JBiopest 14(2):106-118(2021)

Susceptibility of some dry date varieties to infestation with the saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.)

Esraa S.E.M. Eldeghidy[1], Shadia M. Omara[1], Hassanein[1], S.S.M., Gharib[2], M.S.A. and Sherin M.M.Y. Helaly[1]

ABSTRACT

The saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.) is considered one of the most serious insect pests which attack different stored products in all over the world. This study was carried out in the Laboratory of Plant Protection Department, Faculty of Agriculture, Zagazig University, Egypt to study the susceptibility of six dry date, *Phoenix dactylifera* (L.) varieties (Malkabi, Skooty, Pertomoda, Shamia, Dekina and Gondella) to infestation with the saw-toothed grain beetle under non-choice and free-choice conditions. Parameters of evaluation among the tested varieties as regards resistance were mean complete developmental period, number of F_1 emerged adults, susceptibility index and weight loss % after one and three months of storage. Results showed that the shortest mean complete developmental period of the insect was 28.33 days on Skooty variety, while the longest one was 33.67 days on Gondella variety in free–choice bioassay method. Dekina variety was the most preferred variety to the insect since their fruits produced the highest mean insect number of progeny (73.67 adults), whereas Skooty variety recorded the lowest mean (25.67 adults). Values of susceptibility index (SI) ranged between 4.38% for Gondella and 10.69% for Skooty. After one month of storage the percentage of wet weight loss ranged between 1.83 in Pertomoda and 10.83% in Malkabi, while after three months of storage the lowest rate was 5.83 % in Gondella variety and the highest one (25.67%) was detected in Malkabi variety. The relative wet weight loss percent reached the highest value (30.80%) in Malkabi variety and the lowest one was 5.20% in Pertomoda after one month of storage. After three months of storage, Malkabi date variety recorded the maximum value of the relative wet weight loss (28.84%), whereas the minimum value (6.55%) was recorded in Gondella variety. The results clear that all tested dry date varieties were infested with *O. surinamensis* and no immune variety was found free from the insect infestation with preferable some tested varieties to the insect.

Keywords: dry date varieties, *Oryzaephilus surinamensis* (L.), mean developmental period, progeny, weight loss%, susceptibility index.

MS History: 08.05.2021(Received)-20.08.2021(Revised)- 30.08.2021(Accepted)

Citation: Esraa, S.E.M., Eldeghidy, Shadia M. Omara, Hassanein, S.S.M., Gharib, M.S.A. and Sherin M.M.Y. Helaly. 2021. Susceptibility of some dry date varieties to infestation with the saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.).*Journal of Biopesticides*, **14**(2):106-118.

INTRODUCTION

The saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.) (Coleoptera: Silvanidae) is considered one of the most common insect pests of grains and stored products and has been found in high numbers in almost all storage facilities Beckel *et al.,* 2007**.** This insect distributed geographically in many parts of the world (Thomas, 2006) because of its small size, the shape of it is flat body and the running speed which helped the adult insects to reach the grain bags and stored materials.

The adults and larvae of this insect attack a wide range of hosts such as flour, breakfast cereals,

nuts, pastas, dried meats, candies and other similar packaged goods because of their ability as cosmopolitan invaders of packaged food Mowery *et al.* (2002).

The dates are the important product of date palm which used directly as fresh or dry in many countries, especially in the Arab region. The dry dates, *Phoenix dactylifera* (L.) are attacked by numerous pests such as *O. surinamensis*, *Tribolium castaneum* (Herbest), *Ephestia cautella* (Walker), *Tribolium confusum* (Jacquelin du val), *Plodia interpunctella* (Hubner), *Carpohilus hemipterus* (L.) and *Lasioderma serricorne* (F.), which reduce its quality as well as quantity causing weight loss during storage.

Therefore, the present investigation was carried out to study the susceptibility of some dry date varieties to infestation with *O. surinamensis*, also, some biological aspects of the insect as well as, weight loss (%) after one and three months of storage.

MATERIALS AND METHODS

Insect rearing

The adults of the saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.) were obtained from the stored grain insect pests Department, Plant Protection Research Institute, A.R.C., Dokki, Giza, Egypt. The stock cultures were set up by introducing about three hundred adults of the insects in glass jars of 2kg capacity, half filled with sterilized and conditioned diet composed of wheat flour, crushed wheat and dry yeast powder at 5:5:1, respectively according to the method described by Leelaja *et al.* (2007) and tightly covered with muslin cloth, held in place by rubber bands and the adults allowed to oviposit for two weeks, then removed by sieving. The glass jars were labelled and kept in an incubator adjusted at 29±1ºC and 65±5% R.H. in the laboratory of Plant Protection Department, Faculty of Agriculture, Zagazig University.

Eggs collection

The eggs of *O. surinamensis* were obtained by placing about 500-1000 adult beetles in one half-kg jar containing 500g rearing medium which was mentioned before. After 24hrs eggs and adults were separated from the crushed wheat without dust by sieving through US standard sieves of 212-710mm, then the eggs were easily removed by using a sieve with very fine holes and afterwards the eggs were easily placed on a black cardboard using a fine camel hair brush and then were placed within small petri dishes for the experimental use. Large numbers of eggs from 0-2 days old were obtained to use in the biological studies of the present study.

Tested varieties

In this investigation, six cultivars of dry dates [*Phoenix dactylifera* (L.)] produced in Upper Egypt as Aswan was selected. They were Malkabi, Skooty, Pertomoda, Shamia, Dekina and Gondella which were bought from Aswan. All varieties were sterilized in a deep freezer running at –18ºC for two weeks to kill any internal hidden insect stages and then conditioned for two weeks at 29±1ºC and 65±5% R.H. to be equilibrated with the test conditions.

Biological aspects

Incubation period

Three replicates were made, each with thirty freshly laid eggs of *O. surinamensis* at the age of 0-4hrs Each replicate was placed in a small plastic cup (2.0cm base diameter and 1.30cm height) which was fixed in the center of a large plastic petri dish (9cm in diameter). The outer rim of the inner surface of petri dish contained small pieces of each tested dry date variety as a trap of any hatched larva (Chakma, 2014). All these replicates were examined daily to observe the presence of any hatched and neonate larvae to record the incubation period and finally calculate the hatchability percent from the larvae number in respect to the original eggs number.

Larval and pupal duration

Newly hatched *O. surinamensis* larvae old 0-4 hrs were obtained to infest six groups of fifteen replicates of each dry date variety. 0.2 gram from each variety was put in clear penicillin glass (2×4.5cm) and infested by one newly hatched larva. Each glass was covered with small holed plastic cover (Chakma, 2014). All these replicates

were kept at the constant conditions of 29±1°C and 65±5% R.H. Daily observations were made to observe the progress of the larval development and afterward calculating the larval, pupal and complete developmental periods on each tested variety.

Susceptibility

The susceptibility of the six dry date varieties to infestation with O. *surinamensis* was tested by two methods. The first one was non-choice method; twenty grams from each date variety were placed separately in glass jars (250mL). Five pairs of *O. surinamensis* adults (1-3 weeks old) were separated according to (Halstead 1963) and placed into a small vial and tightly covered with muslin carefully and introduced to each jar for each variety, four replicates were used and incubated at constant conditions of 29±1^{O}C and 65±5% RH. The adults were allowed to oviposit for two weeks then removed.

The second test was free-choice method, in order to estimate the preference and the development of *O. surinamensis* on the tested six date varieties, 20g of dates from each variety were placed alone in a small plate (4.30×3cm). All small plates were put in a large circular plastic plate (22×9.50cm) at equal distances from each other and from the center. Three replicates of this plastic plate were conducted. Thirty pairs of adults (1-3 weeks old) were put in the center of petri dish (5.0cm in diameter) and this dish was introduced into the center of large circular plastic plate to give the insects a free chance to choose their favorite hosts and covered well with muslin, held in place by rubber bands. The adults were allowed to oviposit freely and separated after two weeks. Jars containing the infested dates were incubated under open laboratory conditions of 29.30^{O}C and 50.28% RH until adult emergence.

The date of adult emergence was recorded in the two tests and the emerged adults (F_1) were daily separated and counted to calculate the total number of emerged adults.

To demonstrate the susceptibility of all tested date varieties to *O. surinamensis* infestation, the susceptibility index (SI) was calculated by the percentage of dividing the logarithm of the adult survival total number (Log S) by the mean developmental period (T) according to the equation provided by (Howe 1971, Dobie 1974 and Mohamed *et al.,* 2019) as follows:

Susceptibility index (SI) = [Log F_1 (Total progeny number) ÷ Mean developmental period (day)] × 100

Food preference

To study the food preference of *O. surinamensis* to some tested date varieties two methods were used. First one, twenty grams of each dry date variety was put in plastic bottles (5.30x8cm). Each bottle was infested with fifty eggs old 0-2 days and covered with muslin cloth and kept under laboratory conditions (28.34^{O}C and 47.01% RH). Each variety was replicated three times. All these bottles were covered with plastic covers to prevent escape the beetles and kept at laboratory conditions until adult emergence. The reduction of progeny, growth index, feeding debris and adult weight were calculated.

In the second method, twenty grams (about 10 fruit) of each variety which were free from insect infestation were weighed and kept in small plastic bottles (5.50×8.50cm) and infested with fifty newly hatched larvae old 0-4hrs. Each variety was replicated four times. All these bottles were covered with plastic cover to prevent escape the beetles and kept under laboratory conditions (30.53^{O}C and 55.22% RH) until emergence of the adults. The reduction of adult emergence, the growth index, percent of infested date fruits, feeding debris and its percentages were calculated. Growth index of immature stages was calculated according to equation of (Howe, 1971; Al-Dosari *et al.,* 2002; Mohamed *et al.,* 2019) as follows:

Growth index = N/D

Where, N = Larvae or eggs that become adult (%).

D = the total development time.

Weight loss (%)

In this study, twelve replicates from each dry date variety were conducted. Each replicate contained twenty grams of tested date variety into plastic jars (5.50×8cm). Six plastic jars of each variety were

infested with fifty eggs of *O. surinamensis* old 0-2 days. Three of these jars were stored for one month and the other for three months. Three plastic jars were left without any infestation (control treatment) for each tested storage period. All these jars were covered with muslin cloth, held in place by rubber bands and stored under open laboratory conditions with average of 33.44^{O}C and 43.85% RH.

At the end of each storage period (1 and 3 months) the insects had been removed and were counted and all replicates plus the control were weighed at the end of each storage period to calculate the wet weight loss. Loss in weight was calculated after one and three months on the dry weight basis of the differences between the initial and final weight after subtracting the amount of moisture content according to the equation of (El-Sayed *et al.,* 2005).

Weight loss (%) = [(Initial dry weight – Final dry weight) ÷ Initial dry weight] × 100

To determine moisture content, ten grams of each replicate dry date varieties were weighed initially (wet weight) then, the samples were dried in an oven running at 90-100^{O}C for 24hrs. After this period, these samples reweighed again to calculate wet and dry weight loss % and relative weight loss % in respect with the total mean weight loss percentage of all varieties.

Statistical Analysis

Data were statistically analyzed by using analysis of variance (ANOVA) and the differences among treatment means and their variance were determined through F. test by using SAS program (SAS 2004). Means comparison was done according to Duncan's LSD (Duncan 1955) at 5% probability level.

RESULTS

Biology of *Oryzaephilus surinamensis*

Data of the different biological parameters of *O. surinamensis* are presented in Table (1). It clearly demonstrates that the different life stages of *O. surinamensis* varied completely among the tested date varieties except, incubation period and the pupal period among the varieties which not significant and almost equal which ranged from 4.83 to 5.04 and 4.40 to 4.80 days, respectively. These results obviously indicate that the differences of date varieties have no obvious influence on both the incubation period of eggs and the pupal period. The statistical analysis of the variance demonstrated non- significant differences at 0.05 level of probability. The other biological traits as eggs hatchability percentage, larval period, larval-pupal period and the complete developmental period were significantly different.

As to the percentage of eggs hatchability, the results given in Table (1) reveal that the highest percentage of eggs hatchability (86.67%) was noticed in two varieties named Malkabi and Shamia. On the other hand, the lowest percent (66.67%) was detected with Gondella variety. Statistical analysis of these results showed that the differences among the tested varieties exhibited significancy at 0.05 level of probability.

The obtained results agree with those mentioned by (Govindaraj *et al.*, 2015; Kousar *et al.*, 2021) who reported that the hatchability of eggs varied according to date variety in different date palm varieties.

With respect to the larval period, the results showed that significant differences were appeared among the tested varieties at 0.05 level of probability. The shortest larval development period (14.20 days) was recorded with larvae which fed on Malkabi variety, whereas the longest one (18.00 days) was detected on Gondella variety which proved to be the least preferred food for this insect.

The pupal period ranged from 4.40 days in Skooty to 4.80 days in Malkabi. This result gave a clear indication that the different varieties of dry dates had no obvious influence on the pupal period. The complete developmental period from egg to adult emergence greatly varied among the different date varieties. The shortest mean developmental period was noticed on Malkabi, while the longest mean was detected on Gondella variety. The present results clearly prove that the differences between varieties were significant at 0.05 level of probability.

Table 1. Duration of the different developmental stages in days of *O. surinamensis* on some dry date varieties ± SE under constant conditions at 29±1C^{O} and 65±5% R.H.

Date Variety	Incubation period (day)	Eggs hatchability (%)	Larval period (day)	Pupal period (day)	Larval –pupal Period	Complete developmental period
Malkabi	4.96± 0.02a	86.67± 1.92a	14.20± 0.08c	4.80±0.07a	19.00± 0.07d	22.96± 0.07d
Skooty	4.96± 0.02a	83.33± 1.92ab	15.00± 0.06b	4.40± 0.03a	19.40± 0.07cd	23.36±0.07cd
Pertomoda	4.83± 0.10a	73.33± 1.92bc	15.33± 0.05b	4.47± 0.03a	19.80± 0.05bc	23.63±0.05bcd
Shamia	5.00± 0.00a	86.67± 1.92a	15.53± 0.08b	4.53± 0.04a	20.06± 0.06bc	24.06± 0.06bc
Dekina	5.04±0.02a	73.33± 1.92bc	15.67± 0.07b	4.60± 0.03a	20.27± 0.08b	24.31± 0.08b
Gondella	5.00± 0.00a	66.67± 1.92c	18.00± 0.06a	4.53±0.03a	22.53±0.08a	26.53± 0.08a
F. test	NS	*	*	NS	*	*

Means followed by similar letters indicate that the differences between means are not significant at 0.05 level of probability.

Table 2. Attraction of *O. surinamensis* adults to some dry date varieties and their susceptibility index and weight loss in free-choice bioassay method± SE under open laboratory conditions at 29.30^{O}C and 50.28% R.H.

Date variety	Females attraction (%)	Males attraction (%)	Adults attraction after 15 days (%)	MDP (day)	Progeny no.	Susceptibility index (%)	Weight loss (%)	Relative weight loss (%)
Dekina	40.00± 1.92a	41.11± 1.28a	40.56±1.40a	29.33± 0.38bc	73.67± 0.19a	6.37± 0.09c	6.75±0.08a	31.76±0.39a
Shamia	17.78± 0.64b	14.44± 0.64bc	16.11±0.32b	31.33±0.19ab	44.00± 0.33b	8.03± 0.16b	7.25±0.42a	34.12±1.96a
Pertomoda	10.00± 1.11cd	10.00± 1.11cd	10.00±0.56c	33.33± 0.38a	36.00±0.00c	4.67±0.05d	4.00± 0.00b	18.82±0.00b
Malkabi	8.89± 0.64d	5.56±0.64de	7.23±0.64cd	31.67± 0.51ab	30.00±0.00d	4.67± 0.07d	1.75± 0.25c	8.24±1.18c
Gondella	14.44± 0.64bc	18.89± 1.70b	16.67±0.96b	33.67± 0.69a	29.67±0.19d	4.38±0.09d	1.00± 0.17cd	4.71±0.78cd
Skooty	6.67± 1.11de	5.56±0.64de	6.12±0.64cd	28.33± 0.84c	25.67±0.51e	10.69± 0.13a	0.50±0.00d	2.35±0.00d
Out	2.22±0.64e	4.44±0.64e	3.33±0.00d	-	-	-	-	-
F. test	*	*	*	*	*	*	*	*

Means followed by similar letters indicate that the differences between means are not significant at 0.05 level of probability.

With regard to the larval and pupal periods, (Govindaraj *et al.*, 2015) reported that the larval and pupal periods ranged between 18.80–35.90 days and 4.75–6.60 days, respectively when *O. surinamensis* was reared on different date products. Moreover, Kousar *et al.* (2021) stated that the larval stage differed among the tested date varieties.

Generally, the tested dry date varieties can be arranged based on the value of the complete developmental period into three groups; the first group includes Malkabi wherein the beetle developed faster. The second group contains varieties having median developmental rate as Skooty, Pertomoda, Shamia and Dekina showing intermediate mean complete developmental periods ranged between 23.36 and 24.31 days. The third group is represented by Gondella variety on which the insect lasted the longest period (26.53 days) to emerge as adult. Statistical analysis of variance of the present results using F. test obviously indicates that the differences between means proved to be significant.

The present results are in harmony with those obtained by (Govindaraj *et al.,* 2015 and Kousar *et al.,* 2021) who cleared that the complete developmental period of the insect varied according to the tested date varieties.

Varietal resistance

Under free–choice method

The results compiled in Table (2) reveal adult male and female attraction as well as mean developmental period (MDP) and the mean number of F_1 emerged adults of the saw-toothed grain beetle reared on six different dry date varieties. With regard to the varietal effect, it was found that Dekina variety attracted more to lay more eggs showing the highest rate of adults attraction. This was proved by the highest F_1 progeny numbers. On the other varieties as Skooty which was unsuitable for the insect produced the lowest progeny number of 25.67 adults.

From the obtained results, it is worthy to mention that the differences in the studied biological characters among the date varieties proved to be statistically significant at 0.05 level of probability.

The varietal resistance of the six tested dry date varieties to the saw-toothed grain beetle was assessed on the basis of calculated value named the susceptibility index which depends on the complete developmental period and the mean number of emerged adults respecting each variety. The results concerning this parameter are given in Table 2.

All the tested date varieties were infested with the test insect but with variable degrees of susceptibility index (SI). The statistical analysis showed that the tested date varieties could be separated into four categories. The first one included Skooty which was the most susceptible variety with a value of SI equal 10.69. Gondella, Malkabi and Pertomoda having the lowest value of susceptibility index of 4.38, 4.67 and 4.67%, respectively. On the other hand, Dekina and Shamia varieties were considered moderately resistant to infestation with *O. surinamensis*.

The insect preference toward date varieties can be monitored also on the basis of the weight loss %. From the results presented in Table (2), it is clear that the percent weight loss was higher on Shamia variety and Dekina compared with the other tested varieties which ranging from 0.50% for Skooty to 4.0% for Pertomoda. The differences between weight losses (%) of the tested date varieties are significant.

Similar results were obtained in Pakistan by Shatio *et al.*, 2017; Kousar *et al.*, 2021 who studied varietal resistance of dry and semi dry varieties to saw–toothed grain beetle as well as some biological aspects of this insect pest.

Under non-choice method

Statistical analysis obviously cleared significant differences among all the tested date varieties, in respect to infestation with *O. surinamensis*, mean developmental period, progeny, and susceptibility index and weight loss %. The data presented in Table (3) clearly demonstrate that the insect completed its development on Skooty showing the shortest mean developmental period of 21.50

Table .3 Effect of some dry date varieties on some biological parameters of *O. surinamensis* under non-choice method± SE at constant conditions of 29±1^{O}C and 65±5% R.H.

Date variety	MDP (day)	Progeny no.	Susceptibility Index (%)	Weight loss (%)	Relative weight loss (%)	Mean weight / female (mg)	Mean weight /male(mg)	Mean weight /adult (mg)	Relative mean weight/ adult (%)
Malkabi	23.50±0.32cd	178.50±6.97a	9.60±0.20b	15.55±0.79a	23.69±1.20a	2.55±0.03a	2.25±0.01a	2.40±0.01a	18.39±0.08a
Skooty	21.50±0.43d	154.25±3.90b	10.43±0.15a	11.18±0.67b	17.03±1.02b	2.50±0.04a	2.18±0.01a	2.34±0.01a	17.93±0.09a
Shamia	25.50± 0.25bc	113.75± 3.51c	8.06± 0.10c	5.94± 0.11c	9.05±0.16c	2.48±0.01a	2.23±0.02a	2.36±0.02a	18.08±0.14a
Dekina	22.75± 0.13d	103.75± 1.13c	8.49± 0.07c	17.75± 0.09a	27.04±0.13a	2.50±0.03a	1.55±0.01b	2.03±0.02b	15.56± 0.12b
Pertomoda	28.50± 0.43a	92.50± 1.75c	6.92± 0.13d	7.18±0.13c	10.94±0.19c	2.48±0.02a	2.20±0.03a	2.34±0.02a	17.93±0.12a
Gondella	26.00± 0.35B	65.50± 1.45d	6.99± 0.06d	8.05± 0.04c	12.26±0.06c	1.60± 0.00b	1.55± 0.02b	1.58±0.01c	12.11±0.10c
F. test	*	*	*	*	*	*	*	*	*

Means followed by similar letters indicate that the differences between means are not significant at 0.05 level of probability

Table 4. Susceptibility of some dry date varieties to infestation with *O. surinamensis* eggs± SE under laboratory conditions of 28.34^{o}C and 47. 01% RH

Date Variety	MDP (day)	Progeny no.	Adult emergence (%)	Reduction ofprogeny (%)	Growth index	Feeding debris (%)	Mean weight / female (mg)	Mean weight /male (mg)	Mean weight / Adult (mg)	Relative mean weight / adult (%)
Pertomoda	33.00±0.33a	48.33± 0.19a	96.67± 0.38a	3.33± 0.38d	2.93±0.03d	1.00± 0.00d	1.93± 0.02a	1.57± 0.02b	1.75± 0.00b	18.46±0.00b
Shamia	26.33±0.51c	48.00±0.00ab	96.00±0.00ab	4.00±00.00cd	3.65± 0.07a	2.33±0.10a	1.67± 0.05b	0.70±0.03e	1.18± 0.04e	12.45±0.44a
Dekina	27.67± 0.51c	47.67± 0.19ab	95.33± 0.38ab	4.67± 0.38cd	3.45± 0.05ab	1.67± 0.10bc	1.60±0.03b	1.30± 0.03c	1.45±0.03d	15.29±0.30d
Gondella	28.67± 0.51bc	47.33± 0.19bc	94.67± 0.38bc	5.33± 0.38bc	3.31± 0.07bc	0.92± 0.05d	1.70± 0.03b	1.50± 0.03b	1.60±0.03c	16.88±0.35c
Skooty	28.00± 0.33bc	46.67± 0.19cd	93.33± 0.38cd	6.67± 0.38ab	3.34± 0.03b	1.33± 0.10cd	2.03± 0.02a	1.10± 0.03d	1.57± 0.02cd	16.56±0.20cd
Malkabi	30.33± 0.38b	46.33± 0.19d	92.67± 0.38d	7.33±0.38a	3.06±0.03cd	1.83±0.10b	2.07± 0.02a	1.80± 0.03a	1.93± 0.02a	20.36±0.20a
F. test	*	*	*	*	*	*	*	*	*	*

Means followed by similar letters indicate that the differences between means are not significant at 0.05 level of probability.

days, whereas the longest one was detected with Pertomoda variety. The other tested varieties showed median periods ranged between 22.75 days on Dekina and 26.00 days on Gondella. In respect to the impact of six dry date varieties on fecundity of the saw-toothed grain beetle expressed by the mean progeny number (F_1) when the insect was obligatory reared on date varieties. The data given in Table (3) clear that Gondella variety is more resistant to the saw–toothed grain beetle development and reproduction because it showed the lowest mean of progeny. On the other hand, Malkabi variety proved to be more susceptible to insect infestation showing the highest mean number of progeny.

According to the results compiled in Table 3, it is worthy to mention that the varietal resistance of the tested varieties can be dissentingly arranged according to their susceptibility index percent to the saw–toothed grain beetle as follows: Pertomoda and Gondella were the least ones followed by Shamia, Dekina, Malkabi and Skooty. Their susceptibility index values were 6.92, 6.99, 8.06, 8.49, 9.60 and 10.43%, respectively.

These findings are in harmony with those obtained by Al-Dosari *et al*., 2002; Moawad and Al-Ghamdi 2013. They reported that the susceptibility indices of different varieties of dry date to infestation with *O. surinamensis* varied in different varieties according to their resistance degree against insect infestation. They also explained these differences to be due to differences in their chemical constituents and the increasing water content.

The percentage of weight loss in the six tested varieties was given in Table 3. The results clearly showed that date varieties of Shamia, Pertomoda and Gondella had the lowest percentage of grain weight loss of 5.94, 7.18 and 8.05%, respectively due to insect infestation under non-choice conditions, whereas Dekina and Malkabi suffered from the highest infestation rates of 17.75 and 15.55%, respectively. The other tested variety named Skooty showed intermediate value of weight loss equal 11.18%.

Food preference

***O. surinamensis* eggs**

The data of the varietal susceptibility of the tested dry dates to infestation with *O. surinamensis* eggs (Table 4). Pertomoda and Shamia varieties were considered the most preferred varieties since they produced the highest F_1 progeny numbers of 48.33 and 48.00 adults, respectively. On the contrary, Skooty and Malkabi varieties produced the lowest progeny of 46.67 and 46.33 adults, respectively.

With regard to the calculated growth index value, it is worthy to mention that the tested varieties can be arranged dissentingly according to growth index values as follows: Pertomoda, Malkabi, Gondella, Skooty, Dekina and Shamia, respectively. The amount of the feeding debris ranged from 0.92 to 2.33% for Gondella and Shamia, respectively.

The Statistical analysis of the above results using F. test showed that the significant differences among the tested varieties and all of the progeny of both males and females, growth index and feeding debris were significant at 0.05 level of probability.

***O. surinamensis* larvae**

The results given in Table 5, clear the insect growth on six date varieties. The Statistical analysis of variance reveals that the date variety had significant effect on growth index of *O. surinamensis* at 0.05 level of probability. The insect was more fecund on Malkabi variety showing the highest F_1 progeny number (48.00 adults). On the other hand, Dekina, Pertomoda and Gondella produced lower progeny numbers of 45.50, 45.75 and 46.00 adults, respectively and proved to be unsuitable variety for insect growth. Present results clearly prove that the differences between progeny numbers were significant at 0.05 level of probability. The variety of the date also affected the growth period of the insect.

The growth index differed among the tested varieties and skooty was the most preferable date cultivar was followed by Pertomoda and Shamia,

Table 5. Susceptibility of some dry date varieties to infestation with *O. surinamensis*± SE larvae under laboratory conditions of 30.53ºC and 55. 22% R.H.

Date Variety	MDP (day)	Mean progeny no.	Adult emergence (%)	Reduction of progeny (%)	Growth index	Infested date fruit (%)	Feeding debris (g)	Relative feeding debris (%)
Malkabi	25.00± 0.20ab	48.00± 0.20a	96.00± 0.41a	4.00± 0.41b	3.84 ± 0.04ab	52.50±2.39ab	0.37± 0.00c	16.30±0.14b
Skooty	23.25± 0.13c	47.75± 0.24a	95.50± 0.48a	4.50± 0.48b	4.11± 0.04a	42.50± 1.25b	0.32± 0.00d	14.10±0.43d
Shamia	24.00± 0.20bc	47.50± 0.14a	95.00± 0.29a	5.00± 0.29b	3.96± 0.04a	60.00±2.04a	0.54±0.00b	23.79±0.00a
Gondella	25.50 ± 0.32ab	46.00± 0.20b	92.00± 0.41b	8.00± 0.41a	3.62± 0.04bc	45.00± 1.44b	0.20± 0.00e	8.81±0.15e
Pertomoda	22.50± 0.43c	45.75± 0.24b	91.50± 0.48b	8.50± 0.48a	4.09± 0.10a	60.00±2.04a	0.22± 0.00e	9.69±0.00e
Dekina	26.00±0.20a	45.50±0.14b	91.00± 0.29b	9.00± 0.29a	3.50± 0.03c	50.00± 2.04ab	0.62±0.00a	27.31±0.00c
F. test	*	*	*	*	*	*	*	*

Means followed by similar letters indicate that the differences between means are not significant at 0.05 %level of probability.

Table 6. Weight loss resulted from growth of *O. surinamensis* eggs on some dry date varieties after one month of storage± SE under laboratory conditions of 33.44ºC and 43. 85**% R.H.**

Date variety	Wet weight loss (%)	Relative wet weight loss (%)	Dry weight loss (%)	Relative dry weight loss (%)	Mean no. of aduts	Relative percentage of adults	Mean no. of pupae	Relative percentage of pupae	Mean no. of larvae	Relative percentage of larvae	Mean no. of total individuals	Relative percentage of total individuals	Feeding debris (%)	Relative feeding debris (%)
Pertomoda	1.83±0.19c	5.20±0.55c	3.50±0.17d	6.92±0.33d	18.00±0.33d	12.08±0.22d	6.33±0.51b	22.34±1.80b	20.67±0.38b	20.5±0.4b	45.00±0.33b	16.17±0.12b	0.22±0.03d	4.89±0.57d
Gondella	2.00±0.29c	5.69±0.82c	4.18±0.07cd	8.27±0.13cd	8.33±0.51e	5.59±0.34e	9.33±0.19a	32.93±0.68a	27.67±0.19a	27.4±0.2a	45.33±0.51b	16.29±0.18b	0.45±0.03cd	10.0±0.6cd
Shamia	2.67±0.10c	7.59±0.27c	4.62±0.12c	9.14±0.23c	29.00±0.33b	19.46±0.22b	4.33±0.19c	15.28±0.68c	12.00±0.33d	11.9±0.3d	45.33±0.19b	16.29±0.07b	0.67±0.1bcd	14.9±1.2bcd
Skooty	8.83±0.25b	25.11±0.72b	12.12±0.08b	23.97±0.16b	22.00±0.58c	14.77±0.39c	2.67±0.38b	9.42±1.36d	20.67±0.19b	20.5±0.19b	45.33±0.19b	16.29±0.1b	0.83±0.1abc	18.4±2.1abc
Dekina	9.00±0.33b	25.60±0.95b	12.7±0.13ab	25.16±0.25ab	44.00±0.33a	29.53±0.22a	2.67±0.19d	9.42±0.68d	1.67±0.19e	1.65±0.19e	48.33±0.38a	17.36±0.14a	1.00±0.17ab	22.22±3.70ab
Malkabi	10.83± 0.48a	30.80±1.37a	13.42±0.30a	26.54±0.59a	27.67±0.51b	18.57±0.34b	3.00±0.0cd	10.59±0.0cd	18.33±0.51c	18.15±0.5c	49.00±0.00a	17.61±0.00a	1.33±0.10a	29.55±2.14a
F. test	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Table 7. Weight loss resulted from growth of *O. surinamensis* eggs on some dry date varieties after three months of storage± SE under laboratory conditions of 30.83ºC and 44. 92% R.H.

Date variety	Wet weight loss (%)	Relative wet weight loss (%)	Dry weight loss (%)	Relative dry weight loss (%)	Mean no. of aduts	Relative percentage of adult	Mean no. of pupae	Relative percentage of pupa	Mean no. of larvae	Relative percentage of larva	Mean no. of eggs	Relative percentage of eggs	Mean no. of total individuals	Relative percentage of total l ndividuals	Feeding debris (%)	Relative feeding debris (%)
Gondella	5.8±0.10d	6.6±0.11d	9.8±0.28e	6.5±0.18e	119.0±1.5a	8.02±0.10e	5.3±0.19c	11.34±0.41c	22.67±1.26e	3.83±0.21e	3.33±0.19c	9.61±0.56c	150.33±2.14e	6.9±0.10e	2.00±0.17c	11.34±0.94c
Pertomoda	6.3±0.10d	7.1±0.11d	19.1±0.20d	12.5±0.13d	138.0±2.6a	9.29±0.18e	5.7±0.38c	12.06±0.82c	55.67±1.84d	9.40±0.31d	4.67±0.19c	13.47±0.56c	204.00±3.93d	9.5±0.2d	2.33±0.10c	13.22±0.55c
Shamia	14.2±0.79c	15.9±0.88c	25.0±0.98c	16.4±0.65c	230.7±6.4d	15.5±0.4d	10.7±0.7ab	22.70±1.48ab	72.00 ±3.48c	12.16±0.59c	4.33±0.19c	12.5±0.5c	317.7±4.5c	14.7±0.2c	2.97±0.02b	16.85±0.11b
Dekina	18.2±0.63b	20.4±0.71d	30.1±0.74b	19.7±0.49b	326.3±6.9b	21.9±0.5b	2.67±0.19d	5.68±0.41d	1.67±0.19f	0.28±0.03f	3.33±0.19c	9.6±0.6c	334.0±6.8c	15.47±0.32d	3.17±0.10b	17.98±0.55b
Skooty	18.8±1.08b	21.2±1.22b	31.3±0.45b	20.6±0.30b	260.3±2.2c	17.5±0.2c	10.0±0.3b	21.27±.0.71b	200.00±2.03b	33.78±0.34b	7.00±0.67b	20.2±1.9b	477.3±3.9b	22.12±0.18b	3.33±0.10ab	18.89±0.55ab
Malkabi	25.7±0.84a	28.8±0.94a	36.9±1.55a	24.3±1.02a	410.3±1.4a	27.6±0.1a	12.7±0.2a	26.95±0.41a	240.00±1.67a	40.54±0.28a	12.00±0.33a	34.6±0.9a	675.0±0.7a	31.27±0.03a	3.83±0.10a	21.72±0.55a
F. test	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Means followed by similar letters indicate that the differences between means are not significant at 0.05 level of probability.

reaching 4.11, 4.09 and 3.96, respectively, while Dekina, Gondella and Malkabi obstructed the larval growth, so it was recorded the lowest growth index being 3.50, 3.62 and 3.84, consecutively.

These results agree with Mowad and Al- Ghamdi 2013 who reported that the growth index of immature stages increased in the most susceptible cultivars (Sukari) but reduced in the resistant ones (Deglet Noor and Ajwa). As shown in Table 5, the amount of the feeding desbris ranged from 0.20 to 0.62 g for Gondella and Dekina, respectively.

Weight loss (%)-After one month of storage

The results of Table (6) clearly demonstrate the mean number of larvae, pupae and adults as well as, the percentage of weight loss in the tested date varieties. From the obtained results, it is clear that Malkabi and Dekina varieties were more preferable for development of the immature and mature stages of saw–toothed grain beetle indicating the highest mean number of total individuals. Contrariwise, Gondella, Shamia and Skooty varieties were infested with the insect, although favored insect growth but showed equal number of total individuals. The lowest mean was recorded in Pertomoda variety.

In respect to the weight loss, data show that the percentage of wet weight loss due to the infestation with *O. surinamensis* eggs varied among the tested varieties. The highest wet weight loss percentage reached its maximum 10.83 and 9.00% for Malkabi and Dekina, respectively. Pertomoda and Gondella varieties showed the lowest one.

The highest number of adults emerged from Malkabi variety showed the highest percentage of feeding debris followed by Dekina, Skooty, Shamia, Gondella and the most resistant date variety was Pertomoda which showed the lowest percentage of feeding debris of 0.22%.

Significant differences were found among the tested date varieties in respect to number of emerged adults, total individuals, wet weight loss and the percent of the feeding debris.

Weight loss (%)-After three months of storage

The data given in Table (7) show that after three months of storage the infestation with *O. surinamensis* to dry dates increased the progeny number, a wet and dry weight loss with prolonging the storage period.

In respect of the impact of six date varieties on the saw–toothed grain beetle growth representing by the mean progeny number, the data given in Table (7) clearly show that Gondella variety seemed to be more resistant to *O. surinamensis* development and reproduction showing the lowest mean number of total individuals. On the other hand, Malkabi variety proved to be more susceptible to insect infestation showing the highest mean number of individuals. The other tested varieties had intermediate numbers and can be descendingly arranged as follows: Skooty, Dekina, Shamia and Pertomoda.

After three months of infestation the results of the percentage of weight loss in the tested date varieties showed significant differences. In respect to the percentage of wet weight loss, a wide range from 5.83% (Gondella) to 25.67% (Malkabi). The other tested varieties showed median percentages of wet weight loss ranging between 6.33 (Pertomoda) and 18.83% (Skooty). The feeding debris ranged from 2.00 to 3.83% for Gondella and Malkabi, respectively.

The differences among the tested varieties in respect to wet weight loss %, dry weight loss %, progeny number and feeding debris proved to be statistically significant at 0.05 level of probability. The previous differences might due to differences in the chemical composition among the tested varieties.

The present results are in agreement with those obtained by some authors such as Metwally *et al.,* 2007 who cleared that the weight loss of dates caused by *O. surinamensis* reached 4.5% / kg after one month of storage. Also, Hussain 2008 demonstrated that weight loss of Firihi date infested with *O. surinamensis* was 12.47% after one month of storage. Govindan and Nelson 2009 showed that weight loss in paddy grains infested with *Sitophilus oryzae* L. were 39.21% after 45

days from infestation. Moawad and Al- Ghamdi 2013 showed that the highest rate of the weight loss in the tested date cultivars caused by infestation of saw–toothed grain beetle, was for Barhi followed by Barni Al Madina, Rushodia and Sukari which ranged between 62.7 to 43.7% after six months, while the least weight loss was recorded to Deglet Noor and Ajwa, recording 11.6 and 21.5% after six months.

In conclusion, from the results mentioned above, it is clear that all tested date varieties were infested with the test insect and the differences in the biological parameters of the insect could be attributed to physical date characters as color, texture and size. Also, the chemical constituents of the selected date varieties might also be responsible of differences in duration of development larval and pupal growth, progeny number, susceptibility index as well as the weight loss. The longer storage period for three months affected the insect infestation, the insect productivity and amount of the weight loss (%) compared to the storage period for one month.

REFERENCES

Al- Dosari, A., A. Saleh, A., Suhaibani, M.A. and Ali, A.G. 2002. Susceptibility of some dry date palm varieties to infestation by *Oryzaephilus surinamensis* (L.) (Coleoptera: Silvanidae) in relation to their chemical composition. *Assiut Journal of Agricultural Sciences (Egypt),* **33** (2): 187-193.

Beckel, H., Lorini, I. and Lazzari, S. 2007. Rearing Method of *Oryzaephilus surinamensis* on various wheat grain granulometry. *Revista Brasileira de Entomologia,* **51**(4): 501-505.

Chakma, A. 2014. A study on the biology of cigarette beetle, *Lasioderma serricorne* (F.) and its damage assessment in different spices. Doctoral dissertation, Depatment of Entomology. Shere-Bangla Agricultural University, Dhaka, 61**PP**.

Dobie, P. 1974. The laboratory assessment of the inherent susceptibility of maize varieties to post- harvest infestation by *Sitophilus zeamais* (Mostch.)(Coleoptera: Curculionidae). *Journal of Stored Product Research,* **10**(3-4): 183-197.

Duncan, D.B. 1955. Multiple range and multiple F tests. *Biometrics,* **11**: 1-42.

EL-Sayed, F.M.A., Ali, M.A.M. and EL-Beshlawy, H.M.I. 2005. Effect of storage and controlled temperatures on infestation potenial, food consumption, damage and weight loss of cowpea and faba been seeds infested with *Callosobruchus maculatus* (F.). Egypt. *Journal Agriculture Research,* **83**(2): 609-625.

Govindan, K. and Nelson, S. J. 2009. Insecticidal activity of plant powders on mortality, adult emergence of *Sitophilus oryzae* L. and grain weight loss in paddy. *Journal of Biopesticides*, **2**(2): 169 – 172.

Govindaraj, R., Mohankumar, S., Rajosekaran, B. and Mohan, S. 2015**.** Biology of the saw-toothed grain beetle, *Oryzaephilus surinamensis* (Linnaeus) on different stored products and its associated genetic variability. 11th International Working Conference on Stored Product Protection, Tamilnadu, India: 128-135.

Halstead, D.G.H. 1963. External sex differences in stored – products coleoptera. *Bulletin of Entomological Research,* **54**(1): 119–134.

Howe, R.W. 1971. A parameter for expressing the suitability of an environment for insect development. *Journal Stored Product Research,* **7**: 63-65.

Hussain, H.B.H. 2008. Using some safe methods in controlling certain insect pests of stored dates. Ph.D. Thesis, Al – Azhar University.

Kousar, T., Memon, Z.N., Sahito, H.A., Mangrio, W.M., Jatoi F.A. and Shah, Z.H. 2021. Biology, morphology and varietal distribution of saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.) on date palm dry and semi-dry dates at district: Khairpur, Sindh – Pakistan. *Pure and Applied Biology,* **10**(3): 539-584.

Leelaja, B.H.Y., Rajashekar, Y. and Rajendran, S. 2007. Detection of eggs of stored-product

insects in flour with staining techniques. *Journal Stored Product Research*, **43**: 206-210.

Metwally, M.M., Ali, M.A. and Hussain, A.R.E. 2007. Estimation of losses in stored semi – dry and dry date during storage. The fourth symposium on Date Palm in Saudi Arabia, 18–21 Rabi– 11, 1428, 5-8 May.

Moawad, S.S. and Al- Ghamdi, F.F. 2013. Susceptibility of some dry date cultivars to infestation by *Oryzaephilus surinamensis* (L.) (Coleoptera: Silvanidae). *American Journal of Experimental Agriculture*, **3**(3): 651– 663.

Mohamed, E.M., Abdelmonem, A.E., Gharib, M.S.A. and Hafez, S.F. 2019. Susceptibility of some cowpea seed varieties to two storage bruchid infestation. *Journal Agriculture Research,* **79**(1):121-136.

Mowery S.V., Mullen, M.A., Campbell, J.F. and Broce, A.B. 2002. Mechanisms underlying saw-toothed grain beetle [*Oryzaephilus surinamensis* (L)] (Coleoptera: Silvanidae). infestation of consumer food packaging materials. *Journal of Economic Entomology,* **95**: 1333-1336.

SAS 2004**.** Software program for the design and analysis of agronomic research experiments. Statistics SAS Institute Inc, Cary, NC.

Shatio, H.A., Mallah, N.A., Kousar, T., Kubar, W.A., Shah, Z.H. Jatoi, F.A. and 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.

Thomas, M.C. 2006**.** Division of Plant Industry. Univ. of Florida. EEENY 188.

Esraa S.E.M. Eldeghidy[1], Shadia M. Omara[1], Hassanein[1], S.S.M., Gharib[2], M.S.A. and Sherin M.M.Y. Helaly[1]

[1]Plant Protection Department, Faculty of Agriculture, Zagazig University, Zagazig, Egypt.

[2]Stored Grain insect pests Department, Plant Prot. Res. Institute, ARC, Egypt.

Communication author

abdelraheem_nrc@hotmail.com