J. Entomol. Res. Soc., 24(2): 233-244, 2022 *Research Article*
Doi: 10.51963/jers.v24i2.2123 *Online ISSN:2651-3579*

Some Biological Characteristics and Life Table of *Heliothis peltigera* (Denis & Schiffermüller, 1775) (Lepidoptera: Noctuidae) on Safflower

Sevgi AYTEN[1]* Selma ÜLGENTÜRK[2]

[1]Ministry of Agriculture and Forestry, Directorate of Plant Protection Central Research Institute, 06172 Ankara, TURKEY
[2]Department of Plant Protection, Faculty of Agriculture, Ankara University, 06100 Ankara, TURKEY
e-mails: [1]*loveblacklion.sa@gmail.com, [2]ulgentur@agri.ankara.edu.tr
ORCID IDs: [1]0000-0003-1735-4764, [2]0000-0003-2521-8471

ABSTRACT

Biology and life table of *Heliothis peltigera* (Denis & Schiffermüller, 1775) (Lepidoptera: Noctuidae), an important safflower pest, studied on two safflower varieties (Balcı and Dinçer) in the laboratory (25 ± 1 °C temperature, 65 ± 5% relative humidity and 16: 8 photoperiod). The longer pre-adult time of *H. peltigera* was found on Dinçer variety than Balcı variety, as 33.97±0.16 days, and 32.82±0.23 days, respectively. While the higher intrinsic rate of increase (*r*) (0.134±4.59 d^{-1}), and the finite rate of increase (*λ*) (1.144±0.005 d^{-1}) were estimated on Balcı variety, also shortest mean generation times were found on Balcı variety (37.49±0.34 days) than Dinçer variety (0.119±5.123 d^{-1}, 1.126±0.005 d^{-1}, and 39.25±0.40 days, respectively). According to these results, it was determined that Balcı variety was more suitable host plants than Dinçer variety for *H. peltigera*. These basic informations obtained in this study on *H. peltigera* will be useful for pest control and prefer to produce Dinçer variety that could be reducing of *H. peltigera*.

Key words: Bordered straw, biology, biological parameters, *Heliothinae*, pest management

Ayten, S. & Ülgentürk, S. (2022). Some biological characteristics and life table of *Heliothis peltigera* (Denis & Schiffermüller, 1775) (Lepidoptera: Noctuidae) on safflower. *Journal of the Entomological Research Society*, 24(2), 233-244.
Received: August 24, 2021 *Accepted: March 05, 2022*

INTRODUCTION

The Bordered Straw (BS)*, Heliothis peltigera* Denis & Schiffermüller (Lepidoptera: Noctuidae) which is mainly distributed in the Paleosubtropic- Paleotropical regions (Matov, Zahiri, & Holloway, 2008), it is a well known migratory species in the Mediterranean Basin and Near and Middle East (Matov et al, 2008). It spread to new countries such as Canada and New Zealand with the effect of global warming and recently became a potentially important pest in Europe (Ragionieri et al, 2017). *Heliothis peltigera,* which is a polyphagous species is a pest of economically important plants such as tomato, cotton, corn, soybean, sunflower, bean and especially safflower besides some weeds and aromatic plants (Manjunath, Patel, & Yaoav, 1976). It has 3 generations a year in safflower fields in Iran and spends the winter under the soil as a pupa. Their larvae are fed in safflower leaves and capsules (Parvin, 1990).

Heliothis peltigera has been recorded on vegetable, corn and ornamental plants in warm regions where the Mediterranean climate in Turkey, in Adapazarı and Istanbul (Keyder, 1961); on cotton in the Aegean Region (İyriboz, 1971), on cotton, chickpeas and corn in Adana, Antalya, Hatay and İçel (Kornoşor & Düzgüneş, 1980), and on culture thyme in Turgutlu and Salihli (Tezcan, Okyar, & Beyaz, 2004). This pest was first reported by Damkacı (2013) on safflower in the Central Anatolia (Konya) region with a continental climate, and then from Niğde (Hüseyinoğlu & Atay, 2017). Eroğlu et al, (2019) collected 357 larvae *of H. peltigera* feeding on safflower in Adana to investigate the contents of NPV (Nucleopolyhedrovirus) and obtained a new isolate. *H. peltigera* has pests in the safflower fields in Ankara and has become a problem of safflower growers since 2014. The prevalence and incidence of *H. peltigera* in Ankara safflower areas were 96%, 2.5%, and 98.7%, 79.80% in 2018-2019, respectively (Ayten & Ülgentürk, 2020).

Studies on *H. peltigera* in Turkey and the world are determining its prevalence, host plants and natural enemies in a region. There is scarcely information about the biology of this species. The results presented by Ayten & Ülgentürk (2020) show that this species has a high spreading and significant pest potential. Having sufficient information about the population size, age distribution, growth rate, reproduction and survival rate of a pest is critical in control. Without this information, it is impossible to estimate the growth rate and damage of a pest population, the time and method of control and the number of these practices (Atlıhan, Özgökçe, & Hsin, 2018). Life tables are a fundamental tool used to study insect populations, resulting in crucial information for integrated pest management programs. For this reason, knowing the bio-ecology and life table of the pest is necessary to make an effective control against *H. peltigera*. In this study, the biological characteristics of *H. peltigera*, which is polyphagous and can be an important pest, are determined in laboratory conditions and a life table was created with the data obtained.

MATERIAL AND METHODS

Cultivation of safflower and *Heliothis peltigera*

Two varieties (Balcı and Dinçer) of safflower (*Carthamus tinctorius* L., Asteraceae), which are the hosts of *H. peltigera* (BS) and which are mostly grown by the producers, were obtained from Eskişehir Transitional Zone Agricultural Research Institute. While Balcı is a prickly variety and has an oil content of 31%, Dinçer, a prickless variety, has an oil content of 28.12% (Arslan & Çulhan, 2020). Safflower plants needed for feeding *H. peltigera* larvae were grown in Ankara Plant Protection Central Research Institute's garden. The stock culture was established from individuals obtained from eggs laid by *H. peltigera* adults collected from Ankara safflower fields.

Determination of the biology of *Heliothis peltigera* and creating a life table

The studies were conducted with leaves of safflower varieties, Balcı and Dinçer, at 25 ± 1 °C temperature, 65 ± 5% RH and 16: 8 (Light:Dark) photoperiods. Biology studies were started with 142 individuals (eggs) on Balcı and 146 individuals (eggs) on Dinçer when *H. peltigera* adults lay eggs. One egg was transferred to 9 cm diameter plastic Petri dishes containing blotter paper and fresh safflower leaves (separately for each variety of safflower). These Petri dishes were monitored daily, the eggs and larval stages were determined. The end of larval stages, they were transferred to plastic containers with sterilized soil at a height of 10-15 cm to follow the pupal stage and checked daily. Then, one adult female and one male were taken to a container that its top was covered with cheesecloth. Cotton soaked in 10% honey + 10% sugar water solution was placed in a container to feed to adults (Shorey & Hale, 1965). With the daily monitoring of adult individuals that its larvae feeding in two safflower varieties, the duration of life, pre-oviposition, oviposition and post-oviposition periods and fecundity of female individuals were determined. Observations were continued daily until the last individual died.

The pupal and adult sex ratio was determined by examining the genital segments of the pupae and adults grown in the laboratory using Leica M binocular microscope.

The raw life table data of *H. peltigera* reared on two safflower varieties were analyzed according to Chi & Liu (1985) and Chi (1988) using the computer program TWOSEX-MSChart (Chi, 2018; Wei et al, 2020). The variances and standard errors of population parameters were evaluated using the bootstrap technique (HesHesterberg, Moore, Monaghan, Clipson, & Epstein, 2005; Özgökçe, Chi, Atlıhan, & Kara, 2018) with 100,000 resampling to obtain stable estimates.

The mean development time of each stage of *H. peltigera*, adult female pre-oviposition period (*APOP*), total pre-oviposition period (*TPOP*), the total longevity of adults, gross reproductive rate (*GRR*), and mean number of eggs were calculated. The intrinsic rate of increase (r), finite rate of increase (λ), net reproductive rate (R_0) and mean generation time (T_0) were also determined using the computer program, TWOSEX-MS Chart (Chi, 2021). Based on life table data, population size of *H. peltigera*

was estimated using the computer program Timing-MSChart (Chi, 2019a) according to the method reported by Chi and Liu (1985) and Chi (1990). In this method, when a certain number of individuals are taken as the initial population of *H. peltigera,* the size that the population can reach at the end of the period to be determined can be estimated from the total number of individuals specific to age (*x*) and stage (*j)*.

RESULTS AND DISCUSSION

Development time and adult life

The egg development times of *H. peltigera* fed on Balcı (3.19±0.07) and Dinçer (3.23±0.07) safflower varieties were found to be statistically similar (P>0,05). A mean of 439.2 (282-1240) larvae emerged from 72% of the mean 610 eggs obtained on Balcı. A mean of 344 (149-1052) larvae emerged from 65% of the 531 eggs obtained on Dinçer. The difference between the number of larvae obtained depending on the variety was found to be statistically significant (P<0,05).

In our research, it was determined that *H. peltigera* individuals had six larval stages in both safflower varieties as in *H. armigera* (Borah & Dutta, 2002). According to the safflower varieties, a statistical difference was determined between the development periods of the first and third stage larvae (P<0,05, Table 1). For other larvae, prepupa and pupa stages, development times were very close to each other in both varieties (P>0,05). However, the pre-adult time of BS took a mean of 32.82±0.23 days on Balcı and 33.97±0.16 days on Dinçer and the effect of safflower variety on the growth period of *H. peltigera* was found to be significant (P<0,05). In contrast, pre-adult survival rates are very close to each other in both varieties (0.56±0.04 on Balcı and 0.48±0.04) on Dinçer (P>0,05) (Table 1). The fact that the oil content of the Balcı is higher than the Dinçer (Arslan & Çulhan, 2020), have enabled to develop of the larvae better and faster. The difference can be seen in durations of the larvae at different stages of *Heliothis* species feeding on different host plants (Gomes, Santos, & Avila 2017; Rhudong et al, 2019). The durations of *H. armigera*'s first, third, fifth stage larvae and pupa stages were found different from each other according to the plant variety, it was very close in other larval periods (Dhandapani & Balasubramanian, 1980). Similarly, Naseri, Golparvar, Razmjou, & Golizadeh (2014) found that the development period of *H. armigera* fed on different soybean varieties ranged from 31.82±0.42 days to 37.58±0.90 days. Amer & El-Sayed (2014) noted that the pupal period of *H. armigera* fed on different plants at 26 °C and 14:10 photoperiod was not different from each other. The life span of *H. peltigera* adults was determined 10.58±0.31 days on Balcı and 9.98±0.28 days on Dinçer. It is seen that the life span of adults is not different from each other in both safflower varieties (P <0.05) (Table 1). There is no study on the adult life span of *H. peltigera* and effect of its host on the adult life span. In accordance with our study, several researchers (Naseri et al, 2014; Gomes et al, 2017) reported that the adult life of *H. armigera* was affected by different bean varieties.

Table 1. Means and standard errors (Ses) of larval durations, preadult times, and preadult survival rates of *Heliothis peltigera* on two safflower varieties.

Biological stages	Safflower varieties			
	n	Balcı	n	Dinçer
Eggs	131	3.19±0.07a	129	3.23±0.06a
L_1	121	3.24±0.07 b	115	4.17±0.09a
L_2	103	2.87±0.09 a	101	2.81±0.10a
L_3	102	2.60±0.07 a	101	2.32±0.06b
L_4	101	1.98±0.03 a	101	2±0.009 a
L_5	100	1.92±0.03 a	100	1.97±0.02 a
L_6	100	2.05±0.03 a	100	1.97±0.02 a
Prepupa	96	2.07±0.03a	100	2.01±0.01a
Pupa	80	12.82±0.18a	71	13.23±0.16a
Preadult time (d)	80	32.82±0.23 b	71	33.97±0.16a
Preadult survival rate (sa)	142	0.56±4.14 a	146	0.48±4.14 a

* See was estimated using the bootstrap technique with 100.000 resampling. The means followed by different letters in the same row were significantly different according to the paired bootstrap test based on the confidence interval of differences P <0.05.

Sex ratio, oviposition and fecundity

Other data obtained in this study was about the sex ratios on two different host plants of the pest. Pupa sex ratio (♀:♂) of *H. peltigera* was found as 1.17: 1 on Balcı, and 1: 1.19 on Dinçer. In adults, it was determined as 1.05: 1 on Balcı and 1: 1.21 on Dinçer. The findings showed that the share of females on Balcı and males on Dinçer variety in the population was higher. Similar studies with *H. armigera* show that the sex ratio favors males. Kaya & Kovancı (2000) noted that the sex ratio (♀:♂) of *H. armigera* pupae was 1.00: 1.07 and 1.00: 1.08 in adults.

It was determined the APOP, TPOP and oviposition period of *H. peltigera* females feeding with two safflower varieties were 3.24±0.20, 35.91±0.4 and 3.45±0.17 days on Balcı; 4.46±0.36 and 37.96±0.42, 3.36±0.15 days on Dinçer, respectively. The differences in APOP and TPOP of these adult females were found to be statistically significant, while oviposition periods were similar (P<0,05) (Table 2). Jha, Chi, & Tang (2012) reported that the APOP period of *H. armigera* was not affected by different bean varieties however the TPOP period of *H. armigera* was affected feeding with different bean varieties (Naseri et al, 2014) in our study.

The mean number of eggs of *H. peltigera* females were 606.89±48.09 on Balcı and 530.53±42.89 on Dinçer. The differences between the egg numbers of *H. peltigera* feeding in two safflower varieties were not statistically significant (P>0,05). Population doubling time (*DT*) shows that it is 5.13±0.17 days on Balcı, 5.79±0.25 days on Dinçer and the difference between them is significant (P<0.05). According to these results,

the initial population of *H. peltigera* on both varieties can double in a short period of about 5-6 days. Host plants influence the fecundity, survival and longevity of adults of *H. armigera* (Gomes et al, 2017).

Table 2. Means and standards errors (Ses) of the pre-oviposition period (APOP), total pre-oviposition period (TPOP), oviposition days (O_d), post-oviposition, total longevity, adult life span, fecundity (*F*), gross reproductive rate, and population doubling time (*DT*) of *Heliothis peltigera* on two safflower varieties.

Basic statistics	n	Balcı	n	Dinçer
Adult Pre-oviposition Period (APOP)	37	3.24±0.20 b	30	4.46±0.36 a
Total Pre-oviposition Period (TPOP)	37	35.91±0.39 b	30	37.96± 0.42 a
Oviposition days (O_d),	37	3.45±0.17 a	30	3.36±0.15 a
Fecundity (*F*)	37	606.89±48.09a	30	530.53±42.89 a
Adult life span	80	10.58±0.31a	71	9.98±0.28a
Total longevity	142	30.83±1.38a	146	29.87±1.39 a
Survival rate	142	0.97±3.60 a	146	0.97±3.78 a
GRR	142	293.83±41.13a	146	277.72±51.27 a
Population doubling time (*DT*) (day)	142	5.13±0.17 b	146	5.79±0.25 a

*See was estimated using the bootstrap technique with 100.000 resampling. The means followed by different letters in the same row were significantly different according to the paired bootstrap test based on the confidence interval of differences at the % 5 significal level.

Life table parameters

The population parameters R_o, *r*, *λ* and *T*, estimated using the bootstrap technique, were listed Table 3. The effect of host varieties on the net reproductive rate (R_0) of the population of *H. peltigera* was found to be insignificant (P<0,05). The highest intrinsic rate of increase (*r*) and the finite rate of increase (*λ*) of *H. peltigera* was calculated as 0.134 day^{-1} and 1.144 day^{-1} on Balcı, these values were found 0.199 day^{-1} and 1.12 day^{-1} on Dinçer respectively. It means that the females feeding on the Balcı can bring more live female offspring to the population in one day and have a more reproductive ability. According to these results, it is predicted that *H. peltigera* individuals fed on Balcı can give more female offspring to the population compared to Dinçer. Likewise, the mean generation time (T_0) of the pest fed in two safflower varieties was different from each other, it was shorter (37.5 days) on Balcı than on Dinçer (39.25 days) (Table 3). Naseri et al (2014) found the intrinsic rate of increase (*r*) of *H. armigera* was 0.115±0.009 day^{-1} - 0.142±0.001 day^{-1}; the net reproductive rate (R_0) were 177.3±6.7 - 270.1±6.7 offspring; the mean generation time (T_0) ranged from 37.03±0.05 to 44.64±0.07 days on 13 soybean varieties. Similar to the differences in the (*r*) value in our study, depending on the variety, the *r* value of *H. armigera* was 0.1135 day^{-1} for sunflower (Reddy, Rao, Rao, & Rajasekhar, 2004) and 0.1423 day^{-1} for millet (Patal & Koshyia, 1997) was determined. Basavaraj, Naik, Jagadish, & Shadakshari (2018) reported that the net reproductive rate (R_o) of *H. armigera* was 281.011 with mean length of generation (T_0) was 41.40 days on sunflowers. The

reasons for these differences result from morphological, physiological or ingredients of nutrient differences in each host species or a variety depending on the host plant variation. Additionally, the fact that the intrinsic rate of increase of *H. peltigera* is higher on Balcı with higher oil content support that this variety is more suitable in terms of reproductive ability. The life table parameters obtained indicate that the population of *H. peltigera* fed on Balcı will be higher.

Table 3. Means and standards errors (Ses) of the intrinsic rate of increase, (*r*), finite rate of increase (*λ*), net reproductive rate (R_0) and mean generation time (*To*) of *Heliothis peltigera* on two safflower varieties.

Parameters	Balcı (n:142)	Dinçer (n=146)
The intrinsic rate of increase, (*r*) (day^{-1})	0.134±4.59 a	0.119±5.123 b
The finite rate of increase (λ) (day^{-1})	1.144±0.005 a	1.126±0.005 b
The net reproductive rate (R_0) (egg/ female)	158.13±25.52a	109.01±19.71a
Mean generation time (T_0) (day)	37.49±0.34 b	39.25±0.40 a

See was estimated using the bootstrap technique with 100.000 resampling. The means followed by different letters in the same row were significantly different according to the paired bootstrap test based on the confidence interval of differences at the % 5 significal level.

When the survival rates of *H. peltigera* fed on two safflower varieties were examined, it was found that the eggs survived at the rate of 90.85% on the Balcı variety and 89.73% on the Dinçer variety (Fig. 1). The survival rates were determined on the first, second, third, fourth, fifth and sixth larval period of *H. peltigera* of fed on Balcı variety as 93.8%, 85.12%, 99.03%, 99.02%, 99.01%, and 100%, respectively. On Dinçer, the survival rates of the first, second, third, fourth and fifth larval period were recorded as 87.79%, 87.83% 100%, 100%, 99.01%, and 100%, respectively. From the third larval period to the pupal period, survival rates were high in both cultivars. Additionally, the survival rates of prepupa and pupa were 96% and 83.33%, respectively, on Balcı while prepupa was 100% and pupa was 71% on Dinçer variety. According to the age distribution, the survival rate was determined as 97.71% on Balcı and 97.45% on Dinçer (Fig. 1). Due to the variable development rate among individuals, the age-stage survival rate (sxj) showed the stage differentiation and significant stage overlaps (Fig. 1). In general, the lowest survival rate on both varieties was observed in the pupal stage. The adults emerged faster on Balcı than they did on Dinçer. According to these values, more deaths were observed in the first and second instar larvae and pupal periods compared to other biological periods. Althought the mortality rates in male and female adults are close to each other, the highest male death on Balcı variety is on the 50th day, and the highest female mortality is on the 49th day; On the Dinçer variety, the highest male death was on the 48th day and the highest female death on the 49th day (Fig. 1). It was compared with the probability of survival of *H. armigera*, as no other studies have addressed the probability of survival of *H. peltigera*. The survival probability of *H. armigera* was determined to be 32% from egg to adult on different bean varieties (Naseri et al, 2014), and 33.1% from egg to pupa on cotton (Liu, Li, Gong, & Wu, 2004). Additionally, the survival rate of *H. armigera*'s pupae was reported 85.7% on cotton (Kunjun, Yuping,

& Minghui, 1992); 92.7% on artificial diet (Amer & El-Sayed, 2014), 56% on soybean, 72% on artificial diet (Suzana, Damiani, Fortuna, & Salvadori, 2015).

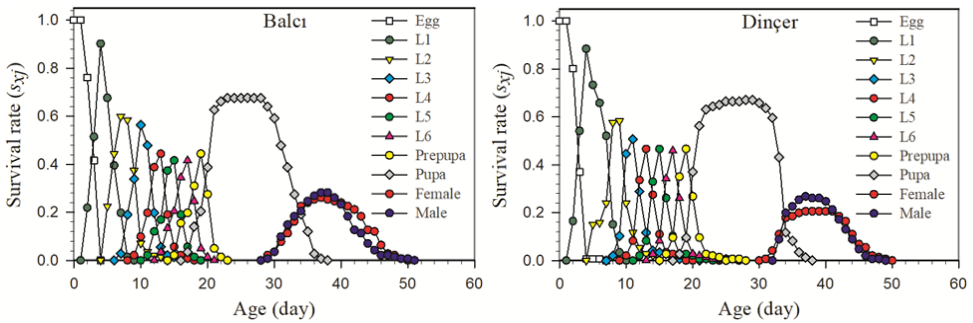

Fig. 1 Age-stage specific survival rate of *Heliothis peltigera* on two safflower varieties Sxj: the probability that a newly laid egg will survive to age x and stage j.

The life expectancy is the estimation of survival time of an individual under certain conditions. The life expectancy of a newborn individual (e_{01}) of *H. peltigera* was estimated as 31 days on on Balcı, and 30 days on Dinçer varieties. But life durations of the pest were found as almost 50 days on both host plants. When the survival rate (l_x) curve of all biological stages was examined, it was seen that the population decreased rapidly at the beginning and the survival rate decreased to 70% on the 10th day, this decline was slow until the 30th day when the adults emerged, and it decreased rapidly from the 40th to 52nd day. On the 30th day, fecundity rate (m_x) increased with the emergence of adult females and males, reaching the highest level between 36.-38 days and ended on the 44th day with the adults starting to die. It is seen that the $l_x m_x$ curve also follows a parallel course on Balcı (Fig. 3).

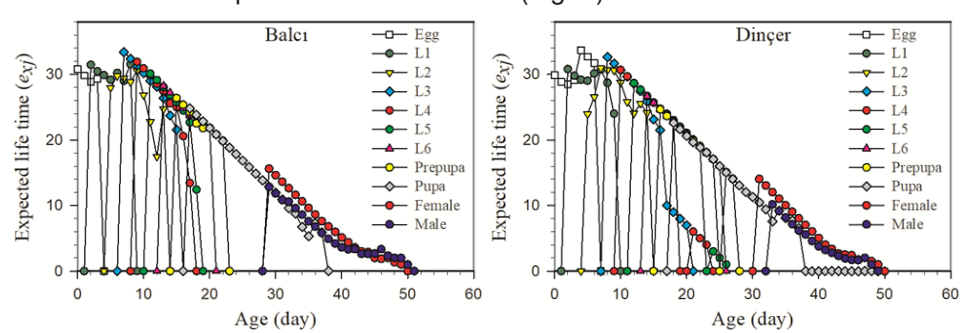

Fig. 2 Expected life time (*exj*) of *Heliothis peltigera* on two safflower varieties.

The higher reproduction values (v_{xj}) of *H. peltigera* were calculated for females on both varieties. It was estimated about 400 eggs in 33th days on Balcı, while it was found 370 eggs in 36th days on Dinçer (Fig. 4). Parallel to v_{xj}, the net reproductive rate (R_o) approaches 158.13 levels. On Dinçer, the reproductive value (v_{xj}) of the population of *H. peltigera* has increased since the 31st day and the net reproductive rate (R_o) reaches 109.01 levels. The obtained data show us that *H. peltigera* has a high reproduction capacity

as soon as it becomes an adult. The reproductive value decreases with the aging of the female, and it ends on the 45th day on the Balcı and the 47th day on the Dinçer (Fig. 5).

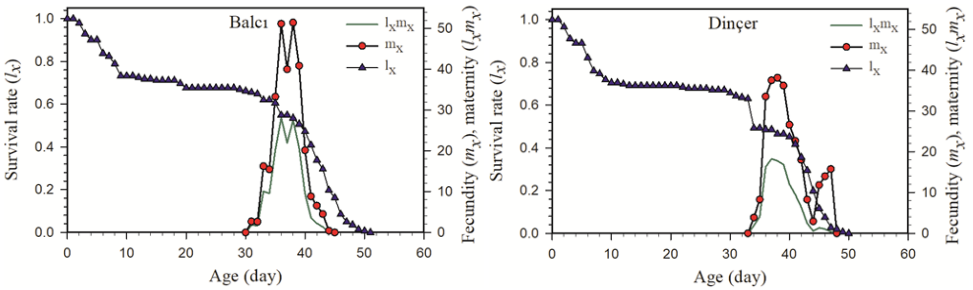

Fig 3. Population survival rate of *Heliothis peltigera* on safflower varieties Balcı and Dinçer. l x: the probability that a new egg will survive to age x. mx: the mean fecundity of individuals at age x. l x*mx: the product of l x and mx, age-stage specifc reproduction.

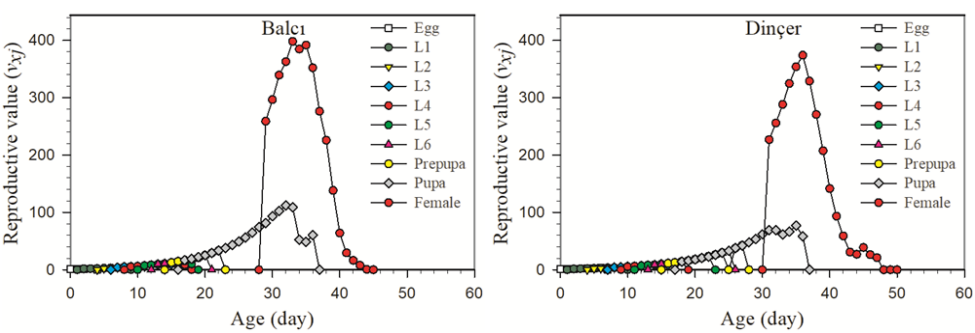

Fig.4 Reproduction value of *Heliothis peltigera* fed on two safflower varieties.

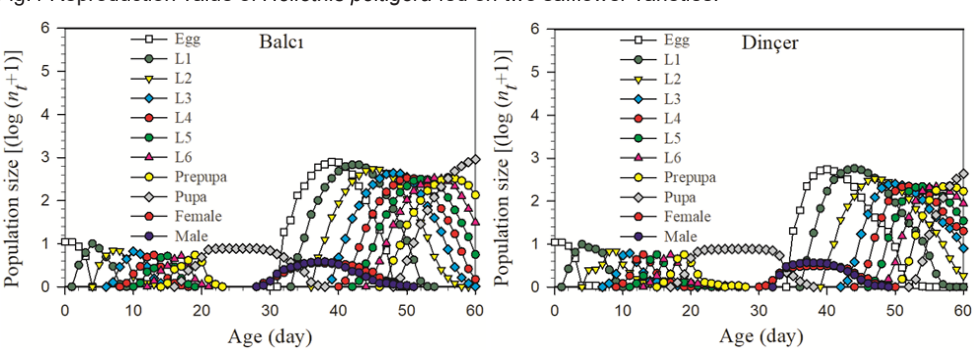

Fig.5 Population sizes of *Heliothis peltigera* on two safflower varieties.

Age-stage, two-sex life tables provide comprehensive information on the pest's population parameters. With this study, the biology and life table of *H. peltigera* in Turkey and the world was revealed for the first time and basic data were obtained about this pest. As a result, the age-stage, two-sex life table we made showed that Balcı variety was more advantageous than Dinçer for *H. peltigera*. However, to better

understand the insect-plant interaction, it is necessary to study the demographic parameters of this pest on safflower cultivars under field conditions. Additionally, the identification and extraction of secondary biochemical of safflower cultivars can significantly assist in planning more practical strategies for the management of *H. peltigera.* The basic information obtained in this study about *H. peltigera* will be useful for pest control and prefer to produce Dinçer variety that could be reducing of *H. peltigera*. With these data, the population of the pest can be estimated under field conditions and can help keep it below the economic damage threshold.

ACKNOWLEDGEMENTS

I want to thank General Directorate of Agricultural Research and Policies and Directorate and Plant Protection Central Research Institute for their support in conducting the research on the project titled Bollworm [*Helicoverpa spp., Heliothis spp.* (Lepidoptera: Noctuidae)] Species Prevalence, Density, Biology and Natural Enemies Determination and Control Possibilities. I want to thank Dr. Mustafa ÖZDEMİR for diagnosing *Heliothis peltigera* adults and Dr. M. Salih ÖZGÖKÇE for evaluation of its population parameters.

REFERENCES

Amer, A.E.A. & El-Sayed, A.A.A. (2014). Effect of different host plants and artificial diet on *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) development and growth index. *Journal Entomology,* 11, 299-305.

Arslan, B. & Çulhan, E. (2020). Determination of agricultural and technological traits of some safflower (*Carthamus tinctorius* L.) genotypes developed by cross breeding. *YYU Journal of Agricultural Science*, 30,742-750.

Ayten, S. & Ülgentürk, S. (2020). Ankara ili aspir alanlarında Yeşilkurt [*Heliothis peltigera* Denis & Schiffermüller (Lepidoptera: Noctuidae)]'un yaygınlığı, yoğunluğu ve bulaşma oranı. *Ziraat Mühendisliği*, 369, 122-132.

Atlıhan, R., Özgökçe, M.S., & Hsin, C.H.I. (2018). Yaş ve döneme özgü, iki eşeyli yaşam çizelgesi: populasyon ekolojisi, biyolojik savaş ve zararlı yönetiminin temeli. *YYU Journal of Agricultural Science,* 28(4), 502-506.

Basavaraj, K., Naik, M.I., Jagadish, K.S., & Shadakshari, Y.G. (2018). Studies on age specific fecundity life tables for *Helicoverpa armigera* Hub., on sunflower (*Helianthus annuus* L.). J*ournal of Entomology and Zoology Studies*, 6(2), 1364-1368.

Borah, S.R. & Dutta, S.K. (2002). Biology of gram pod borer, *Helicoverpa armigera* (Hub.) on pigeon pea. *Journal of the Agricultural Science Society NE. India*, 15, 34-37.

Chi, H.S.I.N. & Liu, H. (1985). Two new methods for the study of insect population ecology. *Bulletin of the Institute of Zoology, Academia Sinica*, 24, 225-240.

Chi, H. (2021). TWOSEX-MSChart: A computer program for the age-stage, Two-Sex Life Table Analysis. http://140.120.197.173/Ecology/

Damkacı, S.A. (2013). Konya ilinde aspir (*Carthamus tinctorius*: Asteraceae) ekim alanlarında zararlı böcekler ve predatörleri. Yüksek Lisans Tezi, Selçuk Üniversitesi, Fen Bilimler Enstitüsü, Bitki Koruma Anabilim Dalı, 44, Konya.

Dhandapani, N. & Balasubramanian, M. (1980)**.** Consumption and utilization of different food plants by *Heliothis armigera* (Hubner) (Noctuidae, Lepidoptera). *Entomology,* 5, 99-103.

Eroğlu, G.B., Nalçacıoğlu, R., & Demirbağ, Z. (2019). A new *Helicoverpa armigera* Nucleopolyhedrovirus isolate from *Heliothis peltigera* (Denis & Schiffermuller) (Lepidoptera: Noctuidae) in Turkey. *Turkish Journal of Biology*, 43, 340-348.

Gomes, E.S., Santos, V., & Avila C.J. (2017). Biology and fertility life table of *Helicoverpa armigera* (Lepidoptera: Noctuidae) in different hosts: biology of *Helicoverpa armigera*, *Entomological Sciences*, 20, 419-426.

HesHesterberg, T., Moore, D.S., Monaghan, S., Clipson, A., & Epstein, R. (2005). Bootstrap methods and permutation tests. In D.S. Moore & G.P. McCabe (Eds.). *Introduction to the practice of statistics* (5th ed.). Freeman and Company.

Hüseyinoğlu, Y. & Atay, E. (2017). A faunistic study of diurnal and nocturnal Lepidoptera in Darboğaz, Bolkar Mountains (Niğde, Turkey). *Journal of the Kansas Entomological Society*, 90, 44-53.

İyriboz, N.Ş. (1971). *Pamuk Zararlıları ve Hastalıkları*. Ticaret Yayınevi, İzmir, 1-104.

Jha, R.K., Chi H., & Tang, L. (2012). A Comparison of artificial diet and hybrid sweet corn for the rearing of *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) based on life table characteristics. *Environmental Entomology*, 41, 30-39.

Kaya, M. & Kovancı, B. (2000). Bursa ilinde Yeşilkurt, *Helicoverpa armigera* (Hübn.) (Lepidoptera: Noctuidae)'nın biyolojisi üzerinde araştırmalar. *Journal Agricultural. Sciences of YYU*, 10, 37-43.

Keyder, S. (1961). *Marmara ve Trakya Bölgesinde Meyve ve Sebzelerde Zarar Yapan Noctuidae Türleri Üzerinde Araştırmalar*. Göztepe Zirai Mücadele Araştırma Enstitüsü Yayınları, Yenilik Yayınevi, İstanbul, 1-27.

Kornoşor, S. & Düzgüneş, Z. (1980). Güney Anadolu Bölgesinde *Heliothis* cinsine bağlı türlerin tespiti ve bunların morfolojik ve genetik özelliklerinin araştırılması. Ankara Ü. Z. F. Diploma Sonrası Yüksek Okulu Doktora Tez Özetleri, 1258-1287.

Kunjun, W., Yuping C., & Minghui, L. (1992). Performances of cotton boll worm, *Heliothis armigera* (Hubner) at different temperatures and relative humidities. *Journal of Environmental Sciences*, 5(2), 158-168.

Liu, Z., Li, D. Gong, P., & Wu, K. (2004). Life table studies of the cotton bollworm, *Helicoverpa armigera* (Hübner) (Lepidoptera:Noctuidae), on different host plants. *Environmental Entomolgy,* 33(6), 1570-1576.

Manjunath, T.M., Patel R.C., & Yaoav, D.N. (1976). Observations on *Heliothis peltigera* (Sehiff.) (Lep.: Noctuidae) and its natural enemies in anand (Gujarat State, India). *Proceedings Indian Academy of Sciences,* 83(2), 55-65.

Matov, A., Zahiri R., & Holloway, J.D. (2008). The Heliothinae of Iran (Lepidoptera: Noctuidae). *Zootaxa*, 1763, 1-37.

Naseri, B., Golparvar, Z., Razmjou J., & Golizadeh, A. (2014). Age-stage, two-sex life table of *Helicoverpa armigera* (Lepidoptera: Noctuidae) on different bean cultivars. *Journal of Agrıcultural Science and Technology*, 16(1), 19-32.

Özgökçe, M.S., Chi, H., Atlıhan, R., & Kara, H. (2018). Demography and population projection of *Myzus persicae* (Sulz.) (Hemiptera: Aphididae) on five pepper (*Capsicum annuum* L.) cultivars. *Phytoparasitica*, 46(2), 153-167.

Parvin, A. (1990). Some biological features of *Heliothis peltigera* Schiff on safflower. *Applied Entomology and Phytopathology,* 57(1-2), 11-12.

Patal, C.C. & Koshyia, D.J. (1997) Life table and innate capacity of *Helicoverpa armigera* (Hbner) on pearl millet. *Indian Journal of Entomology,* 59, 389-395.

Ragionieri, L., Özbagcı, B., Neupert, S., Salts, Y., Davidovitch, M., Altstein M., & Predel, R. (2017). Identification of mature peptides from pban and capa genes of the moths *Heliothis peltigera* and *Spodoptera littoralis*. *Peptides*, 94, 1-9.

Reddy, K.S., Rao, G.R., Rao P.A., & Rajasekhar, P. (2004). Life table studies of the capitulum borer, *Helicoverpa armigera* (Hübner) infesting sunflower. *Journal Entomological Research*, 28, 13-18.

Shorey, H.H. & Hale, R.L. (1965). Mass-rearing of the larvae of nine noctuid species on a simple artificial medium. *Journal of Economical Entomology*, 58, 522-524.

Suzana, C.S., Damiani, R., Fortuna L.S., & Salvadori, J.R. (2015). Desempenho de larvas de *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) em diferentes fontes alimentares. *Pesquisa Agropecuária Tropical*, 45(4), 480-485.

Tezcan, S., Okyar Z., & Beyaz. G. (2004). Manisa ilinde yetiştirilen kültür kekiği (*Origanum* spp., Lamiaceae)'ndeki Noctuidae (Lepidoptera) familyası türleri. *Anadolu*, 14(2), 29-34.

Wei, M., Chi, H., Guo, Y., Li, X., Zhao, L., & Ma, R. (2020). Demography of *Cacopsylla chinensis* (Hemiptera: Psyllidae) reared on four cultivars of *Pyrus bretschneideri* and *P. communis* (Rosales: Rosaceae) pears with estimations of confidence intervals of specific life table statistics. *Journal of Economical Entomology*, 113(5), 2343-2353.