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Research Article

Effect of four commercial barley varieties on life table parameters of *Sitotroga cerealella* (Olivier) (Lepidoptera: Gelechiidae)

Leila Zeinalzadeh, Azadeh Karimi-Malati[*] and Ahad Sahragard

Department of Plant Protection, Faculty of Agricultural Sciences, University of Guilan, Rasht, Iran.

Abstract: Angoumois grain moth, *Sitotroga cerealella* (Olivier) is one of the most important pests of stored products and known as factitious host for mass rearing of insect natural enemies. Effect of four commercial barely varieties including Fajr 30, Behrokh, Nik and Yousef on life table parameters of *S. cerealella* was determined at 26 ± 2 °C, 65 ± 5% RH and a photoperiod of 12:12 h (L: D). Data were analyzed based on the age-stage, two-sex life table theory. The results revealed that there were significant differences among various barely varieties regarding the developmental times, adult longevity and fecundity of *S. cerealella*. The longest developmental time (56.72 ± 0.29 days) was observed on Yousef. The longest and shortest male longevity were obtained on Behrokh (6.77 ± 0.27 days) and Yousef (5.79 ± 0.16 days). Moreover, female longevity ranged from 6.20 ± 0.18 to 7.23 ± 0.24 days on Yousef and Behrokh, respectively. The highest values of intrinsic rate of increase (r) were estimated 0.0719 ± 0.004 and 0.0717 ± 0.003 day^{-1} on Fajr 30 and Behrokh, respectively and the lowest values were 0.0539 ± 0.004 and 0.0542 ± 0.003 day^{-1} on Nik and Yousef, respectively. The longest generation time (T) was observed on Yousef. Furthermore, peaks of reproductive value occurred at ages of 45, 49, 48 and 53 days when reared on Fajr 30, Behrokh, Nik and Yousef, respectively. It can be concluded that Fajr 30 and Behrokh can be used for mass rearing programs of *S. cerealella* as an alternative host for natural enemies.

Keywords: Angoumois grain moth, *Sitotroga cerealella*, barely, developmental time, fecundity

Introduction

Annual losses of stored grains due to insect infestation have been estimated about 10% (90 million tons) worldwide (Munro, 1996), which is caused by approximately 70 species belonging to different families including Pyralidae, Gelechiidae, Noctuidae, etc. (Cox and Bell, 1991). Angoumois grain moth, *Sitotroga cerealella* (Olivier) (Lepidoptera: Gelechiidae) is one of the most important pests of wheat, barley, rice and corn throughout the world (Khattak and Shafique, 1981; Ayerty, 1982; Iqbal and Irshad, 1993; Ashamo and Khanna, 2006). The young larvae bore directly into grains and consume their contents, causing weight loss, reduction in nutritional value, contamination of the cereal products by molting remains, making them unfit for human consumption (Rizwana *et al.,* 2011) and more susceptible to secondary insect pest attacks (Weston and Rattlingourd, 2000). Control of *S. cerealella* throughout the world has been practiced using chemical treatments, plant extracts, temperature treatments, natural

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[*] **Corresponding author**, e-mail: a_karimi@guilan.ac.ir
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enemies and resistant varieties (Phillips and Throne, 2009). Due to enormous losses in cereals, it is desired that resistant varieties are evolved to suppress the population of *S. cerealella* in stored products (Rizwana *et al.,* 2011). Hence, the suitable use of resistant varieties in pest management techniques requires knowledge of life table and biological parameters of the pests (Razmjou *et al.,* 2009).

Life table is often used by scientists as a method of projecting the growth of populations and predicting the population dynamics and size of a population (Chi, 1990; Carey, 1993; Medeiros *et al.,* 2000; Southwood and Henderson, 2000; Carey, 2001; Legaspi, 2004, Hansen *et al.,* 2004). Some biological parameters of *S. cerealella* on different cereals were reported by previous researchers (Cohen and Russell, 1970; Ashamo and Khanna, 2006; Ahmed and Raza, 2010). Shafique *et al.* (2006) emphasized that there was a significant positive correlation between fecundity of *S. cerealella* and weight losses of different wheat genotypes caused by developing larvae. Influence of physical and chemical traits of eight corn varieties on biological parameters of *S. cerealella* was studied by Ahmed and Raza (2010). In addition, the resistance of twelve wheat genotypes to *S. cerealella* was evaluated by Khan *et al.* (2010).

The life-history traits of insects such as fecundity, longevity, and survival rate may be influenced by variation in food quality (Sequiera and Dixon, 1996; Awmack and Leather, 2002; Umbanhowar and Hastings, 2002). Although selection of resistant cereal varieties through life table parameters is an important tool for IPM in stored products, other objectives should be noticed (Hamed and Nadeem, 2012). Rearing different biological control agents, including *Trichogramma*, on factitious hosts such as *S. cerealella* has improved substantially in recent years (Corrigan and Laing, 1994; Abdel-Salem, 2000; El-Hafez *et al.,* 2001; El-Wakeil, 2007; Bezerra *et al.,* 2012). In fact, the susceptible cereal varieties are suitable for mass production of *S. cerealella* as an alternative host for rearing of parasitoids and predators (Hamed and Nadeem, 2012; Saljoqi *et al.,* 2015), because the quality of food resources not only affects the life history properties of the pest, but it also has some tri-trophic effects on natural enemies reared on *S. cerealella* as alternative host. Nathan *et al.* (2006) demonstrated that quality of the parasitoid, *T. chilonis* Ishii was influenced by egg of its host, *Corcyra cephalonica* (Stainton), which was reared on different cereals. Moreover, percentage of adult parasitoid, *T. chilonis* emerging from *C. cephalonica* eggs reared on corn was higher than those reared on wheat and barley (Hamed and Nadeem, 2012). Not only the quality and chemical content of intermediate host eggs were influenced by cereal grains, but the size of host egg would be affected by different cereal types they are reared on (Werren, 1984).

Although some related studies have been conducted on the effects of different stored products on development and fecundity of *S. cerealella* (Shazali and Smith, 1985; Consoli and Filho, 1995; Hansen *et al.,* 2004; Khan *et al.,* 2010), no information is available on life table parameters of the pest on four barely varieties including Fajr 30, Behrokh, Nik and Yousef.

Materials and Methods

Host plants

The seeds of four barley varieties including Fajr 30, Behrokh, Nik and Yusef were obtained from Agricultural and Natural Resources Research Center of Khorasan Razavi, Mashhad, Iran. Seeds of barley varieties were soaked in water and then exposed to air in order to dry their surface.

Insect culture

A population of *S. cerealella* eggs was originally obtained from an insectarium in Fuman, Guilan, Iran, which were reared on barley varieties for three generations before using them in experiments. They were reared in cylindrical containers (19 cm diameter and 8 cm height) on each barely variety until the end of pupal stage. Then, emerged adults were released in plastic funnels (15 cm diameter) covered by fine net at top and kept up-side-down over a piece of paper as egg laying substrate to ease egg collection.

Life table parameters

Developmental time and reproduction of *S. cerealella* were studied on four barley varieties at 26 ± 2 ºC, 60 ± 5% RH and a photoperiod of 12:12 h (L:D). After adult oviposition over a piece of white paper, clusters of eggs attached to paper were counted under binocular microscope. The paper was then cut into pieces each containing one hundred eggs. Eggs of *S. cerealella* were monitored and incubation periods were recorded. After hatching, the newly hatched larvae were individually transferred by a fine brush on different barely seeds in microtubes (1.5 cm diameter and 4 cm height containing two seeds). First instar larvae of *S. cerealella* entered the grains through the median gap of barley seed and completed the larval and pupal stages there. Larvae pupated inside the seeds and made a hole before pupation. Since the larval and pupal developmental times of *S. cerealella* take place within the chamber inside a delicate cocoon, determining larval instars was not possible. Pupal period was recorded from forming a small circular translucent window in the grain until adult emergence (Khattak *et al.,* 1996). There was only one larva in each container, so emergence of adult was considered as an index for survival of *S. cerealella* on larval and pupal stages. Each container was observed daily to record emergence of adults. After emergence, each one couple of adults was confined in a plastic funnel (15 cm diameter) covered by mesh net at top. The number of eggs laid by each female per day, oviposition period and adult longevity were also recorded.

Statistical analysis

Raw data on the development, survival and daily fecundity of *S. cerealella* were analyzed according to the age-stage, two-sex life table (Chi and Liu, 1985; Chi, 1988).

The age-stage specific survival rate (s_{xj}) (where x = age and j = stage), the age-specific survival rate (l_x), the age-specific fecundity (m_x), and the population parameters (r, the intrinsic rate of increase; λ, the finite rate of increase, $\lambda = e^r$; R_0, the net reproductive rate; T, the mean generation time) were calculated accordingly. Data analysis and population parameters were calculated using the TWOSEX-MSChart program designed in visual BASIC for the Windows operation system (Chi, 2015). The TWOSEX-MSChart is available at http://140.120.197.173/Ecology/prod02.htm (Chung Hsing University) and http://nhsbig.inhs.uiuc.edu/wes/chi.html (Illinois Natural History Survey). The standard errors of the developmental time, mean number of eggs per female, longevity and life table parameters were estimated by using 100,000 bootstraps. We used the paired bootstrap test to compare the differences between treatments based on the confidence interval of the difference between treatments (Efron and Tibshirani, 1993; Chi, 2015).

Results

Developmental time and adult longevity

The developmental time and adult longevity of *S. cerealella* on four barely varieties are shown in Table 1. Developmental time including incubation period, larval and pupal periods were significantly influenced by different barley varieties. In addition, there were significant differences in total immature stages, male and female longevities on the different varieties.

The incubation period of *S. cerealella* was influenced by the varieties, and the longest incubation period was recorded on Behrokh and Nik. The larval developmental time ranged from 33.89 ± 0.34 to 38.41 ± 0.35 days on Behrokh and Yousef, respectively. The total immature stages of *S. cerealella* on Yousef (56.72 ± 0.29 days) was longer than on other varieties.

There were significant differences in male and female longevities (Table 1). Among different barley varieties, the longest female longevity was 7.23 ± 0.24 days on Behrokh.

Adult pre-oviposition period (APOP), total pre-oviposition period (TPOP), oviposition period and mean number of eggs per female of

S. cerealella are shown in Table 2. Barley varieties had significant effect on APOP, that is the duration from adult emergence to first oviposition ($P < 0.05$). In addition, the total pre-ovipositional periods (TPOP), that is the duration from egg to first oviposition was affected by host variety and it ranged from 51.52 ± 0.5 days on Fajr 30 to 56.70 ± 0.47 days on Yousef. Regarding oviposition period, a significant difference was detected among different tested varieties ($P < 0.05$). The results confirmed that mean number of eggs per female was affected by the host variety. Mean number of eggs per female was the highest (163.30 ± 17.84 eggs) on Fajr 30 and the lowest (79.27 ± 8.36 eggs) on Yousef variety (Table 1).

Population growth parameters

Age-stage specific survival rate (S_{xj}) of *S. cerealella* on the four barely varieties is shown in Fig. 1. Based on the age-stage, two-sex life table, the age-stage-specific life expectancy (e_{xj}) gives the expected life span an individual of age x and stage j can live after age x (Fig. 2). The highest and the lowest trends of life expectancy were observed on Fajr 30 (48.25 days) and Yousef (36.6 days), respectively. The contribution of an individual of age x and stage j to the future population is described by the age-stage reproductive value (v_{xj}) (Fig. 3). According to results of reproductive value, a newborn egg (v_{01}) had a value of 1.074, 1.074, 1.055 and 1.056 on Fajr 30, Behrokh, Nik and Yousef, respectively. Our results revealed that the peak of reproductive value occurred at the ages of 45, 49, 48 and 52 days of the moth on Fajr 30, Behrokh, Nik and Yousef varieties, respectively. This emphasizes that, in comparison to other ages, females at the mentioned ages made the highest contribution to the population when reared on the respective varieties.

The age-specific survival rate (l_x) and fecundity rate (m_x) are shown in Fig. 4. The curve of l_x is a simplified version of the age-stage survival rate (S_{xj}) and describes the change in the survival rate of the cohort with age. The trend of age-specific fecundity (m_x) showed that the highest fecundity on varieties (Fajr 30, Behrokh, Nik and Yousef) was also observed at the age of 50, 53, 56 and 60 days, respectively.

The population parameters of *S. cerealella* are given in Table 3. The results showed that different barely verities had significant effect on the intrinsic rate of increase (r). The finite rate of increase (λ) ranged from 1.055 ± 0.004 to 1.075 ± 0.004 day^{-1}. The net reproductive rate (R_0) was also affected by varieties and the highest and the lowest R_0 was obtained on Behrokh (48.410 ± 8.64 female offspring) and Nik (20.500 ± 4.60 female offspring), respectively. The gross reproductive rate (GRR) ranged from 40.558 ± 9.10 on Nik to 98.192 ± 14.05 (female offspring) on Behrokh. According to our results, different varieties had significant influence on the mean generation time (T) in which, the highest and lowest mean generation time was observed on Yousef (58.459 ± 0.52 days) and Fajr 30 (52.67 ± 0.61 days), respectively.

Table 1. The developmental times and adult longevity (Mean ± SE) of *Sitotroga cerealella* on four barely varieties.

Entries	Fajr 30	Behrokh	Nik	Yousef
Incubation period (day)	6.00 ± 0.00^{b}	7.00 ± 0.00^{a}	7.00 ± 0.00^{a}	5.00 ± 0.00^{c}
Larval period (day)	36.8 ± 0.38^{b}	33.89 ± 0.34^{c}	36.68 ± 0.40^{b}	38.41 ± 0.35^{a}
Pupal period (day)	9.48 ± 0.17^{d}	11.79 ± 0.15^{b}	10.97 ± 0.19^{c}	13.31 ± 0.18^{a}
Immature stage (day)	52.27 ± 0.33^{c}	52.3 ± 0.32^{c}	54.57 ± 0.33^{b}	56.72 ± 0.29^{a}
Male longevity (day)	6.32 ± 0.13^{ab}	6.77 ± 0.27^{a}	6.14 ± 0.16^{b}	5.79 ± 0.16^{b}
Female longevity (day)	6.74 ± 0.26^{ab}	7.23 ± 0.24^{a}	6.38 ± 0.3^{b}	6.20 ± 0.18^{b}

The means followed by the same superscript letters in each row are not significantly different using the paired bootstrap test (100000 Bootstraps, $P < 0.05$).

Table 2. Reproductive parameters (Mean ± SE) of *Sitotroga cerealella* on four barely varieties.

Reproductive parameters	Fajr 30	Behrokh	Nik	Yousef
APOP (day)	0.00 ± 0.00[b]	0.07 ± 0.05[b]	0.10 ± 0.07[b]	0.17 ± 0.07[a]
TPOP (day)	51.52 ± 0.50[c]	52.73 ± 0.49[bc]	53.95 ± 0.66[b]	56.70 ± 0.47[a]
Oviposition (day)	5.70 ± 0.27[a]	5.73 ± 0.28[a]	5.10 ± 0.27[ab]	4.80 ± 0.25[b]
No. eggs/female	163.30 ± 17.84[a]	161.37 ± 15.11[a]	97.62 ± 11.38[b]	79.27 ± 8.36[b]

APOP, adult pre-oviposition period; TPOP, total pre-oviposition period (from egg to first oviposition). Means followed by the same superscript letters in each row are not significantly different using the paired bootstrap test (100000 Bootstraps, $P < 0.05$).

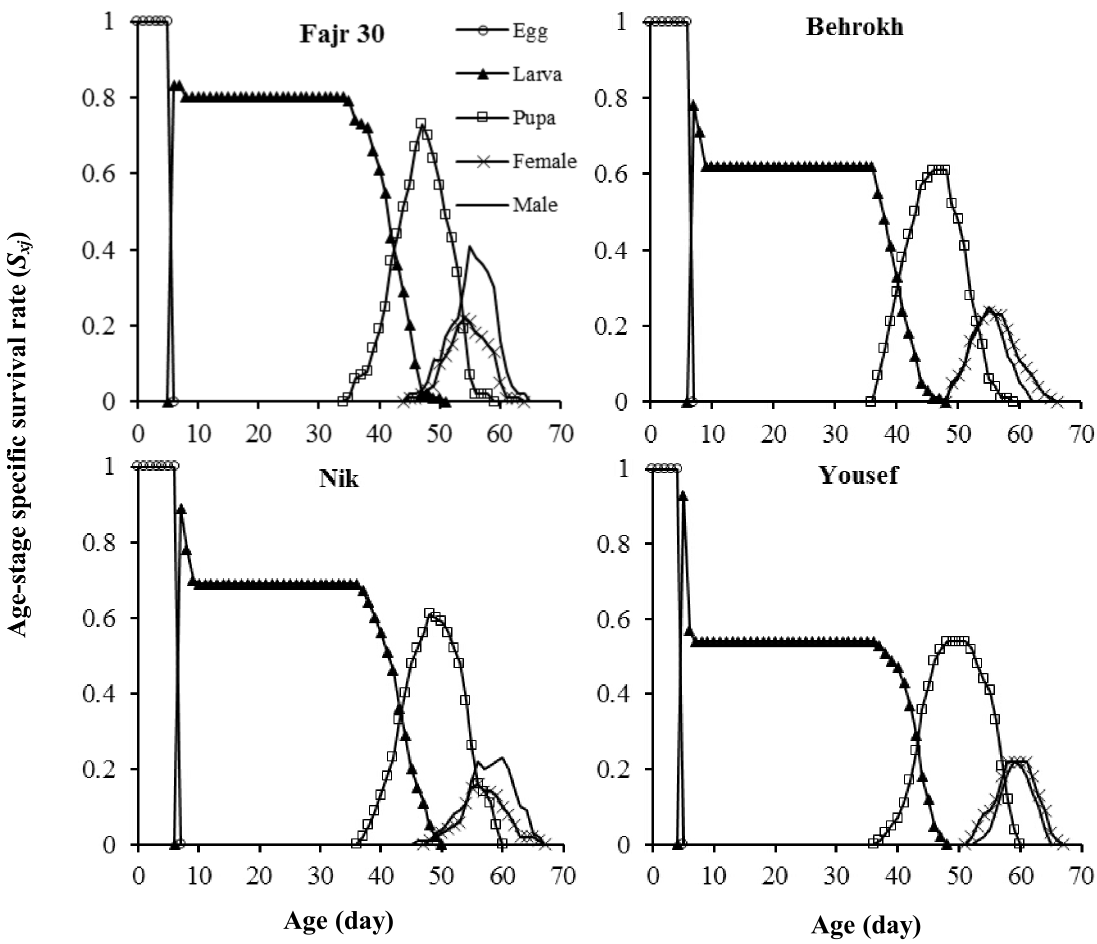

Figure 1. Age-stage specific survival rate of *Sitotroga cerealella* on four barely varieties.

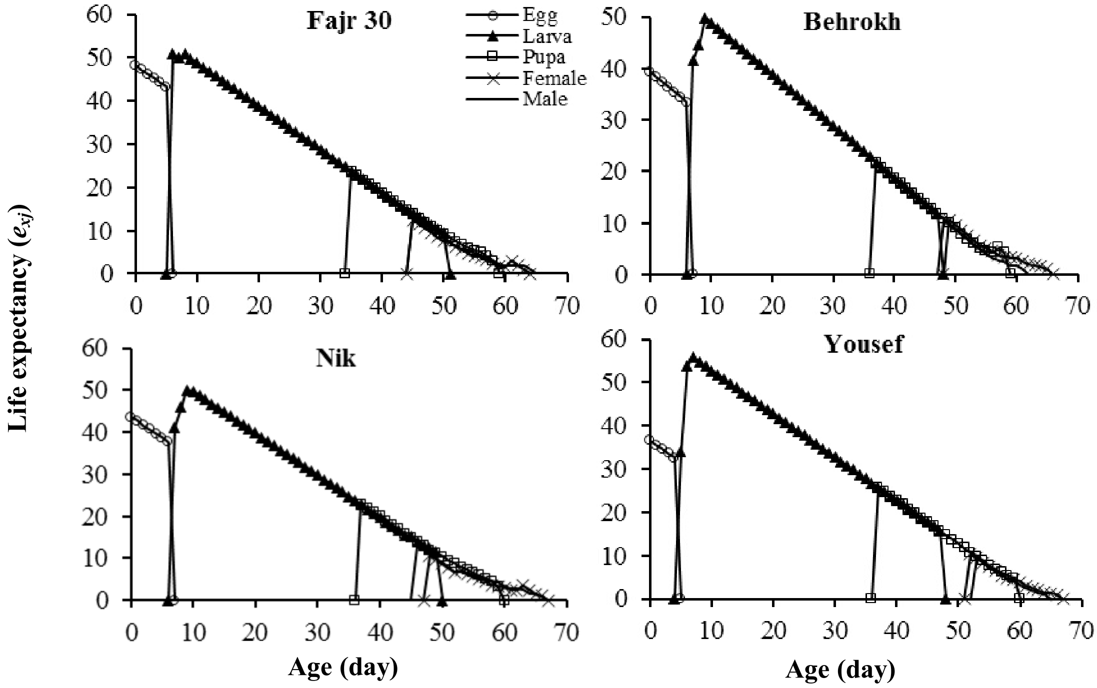

Figure 2. Age-stage-specific life expectancy of *Sitotroga cerealella* on four barely varieties.

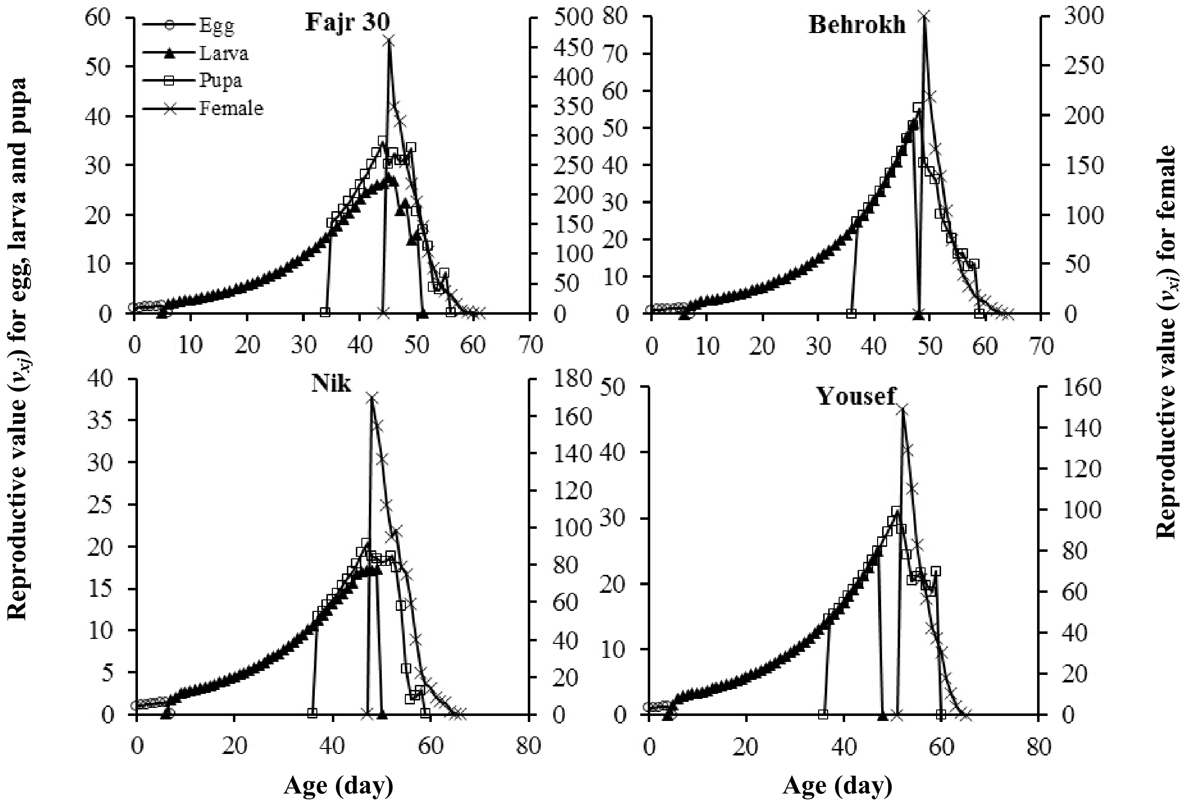

Figure 3. Age-stage-specific reproductive value of *Sitotroga cerealella* on four barely varieties.

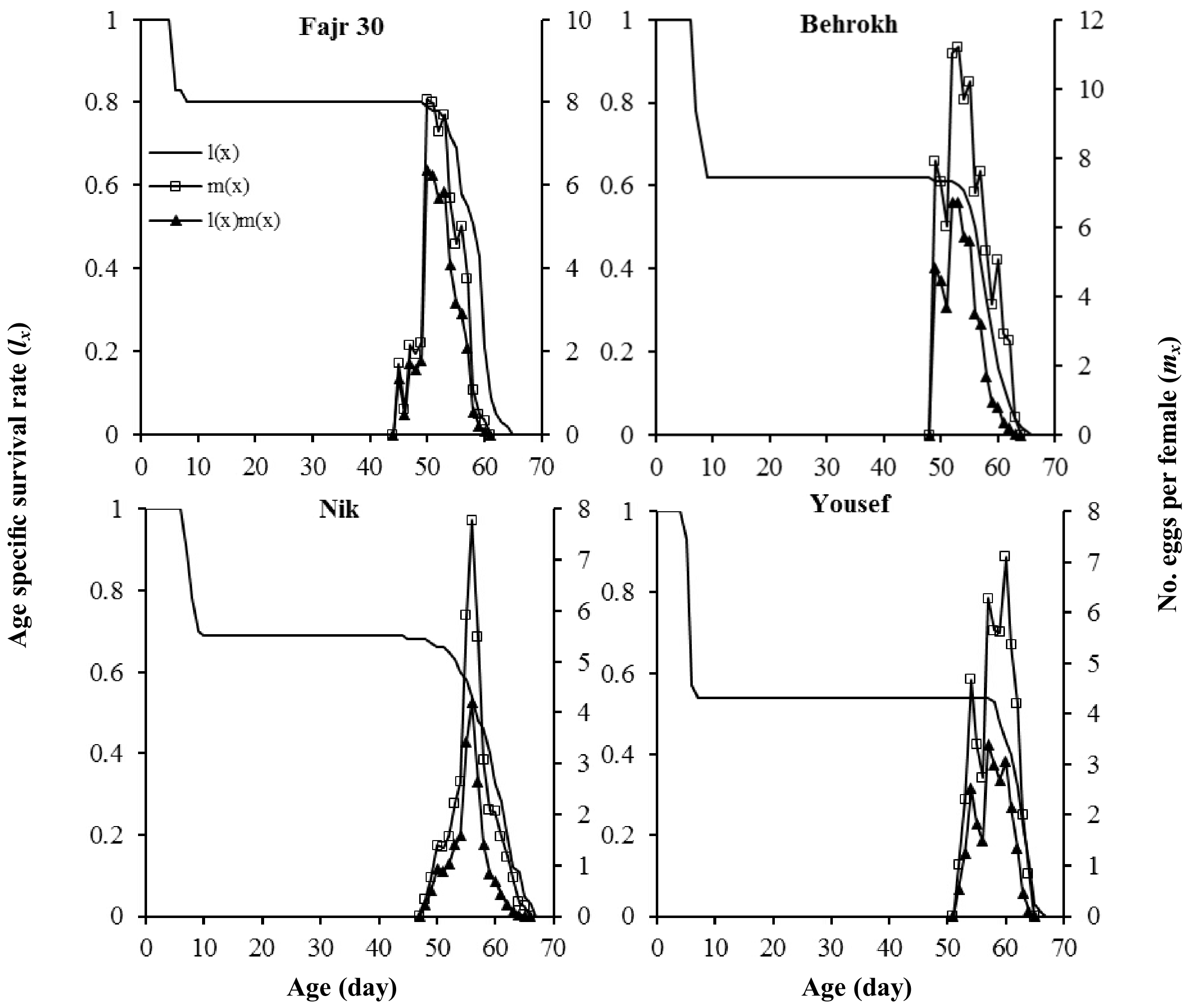

Figure 4. Age-specific survival rate (l_x), age-specific fecundity (m_x) and age-specific maternity (l_xm_x) of *Sitotroga cerealella* on four barely varieties.

Table 3. The life table parameters (Mean ± SE) of *Sitotroga cerealella* on four barely varieties.

Parameters	Fajr 30	Behrokh	Nik	Yusef
r (day^{-1})	0.0719 ± 0.004^{a}	0.072 ± 0.003^{a}	0.0539 ± 0.004^{b}	0.0542 ± 0.003^{b}
λ (day^{-1})	1.075 ± 0.004^{a}	1.074 ± 0.003^{a}	1.055 ± 0.004^{b}	1.056 ± 0.003^{b}
R_0 (offspring)	44.090 ± 8.67^{a}	48.410 ± 8.64^{a}	20.500 ± 4.60^{b}	23.780 ± 4.40^{b}
GRR (offspring)	60.598 ± 11.47^{b}	98.192 ± 14.05^{a}	40.558 ± 9.1^{b}	51.093 ± 8.33^{b}
T (day)	52.670 ± 0.61^{c}	54.086 ± 0.50^{c}	56.035 ± 0.64^{b}	58.459 ± 0.52^{a}

r: intrinsic rate of increase, λ: finite rate of increase, *GRR*: gross reproductive rate, R_0: net reproductive rate and T: mean generation time. The means followed by the same superscript letters in each row are not significantly different using the paired bootstrap test (100000 Bootstraps, P <0.05).

Discussion

Several researches demonstrated that the developmental time, fecundity and survivorship of stored-product pests could be affected by physico-chemical characteristics of stored products such as nutritional value, morphology of grain, hardness and availability of food (Khattak and Shafique, 1981; Iqbal and Irshad, 1993; Khan *et al.,* 2010). Shorter development times and greater total reproduction of insects on a given diet indicate greater food suitability (van Lenteren and Noldus, 1990). Furthermore, resistance and susceptibility of different cereal grains to storage pests has been studied in terms of weight loss, adult emergence (%) and adult weight which were greater on susceptible varieties than resistant varieties (Shafique *et al.,* 2006; Ahmed and Raza, 2010; Saljoqi *et al.,* 2015). Numerous studies have briefly described the biology and reproduction behavior of *S. cerealella* on corn (Consoli and Filho, 1995; Hansen *et al.,* 2004; Shafique and Chaudry, 2007), different wheat genotype (Khan *et al.,* 2010; Saljoqi *et al.,* 2015), sorghum (Shazali and Smith, 1985) and rice (Rizwana *et al.,* 2011). Despite the numerous studies on biological parameters of *S. cerealella* on various stored crops, there is no information on life table parameters of barley varieties.

The results of the present investigation revealed that the incubation period of *S. cerealella* on different barley varieties ranged from 5.00 to 7.00 days, approximately, which is in agreement with those reported by Hansen *et al.* (2004), who observed that the incubation period took 6.57 and 6.36 days at 25ºC, 44% and 80% R.H., respectively. Similarly, Shazali and Smith (1985) estimated incubation period of 5.8 days at 25 ºC on sorghum for the pest.

According to our results, the total immature stage has been affected by the barley grains which larvae reared on and it ranged from 52.27 ± 0.33 days (Fajr 30) to 56.72 ± 0.29 days (Yousef). Based on Hansen *et al.* (2004), the total immature stages varied from 48.62 to 66.89 days at 44% and 80% R.H., respectively. The average value of immature stages obtained in the current study obviously falls within this range. In contrast to our findings, Hamed and Nadeem (2012) reported shorter immature stages (27.3 days) of *S. cerealella* on barley at 27 ± 1 °C, 65 ± 5% RH and a photoperiod of 12:12 h (L:D). The longer immature stages in the current study are probably because of differences in *S. cerealella* population or tested barley varieties. Also the results of the current study differed from estimate of Shazali and Smith (1985) who reported that the immature stages of the pest on sorghum took 32.1 days. In another investigation, the immature stages of *S. cerealella* on twelve wheat genotypes ranged from 21.25 to 23.25 days (Khan *et al.,* 2010). The different results of our study can be attributed to differences in cereals as diets or the strains of *S. cerealella.*

Our finding showed that the male and female longevities of *S. cerealella* ranged from 5.79 ± 0.16 to 6.77 ± 0.27 days and 6.20 ± 0.18 to 7.23 ± 0.24 days, respectively, which were close to the values reported by Hansen *et al.* (2004) for one strain of *S. cerealella* on corn. On the other hand, Shazali and Smith (1985) investigated that adult longevity of *S. cerealella* reared on sorghum took 8.5, 6.5 and 4.2 days at temperatures of 25, 30 and 35 ºC, respectively. Different results were reported by Akter *et al.* (2013), who obtained the male and female longevities of 8 ± 0.13 days and 10 ± 0.32 days, respectively on rice grains. These differences are likely due to either the nutritional quality of food or differences of *S. cerealella* population.

The results of this study revealed that APOP of *S. cerealella* was less than one day on all four tested barley varieties, indicating adults were ready to mate and oviposit immediately after emergence. Similarly, previous studies investigated the duration of the pre-oviposition period of *S. cerealella* as about one day (Crombie, 1943; Hansen *et al.,* 2004). However, pre-oviposition period on corn reported by Throne and Weaver (2013) was longer than one day and took from 1 to 2 days at 25-40 °C. Gabre *et al.* (2005) pointed out that total pre-oviposition period is a more appropriate statistic from the point of view of demography, because it represents the effect of the first reproduction on population parameters. In fact, APOP is calculated based on time after adult emergence while TPOP represents the true duration from birth to the first reproduction. In the present study, TPOP of *S. cerealella* females was affected by different barely varieties and it ranged between 51.52 ± 0.50 days on Fajr 30 to 56.70 ± 0.47 days on Yousef. It seems that developmental time of immature stages influenced TPOP. In addition, there was a significant difference in oviposition period of *S. cerealella* on barley varieties. However, Akter *et al.* (2013) recorded an oviposition period of 3.67 days for *S. cerealella* on rice grain which was shorter compared with that of present findings. This difference may be due to differences among tested cereals.

Our investigation confirmed that Fajr 30 and Behrokh were the most suitable varieties for reproductive performance of *S. cerealella*. Mean number of eggs per female reared as larvae on Fajr 30 and Behrokh variety was 163.30 ± 17.84 and 161.37 ± 15.11 eggs per female, respectively, which was notably more than 105.5 ± 3.66 eggs as reported by Hamed and Nadeem (2012). These discrepancies may be related to the experimental conditions and different barley varieties. According to present study, *S. cerealella* had less fecundity on Nik and Yousef, showing that these two verities were the least suitable food. It should be considered that nutritional content of stored products might be responsible for differences of biological parameters of *S. cerealella* (Saljoqi *et al.,* 2015).

The intrinsic rate of increase (r) is a more useful statistic to compare the population growth potential of different species than R_0, *GRR* and fecundity (Price, 1997; Jha *et al.,* 2014). Since intrinsic rate of increase (r) reflects many factors such as fecundity, survival rate, generation time and adequately summarizes the physiological qualities of an animal in relation to its capacity to increase, it would be a most desirable index to evaluate the performance of an insect on different diets (Birch, 1948; Southwood and Henderson, 2000). There are few studies which investigated the life table parameters of *S. cerealella* on different stored products (Hansen *et al.,* 2004). According to our results, a significant difference was observed in r values with respect to barley varieties. In the present study, r values obtained on Fajr 30 (0.0719 ± 0.004 day^{-1}) and Behrokh (0.0717 ± 0.003 day^{-1}) were significantly higher than those on Nik and Yousef. Poor fitness of Nik and Yousef varieties for *S. cerealella* may be due to nutritional inferiority and poor palatability of these varieties. However, additional studies are needed for a comprehensive comparison. Hansen *et al.* (2004) reported that r values of *S. cerealella* on corn at 25 °C were 0.031 and 0.067 day^{-1} at 44 % and 80 % relative humidity, respectively. Our finding is somehow in agreement with their results at 80 % R.H. In conclusion, the high r value on Fajr 30 and Behrokh variety indicated that *S. cerealella* had a greater reproductive potential and survival rate on these two varieties and they were presumably more suitable nutrient than the others. In fact, faster developmental time and more fecundity resulted in higher r values when *S. cerealella* were reared on Behrokh and Fajr 30.

In this research, R_0 and *GRR* values on Behrokh were 48.41 ± 8.64 female offspring and 98.192 ± 14.05 female offspring, respectively, indicating more suitability of Behrokh variety compared with Fajr 30. But it should be considered that R_0 and *GRR* parameters represent only the reproductive potential rather than the overall fitness of diets. Thus, these two parameters (R_0 and *GRR*) should be used cautiously while evaluating suitability of diets to an insect. Therefore, based on the above discussion, Behrokh and Fajr 30 can be viewed as equally suitable grains for *S. cerealella.*

The mean generation time (T) for *S. cerealella* ranged from 52.670 ± 0.61 days on Fajr 30 to 58.459 ± 0.52 days on Yousef, suggesting that Fajr 30 variety is more suitable for an increase in pest's population.

It is concluded from r values, as the main parameter of resistance response in barley varieties to *S. cerealella*, that Yousef followed by Nik are significantly resistant varieties, while Fajr 30 and Behrokh were the most susceptible ones. Therefore, it is suggested that the last two mentioned varieties are best for mass production of *S. cerealella* recommended for mass rearing of natural enemies for biological control. However, further studies are necessary to analyses the chemical composition of these barley varieties as well as the physical and morphological characteristic of grains.

According to the present study, different barely varieties had significant influence on development, fecundity and life table parameters of *S. cerealella*. It is known that the quality and quantity of nourishment received by an insect can affect its survival and reproduction directly (Iqbal and Irshad, 1993; Khan *et al.,* 2010). Our findings regarding the selection of resistant varieties from those tested, may provide important information to aid the design of a comprehensive scheme for an IPM program of *S. cerealella*. On the other hand, since this pest is one of the most important insects in mass rearing of insect natural enemies, assigning of the suitable susceptible barley variety, would help us improve natural enemy production.

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تأثیر چهار رقم تجاری جو بر پارامترهای جدول زندگی *Sitotroga cerealella* (Olivier) (Lepidoptera: Gelechiidae)

لیلا زینل‌زاده، آزاده کریمی ملاطی* و احد صحراگرد

گروه گیاه‌پزشکی، دانشکده کشاورزی، دانشگاه گیلان، رشت، ایران.
* پست الکترونیکی نویسنده مسئول مکاتبه: a_karimi@guilan.ac.ir
دریافت: ۲۰ مهر ۱۳۹۴؛ پذیرش: ۲۹ دی ۱۳۹۴

چکیده: بید غلات *Sitotroga cerealella* (Olivier)، یکی از مهم‌ترین آفات محصولات انباری می‌باشد و به‌عنوان یک میزبان واسط در پرورش انبوه دشمنان طبیعی نیز شناخته شده است. در این پژوهش تأثیر چهار رقم تجاری جو شامل فجر ۳۰، به رخ، نیک و یوسف بر پارامترهای جدول زندگی *S. cerealella* در شرایط دمایی ۲ ± ۲۶ درجه سلسیوس، رطوبت نسبی ۵ ± ۶۵ درصد و دوره نوری ۱۲ ساعت روشنایی و ۱۲ ساعت تاریکی مورد مطالعه قرار گرفت. داده‌ها براساس فرضیه جدول زندگی سنی-مرحله رشدی دوجنسی مورد تجزیه و تحلیل قرار گرفتند. نتایج نشان داد که ارقام مختلف جو بر دوره رشد و نمو، طول عمر حشرات بالغ و باروری تأثیر معنی‌داری داشتند. بیش‌ترین کل دوره رشد مراحل نابالغ (۰/۲۹ ± ۵۶/۷۲ روز) روی رقم یوسف مشاهده شد. بیش‌ترین و کم‌ترین طول عمر حشرات نر به‌ترتیب روی رقم به رخ (۰/۲۷ ± ۶/۷۷ روز) و یوسف (۰/۱۶ ± ۵/۷۹ روز) به‌دست آمد. علاوه بر این، طول عمر حشرات ماده از ۰/۱۸ ± ۶/۲۰ تا ۰/۲۴ ± ۷/۲۳ روز به‌ترتیب روی رقم‌های یوسف و به رخ نوسان داشت. تفاوت پارامترهای جدول زندگی بید غلات روی ارقام مختلف جو معنی‌دار بود. بیش‌ترین نرخ ذاتی افزایش جمعیت (r) ۰/۰۰۴ ± ۰/۰۷۱۹ و ۰/۰۰۳ ± ۰/۰۷۱۷ (بر روز) بود که به‌ترتیب روی رقم فجر ۳۰ و به رخ به‌دست آمد و کم‌ترین مقدار آن ۰/۰۰۴ ± ۰/۰۵۳۹ و ۰/۰۰۳ ± ۰/۰۵۴۲ (بر روز) مربوط به ارقام نیک و یوسف بود. طولانی‌ترین مدت زمان یک نسل (T) روی رقم یوسف مشاهده شد. هم‌چنین بیش‌ترین مقدار تولیدمثل در روزهای ۴۵، ۴۹، ۴۸ و ۵۳ به‌ترتیب روی ارقام فجر ۳۰، به رخ، نیک و یوسف مشاهده شد. براساس نتایج پژوهش حاضر مشخص شد که ارقام فجر ۳۰ و به رخ می‌توانند در برنامه پرورش انبوه دشمنان طبیعی روی میزبان واسط *S. cerealella* مورد استفاده قرار گیرند.

واژگان کلیدی: بید غلات، *Sitotroga cerealella*، جو، دوره رشد و نمو، باروری