leaves, and feed on the lower epidermis layer of leaves and parenchyma, while the top epidermis layer retains in a membrane-like state. The leaves become lace-like as a result of the eating, and when the damage is severe, it might cover the entire leaf.

There is very little information available regarding pest biology and biological and ecological data accessible across the world, with life tables being one of the most comprehensive. The significance of life tables has been studied previously [6,7], and life table studies have been carried out against some pest species in agricultural fauna [8,9,10,11,12].

Some research on the biology of the pest has been conducted [4], but this is the first time that the *S. vigintiquatuorpunctata* life table study has been included in a study.

These characteristics were measured on alfalfa and evaluated using a two-sex age-stage life table. It is thought that the data obtained can be used for the biology and control of the pest and can be applied to integrated pest management studies. Insects are exposed to several external factors such as temperature, precipitation, humidity, etc. in the environment. Growth, survival, reproduction, and intrinsic rate are all parameters that are studied in life table studies to better understand and assess the effects of these factors on insect populations [13]. To incorporate pests into integrated pest control strategies, is first required to have a thorough understanding of population dynamics. Adult females emerge at different ages due to individual variances in development rates. Using "adult age" in this situation will result in significant errors in life-table analysis and pest management practices based on life tables. To eliminate these errors, Chi and Liu (1985) developed an age and period-specific two-sex life table dealing with period differentiation by including both sexes in the calculations [14]. The survival and fecundity curves also accurately represent changes in the pre-adult development period. Chi and Yang (2003) developed the Twosex-MSChart program to analyze life table data effectively and easily [15].

A life table against *S. vigintiquatuorpunctat*a, a major pest in alfalfa fields, was developed for the first time in this study. It is thought that the information obtained will form the basis for the pest control program and future studies.

MATERIAL AND METHODS

Subcoccinella vigintiquatuorpunctata Production

The 24-spot ladybird was cultured under laboratory conditions. Adults were transferred to plastic cages (20*10*7 cm in size) covered with a screen-lid. Fresh alfalfa plants were provided to feed the pest, and when the plants started to dry, they were replaced with new ones. The alfalfa shoots were immersed in thin-mouth beakers containing water, and the mouth of the beaker was closed with sterile cotton to prevent the adults from falling. The 24-spot ladybird culture was maintained in the laboratory at 25 ± 1^{o}C, 65 ± 2% RH, and a photoperiod of 16:8 (L:D) h. In 2019-2020, the studies were conducted in the Ankara Plant Protection Central Research Institute's laboratory.

Host plant

The alfalfa plant was obtained from the application plots of the Ankara Plant Protection Central Research Institute. The 24-spot ladybird was collected from the alfalfa fields of Yassıören Village, Devrek district of Zonguldak province.

Development and Survival of Preadult Stages

Young adults collected from the field were transferred to the laboratory and put into plastic breeding cages. During the daily controls, the eggs laid in laboratory conditions were taken and transferred to another cage with a fresh alfalfa plant.

To determine the egg duration, each egg was controlled at every 2-hour intervals during the day. When the first instar larvae hatched from egg, the larvae were transferred to another rearing cage one by one. The first instar larvae were controlled, and the larvae that passed to the next instar were recorded and transferred to another rearing cage. All larval developmental stages were followed, and those that passed into the pupal stage were recorded. The emergence of an adult, which passed the pupa stage on the leaf, was determined.

The period from egg to adult under laboratory conditions was calculated by following the plant on which it was found.

Estivation and overwintering periods, Adult Longevity, Fecundity, and Oviposition

Day-old adults newly emerging from the pupa were taken into cages (30 cm in diameter x 10 cm in length) with fresh alfalfa plants. These pots are covered with plastic jars, so that the adults do not escape. Ventilation holes (the size of 10 * 10 cm) were opened on both sides of the plastic jars and these holes were covered with a screen-lid which the adults could not escape. The adults newly emerging from the pupa were checked daily and the date the adults migrated to the soil was recorded. During the controls, the adults were taken from the laboratory as soon as they were in the ground and transferred to the natural environment for overwintering. Thus, it was ensured that the adults naturally estivated and overwintered in cages with alfalfa plants, respectively. In the following spring, the cages were checked daily, and when the adult feeding on the plant was seen, the cages were taken from the outside conditions and transferred to the laboratory conditions. All of the adults spending the winter in their natural environment were recorded and taken into cages containing fresh alfalfa plants. When necessary, new plants were added to the adults fed with alfalfa plants in pots. When mating individuals were seen in the observations, the male individuals were taken and the elytra were marked, and they are separated from the females. After the pairs of female and male individuals were determined in the observations made at 2-hour intervals daily, they were taken into separate breeding cages in pairs. The same rearing cage was used to keep each pair until the experiment ended. The number of eggs deposited by the females was tallied every day, and the eggs were taken from the cage after being counted. Experiments in all cages were continued until the adults died. The studies were conducted in climatic rooms at a temperature of 25°C, relative humidity of 65±2%, and a photoperiod of 16:8 (L:D) h. Except for the pest's estivation and overwintering phases, all studies were conducted in a laboratory setting.

Life table analysis

According to the age-stage, two-sex life table hypothesis, the age-stage specific survival rate (s_{xj}, where x=age in d and j=stage), age-stage specific fecundity (f_{xj}), age-specific survival rate (l_x), and age-specific fecundity (m_x) were determined [14,16]. The following formulas were used to calculate the l_x and m_x:

Age-specific survival rate $l_x = \sum_{j=1}^{k} S_{xj}$

Fecundity $m_x = \dfrac{\sum_{j=1}^{k} s_{xj} f_{xj}}{\sum_{j=1}^{k} s_{xj}}$

The net reproductive rate $\sum_{x=0}^{\infty} l_x m_x = R_0$

With the age indexed from 0, the intrinsic rate of increase was determined using the iterative bisection approach from the Euler-Lotka formula (Goodman 1982).

The intrinsic rate of increase, $\sum_{x=0}^{\infty} e^{-r(x+1)} l_x m_x = 1$

The finite rate of increase (λ) was calculated as $\lambda = e^r$ The mean generation time was estimated as the time it takes for a population to grow to R_0-fold of its original size at a stable age-stage distribution.

The mean generation time, $T = \dfrac{I_n R_o}{r}$

According to Chi and Su (2006), the life expectancy (e_{xj}) was estimated as follows: [13]

The life expectancy, $e_{xj} = \sum_{i=x}^{\infty}\sum_{y=j}^{\beta} S_{iy}'$

According to Tuan and coauthors (2014), the reproductive value (v_{xj}) was determined as follows: [17]

The reproductive value, $v_{xj} = \frac{e^{r(x+1)}}{s_{xj}} \sum_{i=x}^{\infty} e^{-r(i+1)} \sum_{y=j}^{\beta} S_{iy}' f_{iy}$

The variances and standard errors (SE) of the stage development time, reproductive parameters, and population parameters were estimated by the bootstrap resampling method with 100,000 resamplings (B = 100,000) [18,19,20]. The differences in development time and reproductive parameters between females and males were evaluated by using the paired bootstrap test based on the bootstrap percentile confidence interval of difference [21,22]. The TWOSEX-MSChart computer program was used for the bootstrap method and paired bootstrap test [23].

RESULTS and DISCUSSION

The survival rate, development, and longevity

The development periods, longevity, and survival rates of the *Subcoccinella vigintiquatuorpunctata* were given in Table 1. The pre-adult development period was 28.03±0.36 days. The pre-adult development period was determined as 29.77±0.44a days in females and 26.72±0.41b days in males respectively, with the statistical difference being significant in terms of development time. Survival rates varied between 92.65% and 100.00% according to the developmental periods. It was determined that all the eggs had hatched. While the survival rates in the 1st instar larva and pupal stages were 100.00%, the survival rates in the 2nd instar larvae 98.65%, 3rd instar larvae 93.15%, and 4th instar larvae 92.65% decreased, respectively (Table 1).

Table 1. Developmental time (day) and survival of immature stages (%) of *Subcoccinella vigintiquatuorpunctata*.

Stages	All adults ($\bar{x}$ ± SE)	n	Female ($\bar{x}$ ± SE)	n	Male ($\bar{x}$ ± SE)	n	P	df	T	The survival rate (%)
Egg	6.03±0.13	74	6.61 ±0.18a	31	5.45±0.19b	29	0.06	58	1.920	100.00
1st larvae	4.38±0.11	73	4.58±0.16a	31	4.21±0.20a	29	0.15	58	1.468	98.65
2nd larvae	3.49±0.11	68	3.61±0.14a	31	3.21±0.17a	29	0.06	58	1.890	93.15
3rdlarvae	2.67±0.10	63	2.81±0.14a	31	2.48±0.14a	29	0.11	58	1.635	92.65
4th larvae	6.18±0.12	60	6.32±0.17a	31	6.03±0.17a	29	0.23	58	1.204	95.24
Pupae	5.60±0.10	60	5.84±0.14a	31	5.34±0.11b	29	0.10	58	1.690	100.00
Total preadult development time	28.03±0.36	60	29.77±0.44a	31	26.72±0.41b	29	0.11	58	1.635	

Note: n, effective replicate number; $\bar{x}$, mean value; SE, standard error; P, statistical significance; df, degree of freedom. Standard errors were estimated by using 100,000 bootstrap resampling. Means in a row followed by different letters were significantly different according to the paired bootstrap test with 100,000 resamplings ($P < 0.05$).

It was discovered that there was a considerable variation in terms of development periods between males and females of *S. vigintiquatuorpunctata* during the egg and pupa stages (Table 1). It was determined that 18.92% could not reach the adult stage. It was determined that there was no difference in the larval development periods of the pest, which started to feed on fresh alfalfa leaves from the first larval stage. In the first larval stage, the development period of the pest fed with fresh alfalfa plants gradually shortened until the 4th larval stage. The longest development period among the larval stages was observed in the fourth larval stage (6.18±0.12). After the egg development period, the pupal period was determined as the longest

period of all development periods. It was determined that the difference between the male and female development periods of the pest, which spent the pupal development period on the leaf, was significant. The pest spends all its periods on the plant, except for summer and winter. When the data was analyzed, it was discovered that the difference in development durations between male and female individuals was not significant between all larval development phases of the pest except the egg and pupa stages.

The male pre-adult development stage was discovered to be around three days earlier than the female developmental stage. The short-term pre-adult development period of the pest, which was subjected to optimal conditions in the laboratory (25 ^{o}C and 65% RH), lasted 29.77 and 26.72 days in females and males, respectively. Kovancı (1983) stated that the total duration of pre-adult development was 29.8 days at 22.5 °C [24]. Segura and coauthors (2017) determined that *Epilachna difficilis* (Mulsant, 1850) (Coleoptera: Coccinellidae: Epilachninae) had 5 larval stages and the pre-adult development period in the laboratory (16.9-25.8 °C) was 37.8+-1.7 days [25]. Nakano and Katakura (1999) stated that the 14-spotted ladybird, *Epilachna pusillanima* (Mulsant, 1850) (Coleoptera: Coccinellidae: Epilachninae) completed its pre-adult development period at 22.5 °C in 35 days [26]. Furthermore, the pre-adult development period of *Gonioctena fornicata* (Brüggeman), which is an important pest in alfalfa fields and gives one offspring such as *S. vigintiquatuorpunctata* per year, was 24.40 and 24.32 (25±1°C, 65±2%) days in female and male individuals, respectively [27,28].

Use the female age-specific life table to construct the m_x depending on adult age. It has been determined that *S. vigintiquatuorpunctata*, which has reached the adult stage, first migrated to the soil for aestivation and then overwintered after feeding for 4-10 days. During the preoviposition period of the *S. vigintiquatuorpunctata*, the mortality rate detected in both genders (female/male) in individuals who overwintered in the natural environment was 28.33%. Hibernation is insecure, and overwintering adults may have a high rate of death. Pre-adult instars have a lifespan of around 6 weeks in the laboratory. Adults begin to emerge around the end of June. At the end of July, many undergo reproductive diapause [4].

It was determined that *S. vigintiquatuorpunctata* first emerged in estivation and then the overwintering adults emerged in an average of 306 days. Overwintering adults were first fed with fresh alfalfa before mating. The female-male individual ratio was 0.516 (F/F+M). Overwintered adults are likely to die at a certain rate. According to Williams and coauthors (2015), overwintering insects must contend with a variety of stressful environmental conditions, such as a lack of food resources, cold temperatures, and water shortages, and, unsurprisingly, many insect species experience significant mortality during the winter months [29]. The mortality rate in adults who spent the winter under the ground was 28.33%. The pest, which stays a long period under the soil (estivation + overwintering) after feeding for a short time, lays its first eggs in 310.95 days (Apop). Table 2 displays values for developmental time, male and female lifespan, adult pre-oviposition (Apop), total pre-oviposition (Tpop), female fecundity, and female oviposition days for each stage. Lewontin (1965) defined this period as the emergence of the curve (the age was counted from birth) [30]. In entomology, the "adult preoviposition period" (Apop) is generally defined as the emergence of adults and the time they lay their first eggs [31]. Adult pre-oviposition (Apop) was 310.95 days (Table 2).

Table 2. Duration of the development of *Subcoccinella vigintiquatuorpunctata* male and females

Reproductive parameters		n	Day ($\bar{x}$ ± SE)	P	df	T
Apop (days)		21	310.95±0.19			
Tpop (days)		21	340.33±0.59			
Fecundity (eggs/female)		21	343.23±43.3			
Oviposition days		21	29.71±0.7			
Total Longevity	Female	21	265.68±29.5a	0.92	41	0.11
	Male	22	292.69±28.2a			

Note: n, effective replicate number; $\bar{x}$, mean value; SE, standard error; P, statistical significance; df, degree of freedom. Standard errors were estimated by using 100,000 bootstrap resamplings.

The total preoviposition period (Tpop) is the actual time between birth and the first reproduction. In our study, the total preoviposition period was found to be 340.33±0.59 days. The mean fecundity of females was 343.23 eggs, the average duration of oviposition was 29 days, and the average number of eggs laid by females during oviposition per day was 12.31 days. At age 355, the maximum of female age-specific mean fecundity [$f(_{xj})$] = 24.42. The maximum life-long fecundity is 574 days.

The life table of *S. vigintiquatuorpunctata* development, reproduction, and survival were given in tables 1-2 and Figures 1-4. On the alfalfa plant, the age-stage specific survival rate (s_{xj}) of *S. vigintiquatuorpunctata* reflects the likelihood that a newborn will survive to age *x* and mature to stage *j* (Figure 1).

In the lab, the pest's survival rate was impacted by age, and life expectancy declined steadily in the larval stages based on age. Moreover, the survival rate curves differ according to the pre-adult and adult stages of *S. vigintiquatuorpunctata*. In the pre-adult experiments carried out in the laboratory at 25 °C temperature and 65% humidity conditions, the survival rate (s_{xj}) was 0.810, and this rate was found to be 0.4189 in females and 0.3919 in males.

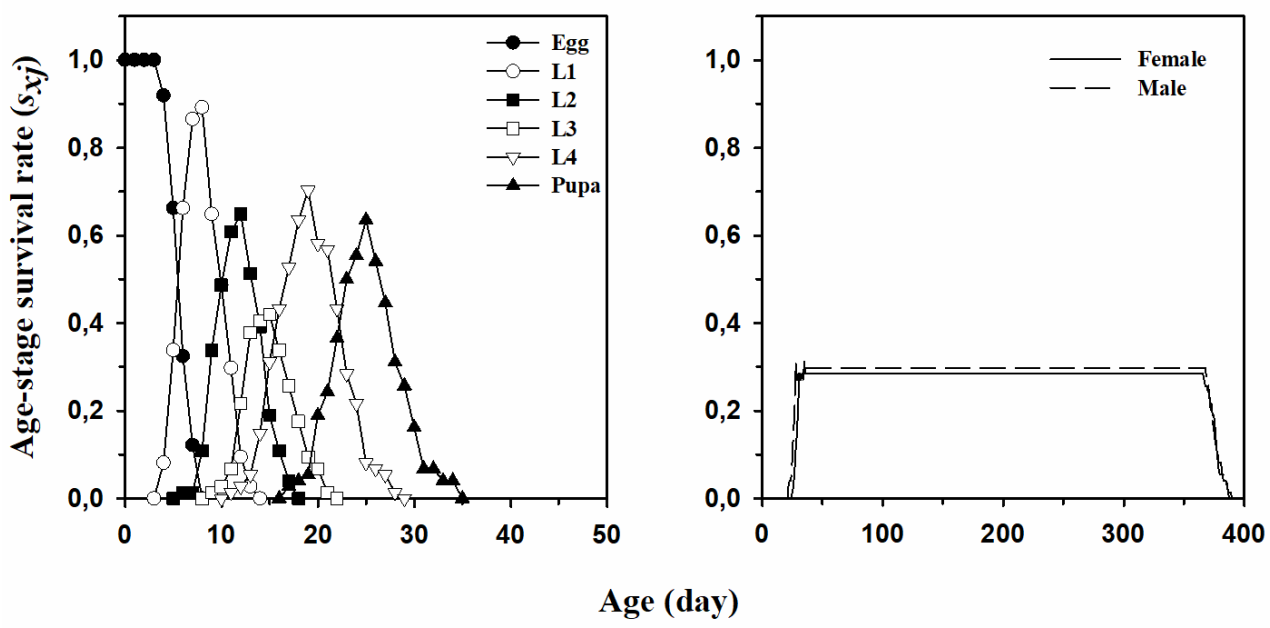

Figure 1. Age-stage survival rate (s_{xj}) of *Subcoccinella vigintiquatuorpunctata*

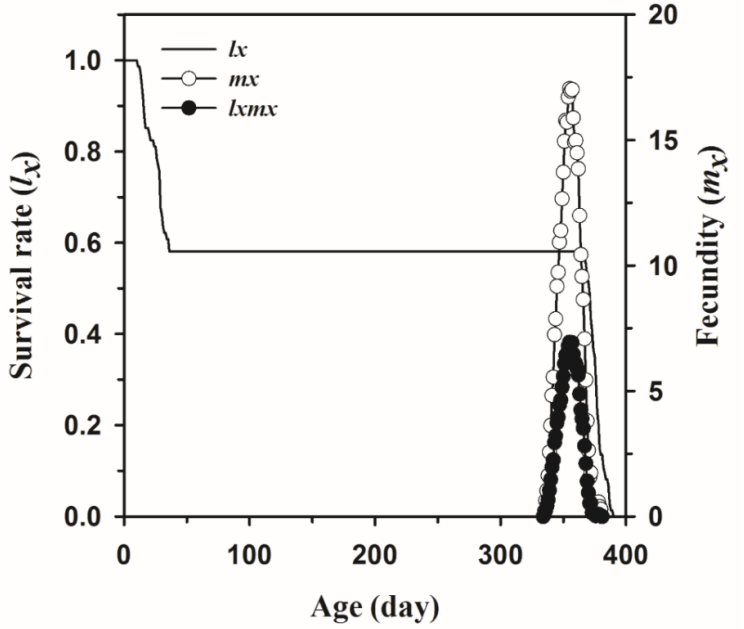

Figure 2. Age-stage survival rate (s_{xj}) of *Subcoccinella vigintiquatuorpunctata.*

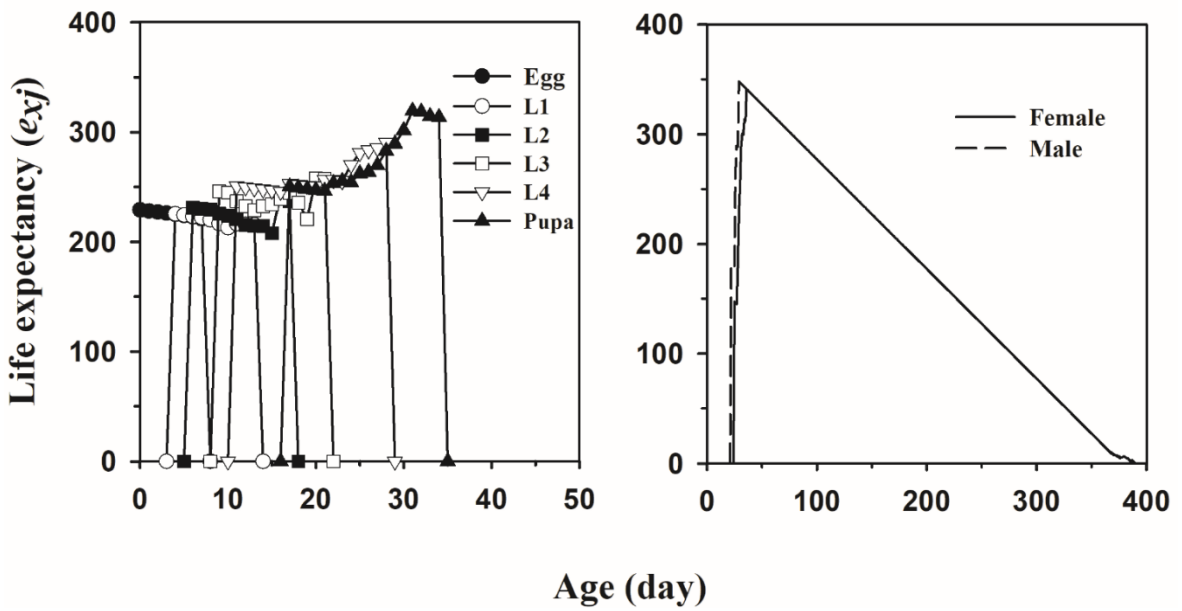

Figure 3. Life expectancy (e_{xj}) of *Subcoccinella vigintiquatuorpunctata*

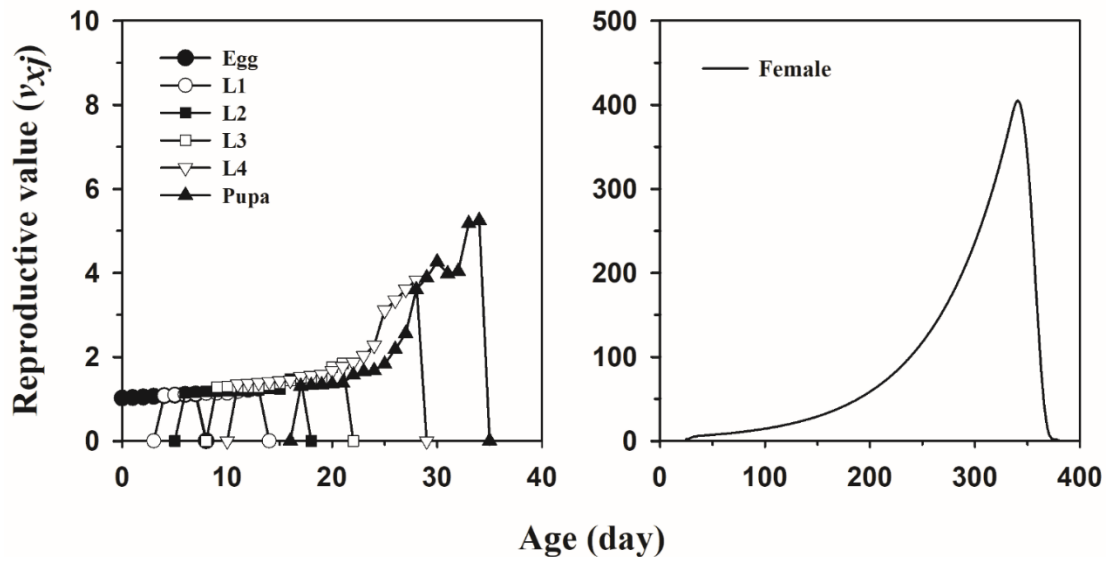

Figure 4. Repreductive value (v_{xj}) of *Subcoccinella vigintiquatuorpunctata*

Figure 2 shows the age-stage, two-sex life table parameters for development (Table 3), as well as the age-specific survival rate (l_x), age-specific fecundity (m_x), and net maternity rate ($l_x m_x$) of *S. vigintiquatuorpunctata*. On the 343.23rd day, females began to lay their first eggs. Then, it showed a sharp increase during the following week and the maximum female age-specific mean fecundity [$f(_{xj})$] = 24.42 at age 355.77 days obtained on the 12th day. Most studies solely look at female populations when evaluating life table characteristics, ignoring male populations and stage differences within and between sexes [32,33,34,35,36]. Solutions to these problems have been proposed by incorporating males into the age stage two sex program developed by Chi (1988), Chi and Su (2006), and Huang and Chi (2012b). The highest daily and lifetime fecundity were found to be 32 and 574 eggs, respectively. Afterward, the number of eggs per day gradually decreased and ended on the 389th day. Kovancı (1983) stated that the number of eggs of the female *S. vigintiquatuorpunctata* was 545 on average in cages in outdoor conditions [24].

The age-stage life expectancy (e_{xj}) is a method of calculating how long an individual of age *x* and stage *j* is predicted to survive in a different stage. The life expectancy (e_{xj}) of *S.vigintiquatuorpunctata* was calculated for both individuals (female/male) in Figure 3. The life expectancy (e_{xj}) continued approximately along the same line in both individuals (Figure 4). The longevity of the maximal life expectancy [Max(e_{xj})] was determined as 347.95 at age 29 d. The life expectancy (e_{xj})of newborns, was determined as 229,09. The difference is believed that arise from experiments conducted in laboratory conditions. In addition, life expectancy (e_{xj}) and the age-specific reproductive value (v_{xj}) of *S. vigintiquatuorpunctata* were calculated (Figure 3-4). The life expectancies (e_{xj}) are defined as the predicted lifespan of an individual at age *x* and stage *j* [37]. In this study, life expectancy in female and male individuals increased at a certain rate at the

beginning, then decreased in the same horizontal line depending on age. A life table of *G. fornicata*, which was stated to be an important pest in alfalfa, was created, and it was stated that both parameters for life expectancy (e_{xj}) and stable age distribution (C_x) proceeded approximately in the same horizontal line in both females and males [28]. It was similar to the results obtained in this study. Furthermore, the reproductive values (v_{xj}) are equal to the finite rate, and the age-specific reproductive value (v_{xj}) indicates the contribution of individuals from age x to the future population. From age x through stage j, the age-stage reproductive value (v_{xj}) reflects an individual's contribution to the future population, with reproductive values (v_{xj}) equaling the finite rate. It has been determined that the reproductive value (v_{xj}) of females started to increase from the moment they start to reproduce. It was determined that this curve increased sharply from the 260th day, especially after the 320th day. It peaked at (v_{xj}) (350) around age 341 days, when most females started laying eggs, which is close to the Tpop mean (340.33 d). It was determined that the curve decreased steeply after reaching the peak level (Figure 2-3).

Table 3 shows the population metrics of *S. vigintiquatuorpunctata*, including the intrinsic rate of rise (r), net reproductive rate (R_0), mean generation time (T), gross reproduction rate (*GRR*), and finite rate of increase (λ). The intrinsic rate of increase (r) 1.397 d^{-1}, net reproductive rates (R_0) 143.783 (offspring/individual), mean generation times (T) 355.547 d, gross reproduction rate (*GRR*) 249.764 (offspring/individual), and finite rate of increase (λ) 1.014 d^{-1} was recorded for *S. vigintiquatuorpunctata* (Table 3).

Table 3. The life table population parameters of *Subcoccinella vigintiquatuorpunctata*

Parameters	Mean±SE
r (d^{-1})	1.397±0.00
R_o (Offspring/individual)	143.7±26.74
T (d)	355.5±0.619
GRR	249.764±39.53
λ (d^{-1})	1.014±0.00
n	21

The characteristics of a life table can be used to assess development, survival, and reproduction. It has been stated that the R_0 value is important in examining insect populations [38]. According to the life table theory, the population increases when $R_0 > 1$ and $r > 0$ [39]. In this study, it was determined that $R_0 > 1$ and $r > 0$. The mean and variance values were calculated using the bootstrap technique. *S. vigintiquatuorpunctata* R_0 value was determined as 143.783. The intrinsic rate of increase (r), which is among other population parameters, is a critical demographic indicator to determine the environmental resistance levels of insects [40]. In our study, it was found to be 1.397.

CONCLUSION

S. vigintiquatuorpunctata was first detected in Turkey in 1958. It has been reported that the pest, which spends the winter as an adult, appears in April and lays eggs on the leaves of the host plants in groups by May, with the developing larvae feeding on the leaves. Because the pest's biology is unknown, it has been determined that it can generate one or more offspring every year [5]. It has been determined that the pest started to appear in April and early May, lays its eggs in groups of 1-25, has four larval stages, new generation adults were seen in June-July, and give one offspring per year in Ankara [24]. *S. vigintiquattuorpunctata* was determined to be a phytophagous pest, harmful to various cultivated and wild plants in Britain, and the time to adulthood in the laboratory was approximately 6 weeks [4]. It has been reported that the pest was important and widespread in previous studies [4,5,24]. In this study, the population dynamics of *S. vigintiquatuorpunctata* on the alfalfa plant were established for the first time by using life table parameters.

However, when the studies were examined, no study was found on life tables, and with this study, the life table parameters of *S. vigintiquatuorpunctata* were revealed for the first time. When a pest feeds on the leaves, it typically creates lace-like spots, and as these areas grow, it covers the leaf area and causes yield losses. It has been observed that it feeds on the upper part of the alfalfa and causes damage as a result of feeding on leaves and flowers. It is thought that the pest is a potential pest in alfalfa fields and may cause economic losses. Although the pest gives only one generation a year, it is thought that the potential for damage will increase in case of an epidemic, considering that both larvae and adults feed on alfalfa leaves and there is no natural enemy to suppress the pest in our country. It can be controlled by monitoring the population of the pest by early or frequent mowing. Life tables are a method for understanding ecology and pest management. In this study, the life table of the pest was discussed for the first time.

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Conflicts of Interest: “The author declares no conflict of interest.”

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