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BIOLOGICAL STUDIES ON THE CIGARETTE BEETLE, *Lasioderma serricorne* (F.) ON DIFFERENT BOTANICAL FOODS

Sarah H. El-Fouly[1*], I.M. Kelany[1], Shadia M. Omara[1], S.S.M. Hassanein[1], M.S. Gharib[2] and Gamila Sh. Seleem[1]

1. Plant Prot. Dept., Fac. Agric., Zagazig Univ., Egypt.

2. Stored Grain insect pests Dept., Plant Prot. Res. Inst., ARC.

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ABSTRACT: The cigarette beetle, *Lasioderma serricorne* (F.) is a serious economic insect pest of many stored products, spices and dried fruits. This work was carried out in the Laboratory of Plant Protection Department, Faculty of Agriculture, Zagazig University, Egypt, to study the effect of eight different botanical foods as insect diets (standard insect rearing diet, wheat germ, oat grains, cumin seeds, corn flakes, chamomile flowers, roselle flowers and fenugreek seeds) on some biological aspects of this insect, population growth after one and three months as well as percentage of weight loss. Also, the effect of the heavy insect infestation on certain chemical constituents of the tested foods as food moisture content, total carbohydrates, total proteins, ash, total fats and total fibers was determined and compared to control after three months of storage. The standard insect rearing diet and wheat germ were the best foods since the insect larval period was very short (14.45 and 15.36 days, respectively), while fenugreek was less preferred food as larval diet (30.55 days). Pupal period ranged from 7.18 to 11.81 days on wheat germ and corn flakes, respectively. The shortest complete developmental period was 30.67 days on wheat germ and the longest one was 53.21 days on fenugreek seeds. Values of the susceptibility index ranged from 3.03 to 8.08% for fenugreek seeds and wheat germ, respectively. The standard insect rearing diet and wheat germ were the best food kinds since they produced the highest mean progeny number after one and three months of storage (204.33, 151.67 and 3151.30, 4313.30 adults, respectively). Mean weight loss percentage ranged from 0.52 to 5.20% on corn flakes and oat grains after one month from insect infestation, respectively. However, it reached its maximum value (31.13%) on the standard insect rearing diet and minimum value on cumin seeds (1.23%) after three months. The highest relative weight loss per each adult insect was 23.75% on chamomile flowers and the lowest one valued 2.66% on corn flakes after one month of storage. After three months the value increased on corn flakes, standard insect rearing diet, roselle flowers and cumin seeds, while decreased on the other tested food kinds. A positive correlation was found between the heavy insect infestation on some foods and the chemical constituents as moisture content, total carbohydrate, total proteins, total fats, ash and total fibers. In contrast a negative one was recorded on the other foods. Positive correlation coefficients with all tested chemical constituents on sound and infested foods were detected by highly significant for total carbohydrates and total proteins as well as significant for total fats. The heavy insect infestation increased both the progeny number and the incurred weight loss and affected the chemical constituents of the different tested food kinds compared to control. All tested food kinds were infested by the cigarette beetle *L. serricorne* and no immune food was found free from the insect infestation with preferable some tested food kinds to the insect. Moreover, the heavy insect infestation after three months affected the chemical constituents of the tested food kinds.

Key words: Botanical foods, *Lasioderma serricorne* (F.), biological aspects, population growth, susceptibility index, weight loss, food chemical constituents.

*** Corresponding author: Tel.:** +201066470200
E-mail address: s_hm248@yahoo.com

INTRODUCTION

The cigarette beetle, *Lasioderma serricorne* (F.) has gained a wide distribution through commerce and nowadays is found throughout the tropical and subtropical parts of the world. The adult beetle is small (2.0-3.7mm), reddish brown in color, and its head is retracted under the front part of the body. Distinguishing characteristics include the smooth elytra and serrate antennae **(Croats, 1978)**. Cigarette beetles are slow flyers and can easily be spotted when flying. *L. serricorne* females oviposit directly onto the dried materials. The eggs are pearly white and elongated and hatch in 6-8 days. The larvae are 3 mm long, C-shaped, greyish white and thinly covered with fine brown hairs. When growth is completed, the larva transforms into an inactive pupa and emerges a fully developed beetle in about 7 days in summer and 14-18 days in the cooler weather conditions of spring and autumn. The complete life cycle of *L. serricorne* spans about 45-70 days, and 3-6 generations occur per year, depending on the food availability, as well as temperature and humidity **(Edwards *et al.*, 1980).** Huge populations of *L. serricorne* can build up very quickly since a protected breeding pair can produce about 2000 offspring in four months **(Howe, 1957).**

The tobacco beetle, *L. serricorne* belongs to order: Coleoptera and family: Anobiidae, and is considered as one of the most serious economic insect pests of stored grain products **(Runner, 1919; Ashworth, 1993; Shinoda and Fujisaki, 2001; Papadopoulou and Buchelos, 2002; Hori *et al.*, 2011; Naveena *et al.*, 2019),** herbarium **(Retief and Nicholas, 1988),** foodstuffs, stored tobacco, cocoa, ground chili, paprika, cayenne pepper and spices **(Powell, 1931; Blanc *et al.*, 2006; Mahroof and Phillips, 2008)**, turmeric **(Nischala and Prasad, 2017)**. Also, this insect infest and damage fenugreek, coriander, cumin, fennel, celery, carom and dried red chili **(Chakma, 2014)** and one of the most common insects that damage stored products such as dried and processed materials of animal origin, nuts, herbs, spices, grains and grain products **(Boatseng *et al.*, 2017)**. Therefore, the present work has been conducted to study the effect of eight different botanical foods on some biological aspects of *L. serricorne*, its progeny number and weight loss after one and three month of storage, as well as the changes in the chemical constituents of different tested foods due to insect infestation under the laboratory conditions were determined.

MATERIALS AND METHODS

Insect Rearing

The cultures of the cigarette beetle, *L. serricorne* were started using one hundred adult insects obtained from the stored grain insect pests Department, Plant Protection Research Institute, ARC, Dokki, Giza, Egypt. The insects were reared on a diet composed of wheat flour and dry yeast powder (95:5%), respectively within flat plastic dishes (35×18×25 cm) at the Department of the Plant Protection, Faculty of Agriculture, Zagazig University, Egypt. The rearing was carried out under controlled conditions at 28±2°C and 65±5% relative humidity within an electrical incubator. Cocoons appear and can be seen easily as small chambers on the sides of the petri dishes. The new progeny started to emerge after four weeks. Dishes were observed daily for adult emergence and adults less than 1-day old were collected for all tests. Males and females were separated during the pupal stage according to the characteristics described by **Halstead (1963)**.

Eggs Collection

To collect large numbers of the insect eggs, many newly emerged adults were placed inside jam jars containing many pieces of black cloth **(Fletcher, 1977; Yu, 2008)**. Folded in a zigzag form and fastened together with support of metal pins. The female prefers lay eggs within the black cloth either singly and/or in small random groups. Eggs were easily removed daily using fine camel hair brush and then were placed within small petri dishes for the experimental use as mentioned by the same previous author. Large numbers of eggs less than 1-day old were obtained for the biological studies and were incubated in petri dishes until cocoons formation.

Tested Food Kinds

Eight different botanical foods were selected as insect diet for *L. serricorne* growth and development. The common, scientific, family names and the used parts of the selected foods were shown in Table 1. Foods were sterilized in a deep freezer at -18°C for two weeks to obtain foods free from any internal hidden pests. The tested foods were placed within the incubator for two weeks maintained at 28±2°C, 65±5 % RH to be equilibrated with the test conditions.

Biology on Different Food Kinds

Incubation period

Five replicates were used with fifty freshly laid eggs per each at the age of 0-18 hours. Each replicate was placed into a small plastic cup (1.5cm base diameter, and 0.7cm height) fastened within the center of a large glass petri dish (9cm in diameter). The inner rim of the larger petri dish contained a thin film of the larval food kind diet as a trap of any hatched larva (**Chakma, 2014**). All replicates were examined daily for eggs hatch to record the incubation period.

Larval-pupal growth duration on different food kinds

The hatched larvae were collected at less than 1-day old, used to infest groups of twenty five replicates of each food type. About 0.2g from each food type was placed into small plastic cup (2×5cm) and infested by one larva of the first instar. The cups covered with small holed plastic cover to allow air ventilation (**Chakma, 2014**). All replicates were incubated within an incubator at 28±2°C and 65±5% RH. The replicates were examined daily for observing the progress of larval development under a binocular microscope to record dates of the pre-pupal and pupal formation as well as adult emergence for calculating the larval, pre-pupal, pupal and complete developmental periods on each food kind.

Food preference on different food kinds under non-free choice bioassay

Five replicates were used from each food kind that mentioned above. Each replicate contained 30g which placed within a plastic cup (9×5 cm). Each replicate was infested with five pairs of *L. serricorne* newly emerged adults. The adults were allowed to oviposit for 10 days, and then removed. The cups were left undisturbed for further two weeks and then inspected daily for recording duration of the first generation. Progeny was removed daily and sex ratio was determined at the end of adult emergence. Sex ratio was determined by dividing the total number of males by the total number of females. The total number of progeny and the relative progeny percentage were calculated for each female. The suitability of the selected foods for insect growth was determined by calculating the susceptibility index (SI) according to equations mentioned by **Howe (1971)**, **Dobie (1974)**, **Al-Dosari *et al.* (2002), Salama and Youssef (2004), Mohamed *et al.* (2019)** as follows:

Susceptibility index (SI) = Log F1 (Total progeny number) ÷ Mean developmental period (day) ×100

Population Growth and the Resultant Weight Loss from the Different Food Kinds

Sixteen replicates from each food type were designed. Each one contained fifty grams of food kind placed into plastic jars. Eight plastic jars of each food kind were infested by three pairs of 0-1 day old adults. Four of them were stored for one month and the other for three months. Four plastic jars were left without infestation as control for each storage period (one and three months). All replicates were covered firmly with muslin cloth and fastened well by rubber bands and stored at laboratory condition (27-33°C and 60-75% RH).

After one month, all groups were inspected before appearance of the new progeny to remove all dead parent adults. Plastic jars of the first group, one month of storage were inspected daily for removing and counting the new progeny to prevent new females from laying more eggs.

All replicates of the various storage periods and the control were weighed at the end of each storage period to calculate the weight loss. Loss in weight was calculated after one and three months on the dry weight basis from the differences between the initial and final weight after subtracting the amount of moisture according to the method described by **Moawad and Al-Ghamdi (2013) and Kemabonta *et al.* (2020)**. Moisture content was determined by

Table 1. Common, scientific and family names with the used parts of the tested food kinds

No.	Common name	Scientific name	Family name	Used part
1	Chamomile	*Matricaria chamomilla* L.	Asteraceae	Flowers
2	Cumin	*Cuminum cyminum* L.	Apiaceae	Seeds
3	Fenugreek	*Trigonella Foenum-graecum* L.	Leguminosae	Seeds
4	Roselle	*Hibiscus sabdariffa* L.	Malvaceae	Flowers
5	Oat	*Avena sativa* L.	Poaceae	Grains
6	Wheat germ	*Triricum aestivum* L.	Gramineae	Germ
7	Corn flakes	*Zea mays* L.	Gramineae	Flakes
8	Standard insect rearing diet	*Triticum aestivum* L. and *Saccharomyces cerevisiae* H.	Gramineae and Saccharomycetaceae	Flour (95%) and dry yeast (5%)

drying homogenous weighed samples of each food kind in the oven at 100°C for 24 hr. The weight of samples after drying was recorded for calculating mean weight loss percentage from the weight differences on the dry weight basis and relative weight loss percentage as compared with the total mean weight loss percentage of all foods. Mean weight loss caused by each insect was calculated by dividing the total gross weight loss by the total progeny number from each food kind.

Weight loss (%) = [(Initial dry weight - final dry weight) ÷ Initial dry weight] ×100

Mean weight loss/adult (mg) = Weight loss (mg) ÷ Number of progeny

Chemical Constituents of Different Infested Food Kinds

After three months of storage, the chemical changes in the constituents of the infested and uninfested food kinds were determined. The percentages of moisture content, total carbohydrates, total proteins, ash, total fats and total fibers of both infested and uninfested foods were determined according to **AOAC (2000)**.

Statistical Analysis

Data obtained were statistically analyzed by the analysis of variance (ANOVA) test by using SAS program **(SAS, 2004)**. Simple correlation coefficient was calculated according to **Hendy (1969)** means comparison was done according to Duncan's LSD (**Duncan, 1955)** at 5% probability level.

RESULTS AND DISCUSSION

Biology of *L. serricorne* on Different Food Kinds

Different developmental periods of *L. serricorne* were greatly influenced by food kinds as shown in Table 2. Incubation period had the same value 5.40 days on the tested foods. The tested food kinds high significantly influenced larval, pre-pupal, pupal and the complete developmental periods. The standard diet and the wheat germ were the best preferred food kinds for the larval period since the larvae spent the shortest periods (14.45 and 15.36 days), respectively. Fenugreek and chamomile were the less preferred foods of the larval period where was the longest periods 30.55 and 27.09 days, respectively.

As to the pupal period, wheat germ and the standard diet were the best preferred foods for pupal period where it was 7.18 and 7.72 days, respectively, while corn flakes and chamomile were less preferred foods of pupal period (11.81 and 11.45 days, respectively). The complete developmental period was shorter on the wheat

Table 2. Incubation, larval, pre-pupal, pupal and complete developmental periods of *L. serricorne* as influenced by different food kinds

Food Kind	Incubation period± SE (day)	Larval period± SE (day)	Pre-pupal period± SE (day)	Pupal period± SE (day)	Complete developmental period± SE (day)
Wheat germ	5.40±0.20	15.36±0.20^{g}	2.72±0.30^{f}	7.18±0.30^{f}	30.67±0.24^{g}
Standard diet	5.40±0.20	14.45±0.20^{h}	3.45±0.20^{e}	7.72±0.10e^{f}	31.04±0.28^{g}
Oat grains	5.40±0.20	17.18±0.20^{f}	2.81±0.20^{f}	8.18±0.40d^{e}	33.58±0.33^{f}
Roselle flowers	5.40±0.20	20.91±0.20^{e}	4.36±0.20^{d}	8.64±0.20^{d}	39.31±0.41^{e}
Cumin	5.40±0.20	22.27±0.40^{d}	5.36±0.30^{c}	9.45±0.40^{c}	42.95±0.34^{d}
Chamomile flowers	5.40±0.20	27.09±0.30^{b}	5.36±0.30^{c}	11.45±0.20^{ab}	49.31±0.28^{c}
Corn flakes	5.40±0.20	24.27±0.80^{c}	9.91±0.20^{a}	11.81±0.30^{a}	50.58 ±0.70^{b}
Fenugreek seeds	5.40±0.20	30.55±0.30^{a}	6.36±0.30^{b}	10.91±0.50^{b}	53.21±0.40^{a}
F. test	-	*	*	*	*

Means in the same column followed by different letters are significantly different (at p<0.05) when analyzed using ANOVA and separated by Duncan test.
* = Significant difference.

germ than the standard diet (30.67 and 31.04 days, respectively) and longer on fenugreek than corn flakes (53.21 and 50.58 days, respectively).

Also, the obtained results in Table 2 show that the differences among the tested foods in respect to larval, pre-pupal, pupal and complete developmental periods were significant.

In addition, results of Table 2 classified the tested foods into two main groups. The first group included wheat germ, standard diet, oat grains and roselle flowers which were the most preferred foods of larval and pupal growth. The second group contains cumin seeds, corn flakes, chamomile flowers and fenugreek seeds as unsuitable foods for the larval and pupal growth. No completely immune food was found completely immune against the insect infestation.

The obtained results of the incubation period mentioned above are comparable with the results obtained by **El-Halfawy (1977)** who found that the incubation period was not affected by the diet on which the insect was bred. However they disagree with those recorded by **Naveena *et al.* (2019)** who indicated that the incubation period ranged from 7.0 to 9.9 days on dried yeast and cigar tobacco, respectively. Also, **Al-Obaidy *et al.* (2019)** mentioned that incubation period ranged from 6 to 10 days when the insect was reared on the baker's yeast. In respect to larval and pupal periods, **Ali *et al.* (1974)** stated that larval periods were affected by kind of the larval food and were markedly retarded on ginger. **Al-Obaidy *et al.* (2019)** reported that larval period differed largely among the tested foods and ranged from 23.8 to 79.8 days on dried yeast and chewing leaf tobacco but on the rearing insect diet (composed of wheat flour and dried yeast) it reached 28.5 days and the pupal period was 7.7 days. Moreover, **Naveena *el al.* (2019)** stated that pupal period ranged from 7.3 to 14.7 days on the wheat flour admixed with dried yeast powder and chilli powder, respectively.

Results presented in Table 3 show that oat grains, wheat germ and corn flakes considered the most preferred foods and produced the highest F_1 progeny numbers of 316.50, 304.00 and 302.50 adults, respectively. Fenugreek seeds and roselle flowers produced the lowest progeny of 41.75 and 100.75 adults, respectively.

Table 3. Mean progeny number, relative production, susceptibility index and sex ratio of *L. serricorne* on some different food kinds after one generation

Food kind	Mean number± SE of				Relative progeny (%± SE) / female	Susceptibility index (SI) (%± SE)	Sex ratio± SE
	Male	Female	Total progeny	Total progeny / female			
Wheat germ	172.67±13.30^{a}	131.33±10.96^{b}	304.00±23.51^{a}	60.80±4.70^{a}	17.65±1.45^{a}	8.08 ±0.12^{a}	1.32 ±0.05^{b}
Standard diet	100.00±10.26^{d}	154.00 ±5.34^{a}	254.00±13.39^{b}	50.80±2.68^{b}	14.70±0.41^{b}	7.74 ±0.12^{b}	0.63 ±0.06^{d}
Oat grains	150.75±9.80^{ab}	165.75±4.20^{a}	316.50±8.30^{a}	63.30±1.66^{a}	18.37±0.53^{a}	7.45 ±0.09^{c}	0.91±0.07^{cd}
Roselle flowers	66.25±7.00^{e}	34.50 ±7.00^{d}	100.75±11.40^{d}	20.15±2.28^{d}	5.87±0.71^{d}	5.06 ±0.21^{e}	1.94±0.48^{a}
Cumin seeds	114.00±2.70^{d}	95.75±5.80^{c}	209.75±8.40^{c}	41.95±1.68^{c}	12.19±0.60^{c}	5.41 ±0.09^{d}	1.20±0.07^{bc}
Corn flakes	141.50±3.30^{bc}	161.00±6.80^{a}	302.50±10.00^{a}	60.50±2.00^{a}	17.56±0.68^{a}	4.88 ±0.06^{f}	0.88±0.03^{cd}
Chamomile flowers	118.00±9.10^{cd}	101.25±7.70^{c}	219.25±15.30^{bc}	43.85±3.10^{bc}	12.67±0.58^{bc}	4.74 ±0.10^{f}	1.17±0.06^{bc}
Fenugreek seeds	24.50±2.50^{f}	17.25±2.30^{d}	41.75±4.70^{e}	8.35±0.90^{e}	2.44±0.31^{e}	3.03 ±0.10^{g}	1.44±0.08^{b}
F. test	*	*	*	*	*	*	*

Means in the same column followed by different letters are significantly different (at $p<0.05$) when analyzed using ANOVA and separated by Duncan test.
* = Significant difference.
SI= Susceptibility index.
Total progeny / female = total / (5 females)

Statistical analysis obviously cleared significant differences between all tested food kinds and all of the progeny number of males, females, total progeny per female, relative progeny production (%) per female, susceptibility index and sex ratio.

The relative progeny production (%) per female was increased on oat grains, wheat germ and corn flakes (18.37, 17.65 and 17.56%, respectively). Other foods showed lower percentages and fenugreek reached the lowest one (2.44%).

Values of susceptibility index (SI) differed among the tested foods. Wheat germ, the standard diet and oat grains were the most suitable foods (8.08, 7.74 and 7.45%, respectively). Fenugreek seeds which are not suitable food recorded the lowest value (3.03%).

Sex ratio of the progeny ranged from 0.63 to 1.94% for the standard diet and roselle flowers, respectively. From the above results, it could be concluded that tested food kinds affected the biological parameters of cigarette beetle.

Weight Loss Percentage and the Mean Progeny Number from Different Food Kinds

The insect infestations by three pairs of *L. serricorne* after one month of storage to the eight tested foods are shown in Table 4. Standard diet produced the highest mean progeny number of (204.33 adults) and considered the most suitable and preferred food, while fenugreek seeds produced the lowest one (13.00 adults) and considered unsuitable food.

Oat grains and wheat germ suffered from the highest mean percentage of weight loss (5.20 and 4.23%, successively). The relative weight loss percentages reached its maximum (30.15 and 24.04%) on oat grains and wheat germ, respectively. Corn flakes, cumin and fenugreek seeds showed the lowest one of (3.11, 3.26 and 3.26%), respectively.

Significant differences were found among the tested foods in respect each of progeny number, mean weight loss percentage, relative weight loss percentage, mean weight loss per adult and relative weight loss per adult percentage after one month.

Table 4. Mean progeny number and weight loss of *L. serricorne* infestation from different food kinds after one and three months of storage

Storage period	Mean progeny No.±SE		Mean weight loss (%±SE)		Relative weight loss (%±SE)		Mean weight loss / adult (mg±SE)		Relative weight loss/adult (%±SE)	
Food kind	**One Month**	**Three Months**	**One Month**	**Three months**	**One month**	**Three months**	**One month**	**Three months**	**One Month**	**Three months**
Standard diet	204.33±10.59^{a}	3151.30±38.00^{b}	2.73±0.20^{c}	31.13±1.10^{a}	15.27±1.05^{c}	47.00±1.30^{a}	6.11±0.16^{d}	5.17±0.60^{b}	6.63±0.18^{d}	16.10±1.80^{b}
Wheat germ	151.67±8.97^{b}	4313.30±102.10^{a}	4.23±0.07^{b}	12.91±0.48^{b}	24.04±0.48^{b}	19.29±0.52^{b}	13.05±0.74^{c}	1.34±0.02^{d}	14.15±0.62^{c}	4.18±0.05^{d}
Oat grains	140.67±10.20^{b}	2401.00±43.00^{c}	5.20±0.21^{a}	11.52±0.66^{b}	30.15±1.01^{a}	17.41±1.00^{b}	17.64±0.81^{b}	2.17±0.07^{cd}	19.12±0.54^{b}	6.75±0.18^{cd}
Corn flakes	106.33±8.67^{c}	143.67±11.30^{ef}	0.52±0.17^{e}	3.00± 0.21^{c}	3.11±0.63^{e}	4.56±0.28^{c}	2.46±0.44^{e}	9.55±0.38^{a}	2.66±0.42^{e}	29.70±1.40^{a}
Roselle flowers	105.33±4.41^{c}	494.67±35.40^{d}	1.33±0.07^{d}	2.80± 0.10^{cd}	6.94±0.51^{d}	3.88±0.08^{cde}	5.37±0.13^{d}	2.45±0.17^{c}	5.84±0.26^{d}	7.65±0.59^{c}
Chamomile flowers	52.00±3.79^{d}	243.00±16.40^{e}	2.47±0.13^{c}	2.67±0.57^{cd}	13.85±0.78^{c}	4.00±0.88^{cd}	21.85±0.59^{a}	4.85±0.67^{b}	23.75±1.07^{a}	15.07±2.06^{b}
Cumin seeds	113.67±8.45^{c}	234.67±26.35^{e}	0.60±0.10^{e}	1.23±0.07^{d}	3.26±0.40^{e}	1.88±0.13^{e}	5.21±0.58^{d}	2.45±0.17^{c}	5.64±0.59^{d}	7.64±0.52^{c}
Fenugreek seeds	13.00±1.53^{e}	51.67±7.80^{f}	0.60±0.10^{e}	1.37±0.15^{d}	3.26±40^{e}	2.00±0.23^{de}	20.48±0.48^{a}	4.17±0.16^{b}	22.22±0.16^{a}	12.98±0.40^{b}
F. test	*	*	*	*	*	*	*	*	*	*

Means in the same column followed by different letters are significantly different (at $p<0.05$) when analyzed using ANOVA and separated by Duncan test.

* = Significant difference

After three months of storage the mean progeny varied significantly and ranged from 4313.30 to 51.67 on wheat germ and fenugreek seeds, respectively. The mean weight loss percent increased in all tested food kinds with increased the insect progeny. The standard diet suffered the highest mean weight loss percent (31.13%) followed by wheat germ (12.91%) and oat grains (11.52%) and the lowest ones were 1.23 and 1.37% on cumin seeds and fenugreek seeds, respectively after three months of storage.

For comparison between the relative weight loss percentage after one and three months of storage the maximum percentage after one month of storage were 30.15, 24.04 and 15.27% in case of oats grains, wheat germ and standard diet, respectively, while the minimum ones were 3.11, 3.26 and 3.26% with corn flakes, cumin seeds and fenugreek seeds, respectively. The relative weight loss decreased on different food kinds after three months except corn flakes where it was 3.11 and 4.56% after one and three months of storage, successively. This is properly due to higher increase of the progeny number and competition among insects for the available food amount.

The calculated weight loss (mg) per adult in corn flakes increased from 2.46 to 9.55 mg after one and three months because corn flakes produced lower progeny number after one month and each insect have a complete good chance to consume more food from the available amount without any individual competition.

The current results are similar to those of **Howe (1957)** who mentioned that growth rate of *L. serricorne* depended upon food types. The growth rate of the cigarette beetle may be largely affected by nutritional, quality and quantity of the tested foods. **Butani (1984)** recorded cigarette beetle as a major pest of coriander in storage. **El-Din (2003)** reported that coriander seeds were the most appropriate seeds for the cigarette beetle growth which showed three generations during the period from May to October. As to the weight loss, **Hill (1983)** found that *L. serricorne* caused serious damage and weight loss on many spices. **Kohno and Ohinishi (1986)** reported that the lower percentage of weight loss in fenugreek seeds is probably due to the presence of hard seed coats which represent a natural resistant factor for deposited eggs and the subsequent larval growth. **Kant *et al.* (2013)** mentioned that damage in fennel and cumin ranged between 50 to 60% and in coriander and ajowan from 40 to 50% and in dill from 30 to 40%. Therefore, a maximum annual loss was recorded in fennel seeds (58.02%) and the minimum was found in dill seeds (39.0%). The insect population growth was related with the damage potential which a maximum of 1,142 insects was produced from fennel seeds and a minimum of 902 insects from dill seeds. **Chakma (2014)** added that *L. serricorne* caused lower percentage of weight loss reached 1.6 and 5.4% after one and three months, respectively in fenugreek seeds. Many authors as **Babarinde *et al.* (2008), Patra (2015) and Memon *et al.* (2017)** mentioned that *L. serricorne* caused serious damage and weight loss on many spices as caraway, fennel, coriander, cumin, red chilli, dandicut chilli, turmeric and **Saeed *et al.* (2015)** different tobacco types. Also, **Memon *et al.* (2017)** determined weight loss and damage caused by *L. serricorne*.

Chemical Changes in Different Food Kinds Caused by *L. serricorne* Infestation

The chemical changes in the constituents of different tested food kinds**,** after three months of infestation by *L. serricorne* were determined (Table 5). The studied chemical changes were moisture content, total carbohydrates, total proteins, ash, total fats and total fibers. The infestation by *L. serricorne* affected negatively the moisture content, total carbohydrates, ash and total fats and positively total proteins and total fibers on some food kinds. Contrast trend happened in other foods. The heavy infestation reduced the moisture content in most food kinds except wheat germ and the standard diet. This is probably due to that adult emergence makes the seeds naked and exposed for moisture loss. Total carbohydrates increased with increasing the insect infestation in oat grains, roselle flowers, fenugreek seeds, chamomile flowers and cumin seeds, from 48.29, 43.41, 33.59, 32.49 and 18.34% in uninfested food kinds to 67.10, 53.16, 44.38, 45.68 and 52.18% in infested foods, respectively. This value decreased in other foods as the standard diet, wheat germ and corn flakes.

Table 5. Changes in foods chemical constituents under infestation by *L. serricorne* after three months of storage

Chemical constituent / Food kind	Moisture content (%)		Total carbohydrates (%)		Total proteins (%)		Ash (%)		Total fats (%)		Total fibers (%)	
	Uninfested food	Infested food	Uninfested Food	Infested Food	Uninfested food	Infested food	Uninfested food	Infested food	Uninfested food	Infested food	Uninfested food	Infested food
Standard diet	1.73	5.85	74.39	72.94	12.79	11.99	1.96	2.74	7.79	6.03	1.34	0.45
Wheat germ	4.96	9.35	34.60	31.55	32.72	30.68	4.58	6.52	20.45	17.02	2.69	4.88
Oat grains	10.24	3.68	48.29	67.10	19.22	16.22	6.07	2.11	14.88	7.08	1.30	3.81
Roselle flowers	16.38	11.83	43.41	53.16	10.93	12.71	0.36	10.37	10.59	8.44	18.33	3.49
Chamomile flowers	11.86	4.34	32.49	45.68	11.49	10.96	16.36	11.97	10.66	10.19	17.14	16.86
Corn flakes	7.75	4.19	74.03	72.06	7.33	10.96	2.04	1.41	8.43	10.68	0.42	0.70
Cumin seeds	10.79	6.59	18.34	52.18	18.76	22.80	7.70	7.84	8.60	6.95	35.81	3.64
Fenugreek seeds	10.81	9.72	33.59	44.38	28.28	28.50	3.50	3.96	11.15	4.14	12.67	9.30
R1	-0.691*	0.046	0.215	-0.094	0.456	0.282	-0.200	-0.273	0.659*	0.481	-0.569	-0.336
R2	-0.791**	-0.149	0.577	0.383	0.005	-0.155	-0.272	-0.406	0.059	0.009	-0.562	-0.424
R3	0.343	-0.079	-0.238	-0.096	-0.047	0.108	0.239	-0.001	-0.429	-0.381	0.344	0.422
R4	0.324		0.783**		0.960**		0.537		0.673*		0.292	

R1: Relation between chemical constituents and progeny number.
R2: Relation between chemical constituents and dry weight loss (%).
R3: Relation between chemical constituents and incomplete developmental period (day).
R4: Relation between sound and infested food kinds.

Total proteins content decreased with the heavy infestation in the standard diet, wheat germ, oat grains and chamomile flowers from 12.79, 32.72, 19.22 and 11.49% in uninfested foods to 11.99, 30.68, 16.22 and 10.96%, respectively but increased in roselle flowers, corn flakes, cumin seeds and fenugreek seeds. Ash increased after infestation in three tested foods as the standard diet, wheat germ, roselle flowers (2.74, 6.52 and 10.73%) and decreased in oats grains, chamomile flowers and corn flakes (2.11, 11.97 and 1.41%), respectively. The total fats were reduced after infestation with lower values compared to uninfested food except for corn flacks where the opposite case was found. The percent of total fibers differed between uninfested and infested foods which decreased in most food kinds but increased in wheat germ, oat grains and corn flakes to reach 4.88, 3.81 and 0.70%, respectively.

The correlation coefficients between chemical constituents in sound and infested foods and total progeny number, weight loss and the complete developmental period was shown in Table 5. The moisture content, ash and total fibers in sound foods affected negatively on the progeny number (R1= -0.691, -0.200 and -0.569%, respectively). Heavy infestation with longer storage period for three months and the resulted progeny number correlated positively with the moisture content, total proteins and total fats (R1= 0.046, 0.282 and 0.481%, respectively) but affected negatively on the total carbohydrates, ash and total fibers (R1= -0.094, -0.273 and -0.336%, respectively).

Percentage of dry weight loss caused by *L. serricorne* infestation affected negatively on moisture content, ash and total fibers (R2= -0.149, -0.406 and -0.424%, respectively). Total carbohydrates, total proteins and total fats in uninfested foods correlated positively with the weight loss. The insect infestation after three months and resulted dry weight loss correlated positively with total carbohydrates and total fats (R2= 0.383 and 0.009%, respectively). Dry weight loss after insect infestation correlated negatively with moisture content, total proteins, ash and total fibers (R2= -0.149, -0.155, -0.406 and -0.424%, respectively). Total carbohydrates, total proteins and total fats affected negatively (R3= -0.238, -0.047 and -0.429%, respectively) and shortened the complete developmental period. Moisture content, ash and total fibers correlated positively with the growth period (R3= 0.343, 0.239 and 0.344%, respectively) in sound foods. Positive correlation coefficients with all tested chemical constituents on sound and infested foods were detected by highly significant for total carbohydrates and total proteins (R4= 0.783** and 0.960**), respectively as well as significant (R4= 0.673*) for total fats.

The obtained results agree with the findings of **Sinha (1984), Jood *et al.* (1996) and Sanchez-Marinez *et al*. (1997)** who mentioned that moisture content increased by increasing the insect infestation. As to ash, **Barney *et al.* (1991)** found that the insect infestation on maize kernels induced increasing the food ash and **Ahmedani *et al.* (2009)** cleared that *Trogoderma granarium* (E.) infestation positively affected ash level. According total proteins, some authors such as **Krzymanska and Goebiowska (1987), Sudhakar and Pandey (1987), Ahmedani *et al.* (2009) and Özkaya *et al.* (2009)** recorded that total proteins increased with increasing the insect infestation period. In terms of fibers, **Helaly (2015)** stated that the maximum percentage of fibers was recorded after 8 months of infestation by *Ephestia kuehniella* (Z.). **El-Sitiny (2016)** added that both fibers and total carbohydrate increased by *Callosobruchus maculates* F. infestation.

In the other hand the obtained results about negatively correlation between insect infestation on some foods and their tested chemical constituents are in particular agreement with the results obtained by **Krzymanska and Goebiowska (1987), Jood *et al.* (1996) and Ghareeb (1998)** who reported that insect infestation reduced fats on some foods. **Helaly (2015)** found that rice weevil effect negatively the fats content. In case of moisture content, **Ghareeb (1998)** recorded that insect infestation in wheat flour decreased by moisture content. **Kailash and Tanjore (2006)** and **Singh *et al.* (2013)** observed that insect infestation corelated negatively with the total proteins. In addition, **Helaly (2015)** stated that the infestation by *S. oryzae* reduced total carbohydrate and **Sudhakar and Pandey (1987)** added that this insect decreased ash in rice.

In conclusion, infestation by *L. serricorne* affected the chemical constituents as moisture content, total carbohydrates, total proteins, total fats, total fibers and ash. Also, it can be concluded that food kind affected the biology of the *L. serricorne* by decreasing or increasing some infestation parameters (progeny, growth and development).

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دراسات بيولوجية علي خنفساء السجائر *Lasioderma serricorne* (F.) على بعض الأغذية النباتية المختلفة

سارة حمدي الفولي[1] - إبراهيم محمد كيلاني[1] - شادية مصطفي عمارة[1]
سعد سالم محمد حسانين[1]- محروس سليمان غريب[2]- جميلة شحاتة سليم[1]

1- قسم وقاية النبات- كلية الزراعة- جامعة الزقازيق- مصر

2- قسم بحوث آفات الحبوب والمواد المخزونة ومنتجاتها- معهد بحوث وقاية النباتات- مركز البحوث الزراعية- مصر

تعتبر حشرة خنفساء السجائر من الآفات الاقتصادية الخطيرة والتي تصيب العديد من المنتجات المخزونة والتوابل والفواكهة المجففة. تم إجراء هذا البحث في معمل قسم وقاية النبات، كلية الزراعة، جامعة الزقازيق، مصر، لدراسة تأثير تغذية الحشرة علي ثمانية عوائل غذائية مختلفة هي جنين القمح، حبوب الشوفان، بذور الكمون، كورن فليكس (رقائق الذرة)، أزهار البابونج، أزهار الكركديه، بذور الحلبة وبيئة التربية القياسية للحشرة (95 % دقيق قمح + 5% خميرة جافة) علي بعض الخصائص البيولوجية للحشرة وعلى نمو التعداد وكذلك نسبة الفقد في الوزن بعد شهر وثلاثة شهور من التخزين. بجانب دراسة تأثير الإصابة الحشرية على بعض المكونات الكيميائية مثل نسبة كل من المحتوي الرطوبي للغذاء، الكربوهيدرات الكلية، البروتين الكلية، الرماد، الدهون الكلية والألياف الكلية بعد ثلاثة شهور من الإصابة ومقارنتها بتلك الموجودة في الأغذية غير المصابة، وجد أن بيئة التربية القياسية وجنين القمح هما أفضل أنواع الأغذية لنمو الطور اليرقى حيث كانت فترة النمو اليرقي قصيرة جداً (14.45 و15.36 يومًا على التوالي)، بينما كانت بذور الحلبة من الأغذية الأقل تفضيلاً لنمو الطور اليرقي حيث وصلت فترة النمو اليرقي لحوالى شهر (30.55 يوماً)، تراوحت فترة نمو طور العذراء بين 7.18 و 11.81 يوماً علي كل من جنين القمح وكورن فليكس على التوالي، وكانت أقل فترة لنمو الحشرة 30.67 يوماً علي جنين القمح واطول فترة 53.21 يوماً علي بذور الحلبة، تراوحت قيم مؤشر دليل حساسية الحشرة للأغذية المختلفة بين 3.03-8.08% علي بذور الحلبة و جنين القمح علي التوالي، وكانت بيئة التربية الأساسية وجنين القمح أفضل أنواع الأغذية للحشرة حيث كان أعلي متوسط عدد للذرية الخارجة هي 204.33 و151.67 حشرة بعد شهر من الإصابة الحشرية، و3151.30 و 4313.30 حشرة بعد ثلاثة شهورمن الإصابة الحشرية علي التوالي، تراوح متوسط نسبة الفقد الكلية في الوزن من 0.52 إلى 5.20% علي غذائي كورن فليكس وحبوب الشوفان بعد شهرمن الإصابة الحشرية علي التوالي، وصلت هذه النسبة لأعلى قيمة لها (31.13%) على بيئة التربية الأساسية للحشرة وأقل نسبة علي بذور الكمون (1.23%) بعد ثلاثة شهور من الإصابة الحشرية، كانت أعلي نسبة فقد نسبية للحشرة الواحدة 23.75% في أزهار الكاموميل وأقل قيمة لها هي 2.66% في غذاء الكورن فليكس بعد شهرمن التخزين، إنخفضت هذه القيمة بعد ثلاثة شهور في معظم الأغذية ماعدا كورن فليكس، بيئة التربية الأساسية للحشرة، أزهار الكركدية وبذور الكمون عند مقارنتها بتلك المسجلة بعد شهر من الإصابة الحشرية، وجد أرتباطاً موجباً بين الإصابة الحشرية الشديدة في بعض الأنواع الغذائية المختلفة والمكونات الكيميائية لها مثل المحتوي الرطوبي للغذاء، الكربوهيدرات الكلية، البروتين الكلي والدهون الكلية، وعلى العكس سجل ارتباطاً سالباً في الأنواع الأخرى، أدت الإصابة الحشرية الشديدة الي زيادة عدد الذرية الناتجة والفقد في الوزن وأثرت سالباً علي التغييرات الكيميائية في مكونات الأنواع المختلفة للأغذية المختبرة بالمقارنة بالكنترول، كل أنواع الأغذية المختبرة تم إصابتها بحشرة خنفساء السجائر ولم تظهر الدراسة وجود أغذية منيعة تماماً من الإصابة الحشرية مع تفضيل الحشرة لبعض الأنواع الغذائية المختبرة. بالإضافة الي ذلك فإن الإصابة الشديدة بالحشرة للعوائل المختلفة أثرت علي المحتويات الكيميائية لأنواع الأغذية المختبرة.

المحكمــــون:

1- أ.د. حمزة محمد الســيد الشرقاوي أستاذ الحشرات الاقتصادية – كلية التكنولوجيا والتنمية – جامعة الزقازيق.

2- أ.د. عبدالعزيز محمود أحمد محسن أستاذ الحشرات الاقتصادية – كلية الزراعة – جامعة الزقازيق.