J. of Plant Protection and Pathology, Mansoura Univ., Vol. 14 (8):249 - 255, 2023

Journal of Plant Protection and Pathology

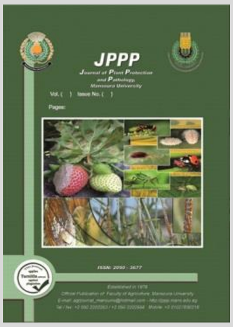
Journal homepage & Available online at: www.jppp.journals.ekb.eg

Influence of Different Stored Grains and Temperature on Developmental Stages and Survival Rates of *Oryzaephilus surinamensis* (L.) (Coleoptera: Silvanidae)

Awadalla, S. S.[1]; A. S. Hashem[2]; Marwa M. Ramadan[1]; Amira A. A. Abdel-Hady[1*] and Omnia O. Abdel- Ghany[3]

Cross Mark

[1]Department of Economic Entomology, Faculty of Agriculture, Mansoura University, Egypt
[2] Stored Product Pests Research Department, Plant Protection Research Institute, Agricultural Research Center, Sakha, Kafr El-Sheikh
[3]General Organization for Export and import control, (GOEIC), Branch Port said, Egypt



ABSTRACT

The sawtoothed grain beetle, *Oryzaephilus surinamensis* (L.), is a secondary pest causes great damage to cereal grains, commodities, and packaged food all over the world. Beyond cereal grains, this species is a concern because it may be differently impacted based on variation in temperature. Therefore, development time, larval and pupal survival, and adult emergence of *O. surinamensis* were evaluated on various substrates at different temperatures regimes (22, 28, 32, and 38 °C). With highly significant differences, the larval stage duation of *O. surinamensis* ranged from 19.2 ± 1.26 days on rice grains to 25.6 ± 0.98 days on white maize grains. The insect exhibited the highest rate of larval survival (95%) on rice grain followed by oat (90%) and wheat grain (89%). The shortest larval stage duration was measured at 38°C (12.1± 0.98 d), followed by 32°C (16.4±1.03 d) with highly significant differences. The total immature stage durations ranged from 22.9 days at 38 °C to 54.2 days at 22 °C. The percentage of larvae that survived varied from 62% at 38°C to 91% at 32°C. The average number of adults that emerged at a temperature of less than 38°C was 5.1 ± 1.12 individuals, which was the lowest recorded value. Therefore, the grain type and temperature range plays a significant role in determining sawtoothed grain beetle infestation, which might have future implications for controlling this insect pest.

***Keywords**: oryzaephilus surinamensis*, susceptibility commodities, storage temperature, controlling pests.

INTRODUCTION

The sawtoothed grain beetle, *Oryzaephilus surinamensis* (L.) (Coleoptera: Silvanidae) is an extremely prevalent and destructive insect lives in warehouses and feeds on the commodities and goods that are kept there (Mahroof and Hagstrum, 2012; Kłys and Przystupinska, 2015). This species is a global nuisance that can be found in a wide range of goods and environments. It is very prevalent in stores, warehouses, and mills (Rees, 2004; CABI, 2019). Although if feeds on the germ of whole kernels (Hill, 2003), it also feeds on frass produced by damaged kernels as a secondary pest of cereals (Throne *et al*., 2003; Hotling *et al*., 2014) .Because it causes allergies in people, this species may pose a risk to the general public's health. *Oryzaephilus surinamensis* has antigens from various sections of its life stages that have been identified as causing allergic reactions in humans, so they can be dangerous when found in products that have been stored (Jakubas Zawalska *et al*., 2016).

The quality and quantity of food that insects consume have an impact on their ability to grow and reproduce, among other things (Papachristos *et al*., 2015; Kavallieratos *et al*., 2019). It is well known that the nutritional value of food can affect an insect's life history in various ways (Jalali *et al*., 2010; Papachristos *et al*., 2015). Different types of food have an impact on adult longevity or/andreproductive capacity (Jalali *et al*., 2009), population growth, or/and the development and survival of immature stages (Kalushkov and Hodek, 2005; Papachristos *et al*., 2015).

The sawtoothed grain beetle is a pest insect that is widespread and has a broad thermal range, allowing it to survive in temperatures that may be unsuitable for other stored grain pests (Arthur, 2000; CABI, 2019). According to several studies (Fields *et al*., 2012; Papanikolaou *et al*., 2013; Ramadan *et al*., 2020; Lü *et al*., 2021), temperature plays an important role in determining many biological characteristics of insects, including lifespan, survival, progeny production, and fecundity. Thus, the behaviour and life-history characteristics of insects are influenced by temperature changes over time. Insect survival at various temperatures is also influenced by additional variables, including exposure intervals, species, stage of development, acclimation, relative humidity, and gender (Fields, 1992; Ramadan *et al*., 2020). Only 5% of the adult sawtoothed beetles lived at 2 °C for 21 days after exposure (Mathlein, 1961), but there was a rapid temperature-mediated decline below 10 °C (Donahaye *et al*., 1995). Compared to other stored-product insects, *O. surinamensis* larvae, pupae, and eggs are more vulnerable to the cold-hardiness (Evans, 1983 and 1987). Although most studies considered one or two of these factors with one or two life stages at most, there is little research on the roles that temperature and living substrates play in determining insect population abundance. This means that there are knowledge gaps related to the control of pest species (Arthur, 2000, 2001; Arthur *et al*., 2004; Nika *et al*., 2020). Therefore, it is essential

[*] Corresponding author.
E-mail address: amiraali@mans.edu.eg
DOI: 10.21608/jppp.2023.227653.1169

to comprehend growth of this species on alternative commodities and how it is impacted by various temperatures, which could result in various degrees of damage. The current study therefore is designed to ascertain how different substrates at various temperatures affected the sawtoothed grain beetle's life history traits, possibly resulting in differential substrate loss. These variations were expected given that this species performs differently in various host substrates and that temperature affects insect development and population expansion (Ramadan *et al*., 2020; Awadalla *et al*., 2021).

MATERIALS AND METHODS

Test insects and commodity

At the Stored Products and Grain Pests Department of the Plant Protection Research Institute (PPRI), Agriculture Research Center (ARC), in Sakha Station (Kafr El-Sheikh, Egypt), the sawtoothed grain beetle colony was reared. Before beginning the studies, this insect population was kept at the Department of Economic Entomology at Mansoura University (Mansoura, Egypt) on cracked rice at 30°-1°C and 65°-5° relative humidity (r.h.) and constant darkness for three generations. 500 adults were allowed to oviposit in a 1 L jar with the aforementioned diet in order to get the necessary insect population for the subsequent tests. The adult insects were removed after one week of egg-laying, and the F1 adults that were created after 60 days were transplanted to the commodities under test to be used later in the bioassays.

For all trials, the feeding substrates—Wheat, white corn, yellow corn, rice, and oat—were kept free of pesticide residues, bug damage, and infestation. All grains tested were kept in cold storage at - 20 C for at least two weeks prior to the study's commencement. By heating the substrates in an oven at 50°C or by adding distilled water in accordance with the commodities' original moisture content, the commodities' moisture contents were changed to 13.5 0.5% for all grains tested (Athanassiou *et al*., 2016). The moisture was tested with a calibrated moisture meter.

Experimental protocol

Twenty grams of each grains tested were added to a Petri dish that was 10 cm in diameter and 2 cm high. Twenty adult insects, ranging in age from one to four days, were then released into the dish and permitted to mate and deposit eggs for five days. The freshly hatched sawtoothed grain beetle larvae were moved to fresh Petri dishes with 20 g of feeding substrate (20 larvae/Petri dish); ten replicates of each grains tested were used, and they were tested at four various temperatures: 22, 28, 32 and 37 °C, and at 65% r.h. The length of immature stages interval, larval and pupal survival rates, and adult emergence rates were recorded (daily). By weighing the substrate in an analytical balance both before and after the tests, feeding substrate loss was also measured (i.e., when the adults emerged). All experiment was carried out under the same controlled conditions of the insect rearing under suitable environmental chambers (30 ± 1 °C, 65 ± 5% r.h., and darkness conditions) (ST 5 COM F/S, Pol-Eko-Aparatura, Wodzislaw Sl´ ąski, Poland).

Statistical analysis

Data of Incubations period, Larval stage, pupal stage, Total developmental time, survival and effect of temperature on Incubations period, Larval stage, pupal stage and survival of *O. surinamensis*, were reanalyzed separately by one-way ANOVA, and the means were separated using Student-Newman-Keuls Test (Costat Software, 2004). The chemical analysis of cereal grains was estimated in Soil, water, fertilizer and plant analysis laboratory - faculty of Agriculture - Mansoura University.

RESULTS AND DISCUSSION

The graminaceous grains

The obtained results in Table (1) show the effect of different graminaceous grains on development of the sawtoothed grain beetle, *O. surinamensis* at conditions of 28±1°C and 60±5 RH%. The incubation periods were the same on the all the graminaceous grains and presented by 6.2 ± 0.52 days with no significantly differences. The larval stages for *O. surinamensis* were ranged between 19.2 ± 1.26 days on rice grains and 25.6 ± 0.98 days on white corn grains with highly significant differences. It can be noticed that, the longest larval stage duration was recorded on white corn grains followed by the yellow corn grains and wheat grains and represented by 25.6 ± 0.98, 25.4 ± 1.01 and 24.5 ± 0.81 days, respectively. Meanwhile, the shortest larval stage duration was recorded on rice grains and presented by 19.2 ± 1.26 days.

According to the pupal stage periods, the results in Table (1) show the pupal stage periods that ranged between 12.9±0.59 days on rice grains and 13.8±0.74 days on yellow corn grains with no significant differences. With respect to the total development, data in Table (1) demonstrate the longest total development for *O. surinamensis* was recorded on yellow grains followed by white corn grains and oat and represented by 45.4±1.08, 45.0±1.02 and 43.8±0.91 days, respectively. While, the shortest total development was recorded on rice and presented by 38.3±0.83 days.

Our findings showed that the sawtoothed grain beetle's overall developmental time was mostly influenced by its larval stage. According to Naseri & Majd-Marani (2020), the larvae time directly correlates to the overall development period because, in contrast to the non-feeding sessile stages, this stage is most affected by changes in the environment. (i.e. eggs and pupae). The larva is also the stage that feeds the most actively. (Beckett and Evans, 1994; Nika *et al*., 2020). It's interesting to note that this stage may be able to survive in unfavourable environments and influence the characteristics of later insect stages (Throne *et al*., 2003; Govindaraj *et al*., 2014).

Table 1. Effect of different graminaceous grains on immature stages of Oryzaephilus surinamensis at conditions of 28±1°C and 60±5 RH%.

Graminaceous grains	Immature stages (days)			Total development (days)
	Egg	Larval	Pupal	
Wheat	6.2±0.52 a	24.5±0.81 b	13.0±0.83 a	43.7±0.98 b
White corn	6.2±0.52 a	25.6±0.98 b	13.2±0.66 a	45.0±1.02 a
Yellow corn	6.2±0.52 a	25.4±1.01 a	13.8±0.74 a	45.4±1.08 a
Rice	6.2±0.52 a	19.2±1.26 c	12.9±0.59 a	38.3±0.83 c
Oat	6.2±0.52 a	24.3±0.79 b	13.4±0.88 a	43.8±0.91 b

Means followed by the same letters in a column are not significantly different at 5% level of probability (Duncan's Multiple Range Test).

The presented results in Table (2) show the effect of graminaceous grains on the survival percentage of the immature stages for the sawtoothed grain beetle *O. surinamensis* under laboratory conditions. The highest survival percentage for the larval stage were recorded on rice grains followed by oat grains and wheat grains and presented by 95, 90 and 89 %, respectively. Meanwhile, the lowest larval survival percentage was recorded on yellow corn grains followed by white corn grains and presented by 66 and 79 %, respectively. Furthermore, the pupal survival percentage was in the same trend and ranged between 62.3% on yellow corn grains and 92.6% on rice grains (Table 2).

Table 2. Effect of different graminaceous grains on survival percentage of different stages for Oryzaephilus surinamensis at conditions of 28±1°C and 60±5 RH%..

Graminaceous grains	Larval survival %	Pupal survival %	Total survival %
Wheat	89	89.3	79
White corn	79	75.6	61
Yellow corn	66	62.3	38
Rice	95	92.6	88
Oat	90	91.4	82

According to the different graminaceous grains, the total developmental stages survival percentage for the sawtoothed grain beetle *O. surinamensis* were the highest on rice grains followed by oat grains and wheat grains and represent by 88, 82 and 79%, respectively. While, the lowest survival percentage for the total developmental stages were recorded on yellow corn grains followed by white corn grains and presented by 38 and 61%, respectively (Table 2).

Data in Figure (1) show the effect of different graminaceous grains on the average number of the adult emergence of the sawtoothed grain beetle *O. surinamensis* under laboratory conditions. The highest average number of the insect adult emergence were recorded on rice grains followed by oat grains and wheat grains and p2ﻙresented by 8.8±0.29, 8.1±0.43 and 7.9±0.38 individuals, respectively. Meanwhile, the lowest average number of the insect adult emergence was recorded on yellow corn grains and presented by 3.8±0.41 individuals.

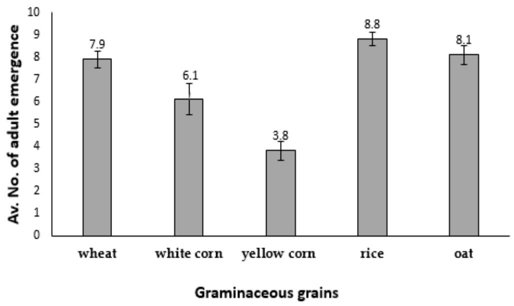


Fig. 1. Effect of different graminaceous grains on the average number of the adult emergence of the sawtoothed grain beetle *Oryzaephilus surinamensis* at conditions of 28±1°C and 60±5 RH%...

Data given in Figure (2) show the weight loss percentage in different graminaceous grains resulting to the Feeding of the insect pest larvae under laboratory conditions. It can be noticed that, the lowest weight loss percentage were recorded on yellow corn grains followed by white corn grains and wheat grains and represented by 8.4, 10.1 and 11.7 %, respectively. While, the highest weight loss percentage was recorded on rice grains and presented by 13.2%.

Another crucial observation is that the identical regression model worked well for all rearing substrates tested, with little variance in emergence until temperatures above 30 °C but rapid decline at 35 °C. These variations may be partially explained by the type and/or size of kernels, which influence how insects develop and also offer a place for them to hide or flee. LeCato and McCray (1973) found that wheat kernels with particle sizes greater than 2.36 mm support 3.85 times more adult sawtooth grain beetle offspring. Additionally, according to Fleming (1988), the sawtoothed grain beetle population should be reduced by using wheat kernels with a particle size of less than 2.68 millimetres (grade 8). Fleming also noted that the production of these insects' eggs and offspring is influenced by the milling grade of the wheat kernels. (Beckel *et al.,* 2007). Although this beetle grows readily on damaged wheat kernels (Weston and Rattlingourd, 2000), it's possible that there is an ideal size for broken wheat kernels that would prevent this species' population growth. As seen in our woﻙrk at 35 °C, the big kernel or particle size may also mitigate the impact of rising temperature up to a point where development is hindered.

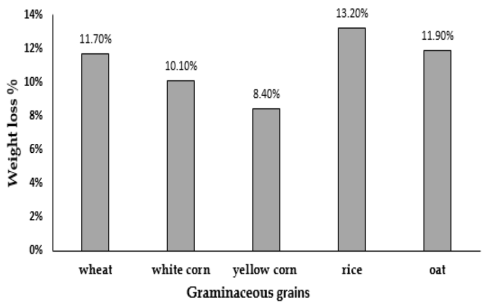


Fig. 2. Weight loss percentage by the larvae of *Oryzaephilus surinamensis* fed on different graminaceous grains at conditions of 28±1°C and 60±5 RH%...

The results arranged in Table (3) show the chemical analysis at the different tasted graminaceous grains. The moisture percentage ranged between 11.37% in rice and 13.11% in Oat. The total carbohydrates percentage ranged between 68.11% in oat and 81.56% in rice. The protein percentage ranged between 6.64% in rice and 12.73 % in oat. The fat percentage ranged between 1.15% in rice and 6.24 % in oat. The total phenol percentage ranged between 18.16 % in rice and 162.94 % in yellow corn.

According to our findings and those of earlier research, the majority of secondary pests do better on a richer diet than they do on cereals solely high in carbohydrates. (i.e., a diet containing additional components such as proteins, lipids, vitamins, yeasts, etc.) (Fraenkel and Blewett, 1943; LeCato and McCray, 1973; Beckel et al., 2007; Locatelli *et al*., 2017). Astuti *et al*. (2020) emphasised that other predictors (such as water, ash, phenol, and riboflvin concentrations) significantly affect the developing period in addition to protein and particle size variation. This finding is consistent with earlier research by Sokoloff *et al*. (1966), which shown that other nutrients, such as minerals and vitamins, are also necessary for the development of *T. castaneum* in addition to protein. These investigations support earlier findings regarding the sawtoothed grain beetle. (Beckel *et al*., 2007; Mallah *et al*., 2016; Awadalla *et al*., 2021 Latifin *et al*., 2020).

Table 3. Chemical analysis of the different graminaceous grains.

Components	Rice	White corn	Yellow corn	Wheat	Oat
		Average Percentages			
Moisture%	11.37	11.98	12.19	12.54	13.11
% Total Carbohydrates	81.56	73.18	72.92	76.23	68.11
Protein %	6.64	9.82	9.97	12.26	12.73
Fat %	1.15	3.41	3.67	1.72	6.24
		Average Minerals (mg^{-1})			
p	95.41	291.12	288.44	141.65	475.18
K	91.17	251.46	255.17	126.11	299.18
Ca	10.13	21.78	22.16	25.11	51.21
Fe	3.46	3.07	3.19	1.05	2.91
Zn	4.23	5.93	6.14	1.99	11.92
Mg	69.17	48.97	48.51	0.73	108.11
Total Phenol	18.16	161.07	162.94	90.18	81.76

Effects of different temperature

For the life of ectotherms like insects, the temperature unquestionably has significant impact on biological features at all levels of organisation. (Kramarz et al., 2016). Constant temperatures are used in the majority of thermal biology research. Therefore, results from such experiments might not be as applicable to evolution and physiology as those from experiments that account for temperature fluctuations. (Hochachka and Somero, 2002). Although data on the individual impacts of temperature and substrates on insect lifetime are available (Fields, 1992; Fields et al., 2012; Nika et al., 2020), little is known about the relationship between live substrate and temperature, especially when different substrates are taken into account.

The present results arranged in Table (1) showed the effect of the different temperature degrees on the immature stages of the sawtoothed grain beetle O. surinamensis. The incubation period was the longest under 22±1°C and was the shortest under 28±1°C and presented by 9.4±0.75 and 3.7±0.39 days, respectively. Statistical analysis revealed that, a highly significant differences in the incubation period according to the different temperature degrees.

Regarding to the larval stage results presented in Table (1) showed that, the shortest larval stage recorded in temperature degree 38±1°C followed by 32±1°C with highly significantly differences and presented by 12.1±0.98 and 16.4±1.03 days, respectively. Meanwhile, under temperature degree 22±1°C the larval stage recorded the longest duration and presented by 30.6±1.47 days. With respect to, the pupal stage was the shortest period under 38±1°C followed by 32±1°C, while the longest period was under 22±1°C with highly significant differences and presented by 7.1±0.51, 8.8±0.63 and 14.2±0.82 days, respectively.

Table 4. Effect of the different temperature regimes on development of Oryzaephilus surinamensis.

Temperature degrees	Immature stages: Egg (days)	Larval (days)	Pupal (days)	Total development (days)
22±1°C	9.4±0.75 a	30.6±1.47 a	14.2±0.82 a	54.2±1.99 a
28±1°C	6.2±0.52 ab	19.2±1.26 ab	12.9±0.59 b	38.3±1.07 b
32±1°C	5.1±0.46 b	16.4±1.03 b	8.8±0.63 c	30.3±1.12 c
38±1°C	3.7±0.39 d	12.1±0.98 c	7.1±0.51 d	22.9±0.18 d

Means followed by the same letters in a column are not significantly differences at 5% level of probability (Duncan's Multiple Range Test).

The obtained results in Table (1) demonstrate the development of O. surinamensis under different temperature regimes. It can be noticed that, the total development ranged between 22.9±0.18 days at 38±1°C and 54.2±1.99 days at 22±1°C.

As a conclusion, the shortest incubation period, larval stage, pupal stage and the total immature stage were recorded with the highest temperature degree 38±1°C and presented by 3.7±0.39, 12.1±0.98, 7.1 ±0.51 and 22.9±0.18 days, respectively. Moreover, the longest periods were recorded with the lowest temperature degree 22±1°C and presented by 9.4±0.75, 30.6±1.47, 14.2±0.82 and 54.2±1.99 days, respectively. Statistical analysis revealed that, a highly significant differences for each insect stage according to the different degrees.

Data illustrated in Table (2) show the survival rates of immature stages of the sawtoothed grain beetle, *O. surinamensis* under different temperature regimes. The larval survival percentage ranged between 62% at 38±1°C and 91% at 32±1°C. The pupal survival percentage ranged between 82.3% and 96.7 % at 38±1 °C and 32±1°C, respectively.

Table 5. Effect of the different temperature degrees on survival rates of the immature stages of Oryzaephilus surinamensis

Temperature	Larval survival %	Pupal survival%	Total survival %
22±1°C	75	90.7	68
28±1°C	87	94.3	82
32±1°C	91	96.7	88
38±1°C	62	82.3	51

The data arranged in Figure (1) demonstrate the effect of different temperature regimes on the average number of the adult emerged of the sawtoothed grain beetle O. surinamensis. It can be noticed that, the highest average emergence adults number were recorded under temperature degree 32± 1°C followed by 28±1°C and 22±1 °C and represented by 8.8±0.63, 8.2±0.89 and 6.8±1.04 individuals, respectively. While the lowest average number of the emerged adults was recorded under 38± 1°C and presented by 5.1±1.12 individuals.

The presented date in Figure (2) show the effect of different temperature regimes on the weight losses percentage by larvae of the sawtoothed grain beetle O. surinamensis. The Lowest weight loss percentage was recorded at 38±1°C followed by 22±1°C and 28±1°C and presented by 7.8%, 9.6% and 13.2%, respectively. Meanwhile, the highest weight loss percentage was recorded under temperature degree 32±1°C and represented by 19.4%.

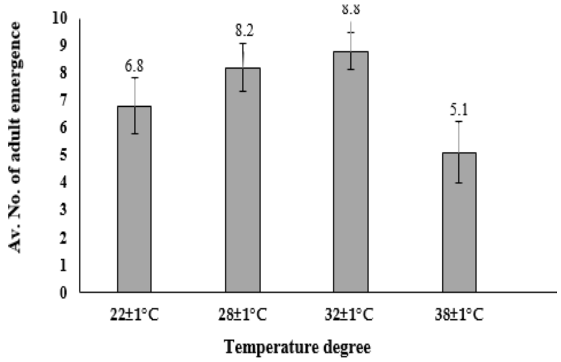


Fig. 3. Effect of the different temperature regimes on the average number of the adult emerged of the *Oryzaephilus Surinamensis* beetles.

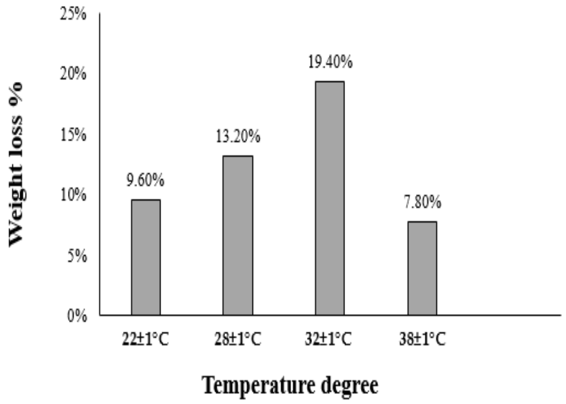


Fig. 4. Effect of the different temperature regimes on the weight losses percentage bylarvae of *Oryzaephilus Surinamensis* beetles.

As a result, the goal of the current study using the sawtoothed grain beetle was to evaluate the effects of temperature-mediated substrate differences on development and survival, which were anticipated and noted despite the fact that there was little interaction between temperature and substrate. One of the study's most intriguing findings was how the insect's reaction to living substrates was directly impacted by the rise in temperature, particularly in dry dates with a comparatively higher moisture content than rice and sesame. This finding is in line with earlier research on the sawtoothed grain beetle. (Latifin *et al*., 2020; Mallah *et al*., 2016). Additionally, temperature influences the nutritional parameters (such as digestive physiology, feeding indices, enzymatic activity, and others) as well as the insect life history by affecting the physical characteristics of living substrates like moisture and starch contents. (Rees, 2004; Sahito *et al*., 2017; Nurul and Noor, 2019).

As a conclusion, the total immature stages of the sawtoothed grain beetle *O. surinamensis* were recorded the highest percentage under temperature degree 32± 1°C followed by temperature degrees 28±1°C and 22±1°C and presented by 88%, 82% and 68%, respectively. Meanwhile, under temperature degree 38±1°C the total survival immature percentage was the lowest and represented by 51%. Our findings also demonstrate that the sawtoothed grain beetle can extend its developmental period in less nutritionally adequate meals in order to obtain the required level of nutrition for further development. In addition, regardless of the substrate utilized for grain beetle rearing, the survival until the adult stage, depicted as adult emergence, resulted in a continually increasing in substrate loss. Therefore, the management of this species is impacted by the relationship between substrate and temperature as major determinants of sawtoothed grain beetle infestation and substrate loss.

REFERENCES

Arthur, F.H., 2000. Immediate and delayed mortality of *Oryzaephilus surinamensis* (L.) exposed on wheat treated with diatomaceous earth: effects of temperature, relative humidity, and exposure interval. J. Stored Prod. Res. 37 (1), 13–21.

Arthur, F.H., 2001. Immediate and delayed mortality of *Oryzaephilus surinamensis* (L.) exposed on wheat treated with diatomaceous earth: effects of temperature, relative humidity, and exposure interval. J. Stored Prod. Res. 37, 13–21.

Arthur, F.H., Yue, B., Wilde, G.E., 2004. Susceptibility of stored-product beetles on wheat and maize treated with thiamethoxam: effects of concentration, exposure interval, and temperature. J. Stored Prod. Res. 40 (5), 527–546.

Astuti, L.P., Rizali, A., Firnanda, R., Widjayanti, T., 2020. Physical and chemical properties of flur products affect the development of Tribolium castaneum. J. Stored Prod. Res. 86, 101555.

Athanassiou, C.G., Kavallieratos, N.G., Boukouvala, M.C., 2016. Population growth of the khapra beetle, Trogoderma granarium Everts (Coleoptera: Dermestidae) on different commodities. J. Stored Prod. Res. 69, 72–77.

Awadalla, H. S., Guedes, R. N. C., Hashem, A. S. (2021). Feeding and egg-laying preferences of the sawtoothed grain beetle *Oryzaephilus surinamensis*: Beyond cereals and cereal products. J. Stored Prod. Res., 93, 101841.

Beckel, H.D.S., Lorini, I., Lazzari, S.M.N., 2007. Rearing method of *Oryzaephilus surinamensis* (L.) (Coleoptera: Silvanidae) on various wheat grain granulometry. Rev. Bras. Entomol. 51 (4), 501–505.

Beckett, S.J., Evans, D.E., 1994. The demography of *Oryzaephilus surinamensis* (L.) (Coleoptera: Silvanidae) on kibbled wheat. J. Stored Prod. Res. 30, 121–137.

CABI (Centre for Agriculture and Biosciences International), 2019. *Oryzaephilus Surinamensis* (Saw Toothed Grain Beetle Grain Beetle). https://www.cabi.org/isc/datasheet/37988.

CoStat Software. (2004). CoStat. www.Cohort.com. Monterey, California, USA.

Donahaye, J.E., Navarro, S., Rindner, M., 1995. Low temperature as an alternative to fumigation for disinfecting dried fruit from three insect species. J. Stored Prod. Res. 31, 63–70.

Evans, D.E., 1983. The influence of relative humidity and thermal acclimation on the survival of adult grain beetles in cooled grain. J. Stored Prod. Res. 19, 173–180.

Evans, D.E., 1987. The survival of immature grain beetles at low temperatures. J. Stored Prod. Res. 23, 79–83.

Fields, P.G., 1992. The control of stored-product insects and mites with extreme temperatures. J. Stored Prod. Res. 28 (2), 89–118.

Fields, P.G., Subramanyam, B., Hulasare, R., 2012. Extreme temperatures. In: Hagstrum, D.W., Phillips, T.W., Cuperus, G. (Eds.), Stored-product Protection. Kansas State University, Kansas, USA, pp. 297–304.

Fleming, D.A., 1988. The inflence of wheat kernel damage upon the development and productivity of *Oryzaephilus surinamensis* (L.)(Coleoptera: Silvanidae). J. Stored Prod. Res. 24 (4), 233–236.

Fraenkel, G., Blewett, M., 1943. The natural foods and the food requirements of several species of stored products insects. Trans. R. Entomol. Soc. Lond. 93, 457–490.

Govindaraj, R., Mohankumar, S., Rajasekaran, B., Mohan, S., 2014. Biology of the sawtoothed grain beetle, *Oryzaephilus surinamensis* (Linnaeus) on different stored products and its host associated genetic variability. In: Proceedings of the 11th International Working Conference on Stored Product Protection 24–28 November 2014, pp. 128–135.

Hill, D.S., 2003. Pests of Storage Foodstuffs and Their Control. Kluwer Academic Publishers, New York.

Hochachka, P.W., Somero, G.N., 2002. Biochemical Adaptation: Mechanism and Process in Physiological Evolution. Oxford University Press, New York.

Hotling, S., Haberlag, B., Tamm, M., Collatz, T., Mack, P., Steidle, J.L.M., Vences, M., Schulz, S., 2014. Identifiation and synthesis of macrolide pheromones of the grain beetle *Oryzaephilus surinamensis* and the frog *Spinomantis aglavei*. Chem. Eur J. 20, 3183–3191.

Jakubas-Zawalska, J., Asman, M., Kły´s, M., Solarz, K., 2016. Prevalence of sensitization to extracts from particular life stages of the saw-toothed grain beetle (*Oryzaephilus surinamensis*) in citizens of selected suburban areas of Southern Poland. J. Stored Prod. Res. 69, 252–256.

Jalali, M.A., Tirry, L., Arbab, A., De Clercq, P., 2010. Temperature-dependent development of the two-spotted ladybeetle, *Adalia bipunctata*, on the green peach aphid, *Myzus persicae*, and a factitious food under constant temperatures. J. Insect Sci. 10, 124.

Jalali, M.A., Tirry, L., De Clercq, P., 2009. Effects of food and temperature on development, fecundity and life-table parameters of *Adalia bipunctata* (Coleoptera: Coccinellidae). J. Appl. Entomol. 133, 615-625.

Kalushkov, P., Hodek, I., 2005. The effect of six species of aphids on some life history parameters of the ladybird *Propylea quatuordecimpunctata* (Coleoptera: Coccinellidae). Eur. J. Entomol. 102, 449-452.

Kavallieratos, N.G., Athanassiou, C.G., Boukouvala, M.C., Tsekos, G.T., 2019. Inflence of different non-grain commodities on the population growth of *Trogoderma granarium* Everts (Coleoptera: Dermestidae). J. Stored Prod. Res. 81, 31–39.

Klys, M., Przystupinska, A., 2015. The mortality of *Oryzaephilus surinamensis* Linnaeus, 1758 (Coleoptera: Silvanidae) induced by powdered plants. J. Plant Protect. Res. 55 (1).

Kramarz, P., Małek, D., Naumiec, K., Zając, K., Drobniak, S.M., 2016. Response of development and body mass to daily temperature fluctuations: a study on *Tribolium castaneum*. Evol. Biol. 43 (3), 356–367.

Latifin, M., Jalili Moghadam, M., Ramzi Jahromi, S., 2020. The survival and biological characteristics of *Oryzaephilus surinamensis* L. (Coleoptera: Silvanidae) in the feeding conditions on three date palm cultivars. Arch. Phytopathol. Plant Protect. 53 (15–16), 698–714.

LeCato, G.L., McCray, T.L., 1973. Multiplication of Oryzaephilus spp. and Tribolium spp. on 20 natural product diets. Environ. Entomol. 2, 176–179.

Locatelli, D.P., Savoldelli, S., Girgenti, P., Lucchini, G.A., Limonta, L., 2017. Can environmental dust from silo area allow the development of stored product insects? J. Stored Prod. Res. 71, 41–46.

Lü, J., Jian, F., Fields, P., 2021. Preference of *Tribolium confusum* (Coleoptera: Tenebrionidae) adults to grain patches under constant and rising temperatures. J. Stored Prod. Res. 90, 101756.

Mahroof, R.M., Hagstrum, D.W., 2012. Biology, behavior, and ecology of insects in processed commodities. In: Hagstrum, D.W., Phillips, T.W., Cuperus, G. (Eds.), Stored Product Protection. Kansas State University, Manhattan, KS, pp. 33–44.

Mallah, N.A., Sahito, H.A., Kousar, T., Kubar, W.A., Jatoi, F.A., Shah, Z.H., 2016. Susceptibility of different varieties of stored date palm fruits infested by saw tooth grain beetle, Oryzaephilus surinamensis (L. 1758) under laboratory conditions. J. Entomol. Zool. Stud. 4, 438–443.

Mathlein, R., 1961. Studies on some major storage pests in Sweden, with special reference to their cold resistance. Meddn. St. Vaxtsk Anst. 1283, l–49.

Naseri, B., Majd-Marani, S., 2020. Assessment of eight rice cultivars flour for feeding resistance to *Tribolium castaneum* (Herbst)(Coleoptera. Tenebrionidae J. Stored Prod. Res. 88, 101650.

Nika, E.P., Kavallieratos, N.G., Papanikolaou, N.E., 2020. Developmental and reproductive biology of *Oryzaephilus surinamensis* (L.)(Coleoptera: Silvanidae) on seven commodities. J. Stored Prod. Res. 87, 101612.

Nurul, A. H., & Noor, M. A. (2019). Food Preference of (Coleoptera:) to Different Types of Plant Products. Malaysian Journal of Halal Research, 2(2), 53-57.

Papachristos, D.P., Katsarou, I., Michaelakis, A., Papanikolaou, N.E., 2015. Influence of different species of aphid prey on the immature survival and development of four species of *aphidophagous coccinellids* (Coleoptera: Coccinellidae). Eur. J. Entomol. 12, 440-445.

Papanikolaou, N.E., Milonas, P.G., Kontodimas, D.C., Demiris, N., Matsinos, Y.G., 2013. Temperature-dependent development, survival, longevity and fecundity of *Propylea quatuordecimpunctata* L. (Coleoptera: Coccinellidae). Ann. Entomol. Soc. Am. 106, 228–234.

Ramadan, M. M., Abdel-Hady, A.A., Guedes, R.N.C., Hashem, A.S., 2020. Low temperature shock and chill-coma consequences for the red flour beetle (*Tribolium castaneum*) and the rice weevil (*Sitophilus oryzae*). J. Therm. Biol. 94, 102774.

Rees, D., 2004. Insects of Stored Products. CSIRO Publising, Collinwood.

Sahito, H. A., Mallah, N. A., Kousar, T., Kubar, W. A., Shah, Z. H., Jatoi, F. A., & Mangrio, W. M. (2017). Life table parameters of saw toothed grain beetle, *Oryzaephilus surinamensis* (L., 1758) on different varieties of stored date palm fruits infested under laboratory conditions. Journal of Entomology and Zoology Studies, 5(1), 95-99.

Sokoloff, A., Franklin, I.R., Overton, L.F., Ho, F.K., 1966. Comparative studies with Tribolium (Coleoptera, Tenebrionidiae) - I: productivity of *T. castaneum* (Herbst) and *T. confusum* Duv. On several commercial-available diets. J. Stored Prod. Res. 1, 295–311.

Throne, J.E., Doehlertb, D.C., McMullen, M.S., 2003. Susceptibility of commercial oat cultivars to *Cryptolestes pusillus* and *Oryzaephilus surinamensis*. J. Stored Prod. Res. 39, 213–223.

Weston, P.A., Rattlingourd, P.L., 2000. Progeny production by *Tribolium castaneum* (Coleoptera: Tenebrionidae) and *Oryzaephilus surinamensis* (Coleoptera: Silvanidae) on maize previously infested by *Sitotroga cerealella* (Lepidoptera: Gelechiidae). J. Econ. Entomol. 93, 533–536.

تأثير إختلاف الحبوب المخزونة ودرجات الحرارة على أطوار النمو ومعدل البقاء لحشرة خنفساء السورينام *Oryzaephilus surinamensis* (L.) (Coleoptera: Silvanidae).

سمير صالح عوض الله[1]، أحمد سراج الدين هاشم[2]، مروة محمود رمضان[1]، أميرة على على عبدالهادى[1] و أمنيه أسامة عبد الغنى[3]

[1]كلية الزراعة –جمعه المنصورة – قسم لحشرات الأقتصادية
[2]قسم افات الحبوب والمواد المخزونة -معهد وقاية النبات -مركز البحوث الزراعية بسخا - كفر الشيخ
[3]هيئة العامة للرقابة على الصادرت والواردات –فرع بورسعيد - مصر

الملخص

تعتبرخنفساء السورينام أفه ثانوية حيث تصيب الحبوب النجيلية ومنتجاتها والأغذية المغلفة في جميع أنحاء العالم . بخلاف تاثير حبوب النجيليات فان حشرة خنفساء السورينام تتأثر ايضا بدرجات الحرارة المختلفة . ولهذا يتم تقدير فترات النمو معدل البقاء لليرقات والعذراء خروج الحشرات الكاملة لخنفساء السورينام تحت أنواع مختلفة من الحبوب تحت تـأثير درجات الحرارة (22،28،32،38). تراوحت فترة الطور اليرقي لخنفساء السورينام بين 19.2 ±1.26 على حبوب الأرز 25.6 ± 0.98 على حبوب الذرة البيضاء.تعتبر حبوب الارز الأعلى نسبة لبقاء اليرقات حيث سجلت (95%) يليها حبوب الشوفان (90%) والقمح (89 %) على التوالى . أيضا أظهرت حبوب الأرز أعلى معدل بقاء للأطوار غير الكاملة للحشرة. سجلت أقصر فتره للطور اليرقي على درجه حرارة 38 م° يليها درجة حرارة 32 م° وذلك بفروق معنوية عالية حيث كانت 12.1±5.98 و 16.4±1.03 على التوالى . تراوحت فترة الأطوار الغير كاملة بين 22.9 يوم على درجه حرارة 38 م° و 54.2 يوم على درجة حرارة 22 م °. وقد وجد إن معدل بقاء الطور اليرقي تراوحت ما بين 62% تحت تأثير درجة حرارة 38 م° و 91% تحت تأثير درجه حرارة 32 م° . حيث سجلت أقل قيمة من خروج الحشرات تحت درجة الحررة 38 م° . حيث كانت 5.1 ±1.12 فرد. ولذلك تلعب نوعية الحبوب و درجات الحرارة المختلفة دورا هاما فى تحديد الإصابة بخنفساء السورينام والتى لها تأثير على طرق مكافحتها لهذا النوع .