



## Effectiveness of natural insecticides against *Lasioderma serricorne*

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### Abstract

Cigarette beetle, *Lasioderma serricorne* (F.) (Coleoptera: Anobiidae) is one of the key storage pests that damage the leaves of tobacco. *L. serricorne* is a significant pest in the food and industry of tobacco in many areas of the world. A great amount of physical and chemical control methods have been established up to now in order to confirm the operational protection of stored tobacco and its products from pests. In this study, 23 different host foods (10 spices, 6 cereals, 4 oil seeds, tobacco leaves, biddi tobacco and Rayon thread), were selected to explore their behavioural responses against *L. serricorne*. As a result, it was found that among spices (Fennel, Coriander, Carum, Cumin, Turmeric, Chilli, Black Mustard, Black pepper, Amchur, Ginger), percent adult emergence was maximum in fennel (68.50%) and minimum in black pepper (5.75 %) whereas the developmental period was observed longest on black pepper (61.25 days) and shortest on fennel (35.50 days). In cereals (Wheat, Crushed Wheat, Barley, Rice, Sorghum, Maize), highest adult emergence was recorded on crushed wheat (33.75) and lowest emergence was observed on maize whereas the mean developmental period was highest on maize (53.20 days) in comparison with other cereals. Apart from cereals and spices, amongst four oil seeds viz., mustard, groundnut, cottonseed and castor seeds, the percent adult emergence recorded was highest on groundnut (35.75) seeds whereas the lowest adult emergence was recorded on mustard. In chewing tobacco and bidi tobacco, the adult emergence was 40.25 and 37.50 percent, respectively, whereas, developmental period was longer when insects were fed with bidi tobacco (52.77 days). When *L. serricorne* was reared on rayon thread, the adult emergence was very poor (only 3.50 percent) with longer developmental period.

**Keywords:** spices, cereals, oil seeds, tobacco, behavioural response, contact activity, *Lasioderma serricorne* (F.)

### Introduction

The cigarette beetle, *Lasioderma serricorne* (Fabricius) (Coleoptera: Anobiidae) is the major pest of stored tobacco, stored cereals (Chaudhary *et al.*, 2004; Hori, 2003; Liu and Ho 1999) <sup>[8]</sup> and appears frequently in tropical and sub-tropical regions of the world (You *et al.*, 2014) <sup>[26]</sup>, attacking commodities in storage, during manufacture and at the retail level. Today, worldwide consumption of synthetic repellents has increased to prevent losses in stored grains, fruit and other cellulosic materials infested by various pests (Nerio *et al.*, 2010) <sup>[18]</sup>. Nevertheless, the use of these synthetic chemicals to control pests raise several concerns related to environment and human health, increasing costs of application, pest resurgence, pest resistance to pesticides, and lethal effects on non target organisms in addition to direct toxicity to users (Isman, 2004) <sup>[16]</sup>. These problems have necessitated a search for alternative eco-friendly insect pest control methods (Philips and Thorne 2010). Antagonistic storage is a method using traditional Chinese medicinal material with insect-repellent volatile odours to store together with medicinal herbs vulnerable to insects to prevent insect harm (Zhang *et al.*, 2015) <sup>[28]</sup>. Mahroof and Phillips (2008a) <sup>[17]</sup> investigated the effects of eight different food sources on the development patterns of *L. serricorne* and found that wheat was more suitable than herbs or tobacco. Nevertheless, *L. serricorne* is considered to be the most serious insect pest of tobacco, followed by the tobacco moth, *Ephestia elutella* (Hübner) (Lepidoptera: Pyralidae). This is because *L. serricorne* is one of the few insect species that are able to develop in tobacco which is

toxic for most other species. Hence, *L. serricorne* can develop on raw and processed tobacco without competition from other species and build up high population densities. Also, *L. serricorne* infests 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).

The life of cigarette beetle *Lasioderma serricorne* (Coleoptera: Anobiidae) is affected by various environmental factors like low temperatures and humidity, which reduces the time needed for the insect to complete its life cycle, because it is usually found in warm places areas (Arbogast *et al.*, 2003) <sup>[4]</sup>. The entire life cycle may take up to 90 days to complete, depending on temperature and humidity and the mating/nutritional status of females (females deprived of food live longer than fed females) (Ashworth, 1993; Shahrabani and ALObaidy, 2020) <sup>[5, 20]</sup>.

The application of repellents can be considered a new way of controlling and alleviating insect problems in storage. Aromatic oils were used as repellents Jemâa *et al.* (2011) <sup>[12]</sup> used the aromatic oils of laurel leaf and observed that it has a repellent efficacy at high doses with a short exposures period. Methanol extracted from fennel plant was used to control adults. Olive oil (Kellouche *et al.*, 2004) <sup>[15]</sup> was also used as a repellent. *Mentha longifolia* extract and *Momordica charantia* extract were used in three concentrations 25, 50 and 75%, and their repellent effect to cigarette beetle adult *L. serricorne* was studied, where the

adults were exposed to the extracts for ten days and the experiment confirmed that whenever the exposure time and the concentrations increased the repellent activity to the insect was increased (Kamal *et al.*, 2019) <sup>[14]</sup>. Extracts of black pepper, garlic, mustard oil, hot pepper oil, cinnamon oil and *Zingiber zerumbet* extract have proven effective against cigarette beetle and does not harm natural enemies.

Therefore, in the present studies, some spices, oil seeds, tobacco and cereals have been evaluated to find out their effectiveness against growth index with respect to their various variable temperatures and relative humidity.

## Materials and Methods

### Rearing of test insect

The cigarette beetle, *L. serricornis*, was used as test insect in this study. The nucleus culture of cigarette beetle was procured from the Department of Entomology, Agricultural Research Station, Durgapura, Jaipur, Rajasthan.

### Experimental Setup

The nucleus culture of cigarette beetle was maintained on fennel seeds, which were obtained from local market which were cleaned, washed with water, dried and then subjected to 60°C for 24 h to eliminate insect and mite infestation if any, hidden or otherwise. The seeds were conditioned for 45 h before use at 30 + 2°C and 75 + 5 percent relative humidity (RH). The culture of the test insect was raised on conditioned fennel seeds from a single adult pair. Subsequent insect culture was maintained by releasing adult pairs for ovi-position in sterilized glass jars 10" X 6" X 4" containing 100 g of fennel seeds. The insects were removed after four days and culture was propagated at 30 + 2°C and 75 + 5 percent RH. In order to get continuous supply of the *L. serricornis* adults for experiments, this procedure was repeated frequently. Than different types of food of different categories like 10 spices, 6 cereals, 4 oil seeds, tobacco leaves, biddi tobacco and Rayon thread were given to the host during this study to evaluate the suitability of the host

### Conditioning of Foods

During the experiment, 100 g of each food was kept in glass jars which was covered with white muslin cloth. Each beaker was placed in oven at 60°C for 48 h for sterilization. Then jars were placed into desiccator where relative humidity (RH) was maintained at 75 ± 5 percent. This was done by dissolving the requisite quantity of KOH in distilled water (SOLOMON, 1951). The desiccator was kept at 30 ± 2°C. The foods were allowed to remain in the desiccator for 48 h. These foods were used for host suitability test. The complete experiment was done in triplicates to see the host suitability of various foods.

### Transfer of freshly emerged larvae

To get freshly emerged larvae of *L. serricornis* in adequate number, 15 pairs of 24 h old adults of *L. serricornis* were released in a jar from uniparental culture containing 200 g sterilized fennel seeds, for ovi-position. The glass jar was kept at 30 ± 2°C and 75 ± 5 percent RH. The females were allowed to oviposit for 24 h. The vials were placed again at similar conditions for hatching of eggs. After hatching newly emerged larvae, 20 larvae were transferred to each test vial containing food. These vials were kept at 75 ± 5 percent RH and at 30±2°C observations were recorded for

total adult emergence total developmental period and adult weight. Newly emerged adults were counted daily till the emergence of last adult. Emerged adults were immediately removed from the vials to prevent further breeding. Percent adult emergence was calculated. From these parameters growth rate index was calculated on different foods by using following formula

$$\text{Growth rate index} = \frac{\text{Weight gained}}{\text{Time duration}} \times 100$$

Later to find out the effect of various combinations of temperature and relative humidity on the development of *L. serricornis* studies were carried out at 21 ± 1°C, 26 ± 1°C, 31 ± 1°C, 36 + 1°C and 41 ± 1°C temperatures. The relative humidity's were maintained at 35 ± 5, 55 ± 5, 75 ± 5 and 95 ± 5 percent.

## Results and Discussion

### Host Suitability Test

To test the suitable host, for the development of *L. serricornis*, studies were carried out with 23 different host foods (10 spices, 6 cereals, 4 oil seeds, tobacco leaves, biddi tobacco and Rayon thread). The suitability of each host food was adjudged on the basis of percent adult emergence, mean developmental period and weight per adult (Table 1) and from these parameters growth rate index was calculated (Table 2).

Among spices percent adult emergence was maximum in fennel (68.50%) and minimum in black pepper (5.75 %) (Table -1) whereas, 63.25, 53.00, 48.50, 48.25, 39.50, 26.00, 22.50 and 8.25 percent adult emergence was recorded on carom, chilli, cumin, coriander, turmeric, amchur, ginger and black pepper, respectively. The developmental period was observed longest on black pepper (61.25 days) and shortest on fennel (35.50 days). No significant difference in mean developmental periods was observed when insects were reared on cumin and coriander which raw 41.80 and 41.25 days, respectively. Jha and Yadav in 1994 <sup>[13]</sup> has also observed fennel as a suitable host for *L. serricornis* with 60% adult emergence and mean developmental period of 43.60 days also they revealed that black pepper was less suitable with mean developmental period of 61 days which is in consonance with present study. Developmental period on chilli (40.75 days) was at par with coriander, but was significantly different from that in black pepper (61.25 days), black mustard (58.33 days), amchur (52.66 days), ginger (48.40 days) and turmeric (47.20 days) whereas as shown in Table 2 growth rate index values was rapid on fennel (GRI 2.394), chilli, carum, coriander, turmeric, cumin, ginger, amchur, black mustard and black pepper with respective growth indices of 2.012, 2.00, 1.575, 1.440, 1.172, 0.909, 0.854, 0.651 and 0.587. Yadav and Tanwar in 1986 <sup>[24,25]</sup> reported that turmeric to be more suitable host than cumin and coriander, but in present study turmeric was found less suitable than cumin and coriander whereas Jacob in 1992 <sup>[10]</sup> and Ali *et al.*, in 1972 <sup>[1]</sup> showed that turmeric, amchur, ginger, black mustard and black pepper showed less adult emergence and more mean developmental period. The percent adult emergence on cereals ranged from 10.25 to 33.75 (table 1) Highest adult emergence was recorded on crushed wheat (33.75) which was at par with that in whole wheat (32.50) but expressively more than that recorded in the case of sorghum, barley, rice and maize which provided

23.50, 21.50 19.50 and 10.25 percent adult emergence, respectively. Present findings were supported by Allotey and Unanaowo in 1993 <sup>[3]</sup> which shows that rapid developmental of *L. serricornis* on crushed wheat than on whole rice. Howe in 1957 <sup>[9]</sup> also recorded mean developmental period of 26.1 days on wheat whereas Ali *et al.*, in 1972 <sup>[1]</sup> revealed the 50.15 days on similar host. Among all the cereals, lowest emergence was observed on maize which was significantly less than other cereals, whereas, adult emergence on sorghum was closely followed by barley. The mean developmental period was highest on maize (53.20 days) on comparison with other cereals. The shortest developmental period was observed on crushed wheat (45.25 days) followed by whole wheat (46.75 days). It is thus obvious that crushed wheat is more suitable food till now. The weight of adults was more when insects were fed on crushed wheat (0.53 mg/adult) or whole wheat (0.50 mg/adult) as compared to other cereals. Minimum adult weight was recorded on maize (0.38 mg) which was at par with that observed in the case of rice (0.39 mg) but significantly less than that recorded with barley (0.41 mg) and sorghum (0.43 mg). Among the different cereals development of *L. serricornis* was slow on maize with longer developmental period and less adult growth rate index.

The development of *L. serricornis* was studied on four oil seeds viz., mustard groundnut, cottonseed and castor seeds. The percent adult emergence recorded was highest on groundnut (35.75) which was significantly more than that recorded with castor seeds (15.50) cottonseeds (12.50) and mustard (10.75). Among four oil seeds the lowest adult emergence was recorded on mustard, which was at par with that recorded in the case of cottonseed and was significantly less as compared to that observed in the case of groundnut. Ali *et al.*, in 1972 <sup>[1]</sup> observed the mean developmental period on groundnut they also reported that groundnut as more suitable food than the cotton seed. They used only mean developmental period for comparison whereas the Sachan and Chandel in 1991 <sup>[19]</sup> compared the developmental period on eight ground nut varieties and observed lesser developmental period of *L. serricornis*.

Among oil seeds the development of *L. serricornis* was rapid on groundnut where mean developmental period was 47.25 days which was significantly higher than that observed when insects were fed on cottonseed, castor seed and mustard where developmental period recorded was 60.20, 59.00 and 57.80 days, respectively. Highest developmental period was recorded on cotton seed indicating slow development of cigarette beetle. Adult weight, when insects were reared on different oil seeds, ranged from 0.41 to 0.70 mg. Highest adult weight was recorded on groundnut (0.70 mg) which was significantly more than that observed with other oil seeds. The adult weight following rearing on cotton seed, castor seed and mustard was (in descending order) 0.49, 0.43 and 0.41 mg per adult, respectively.

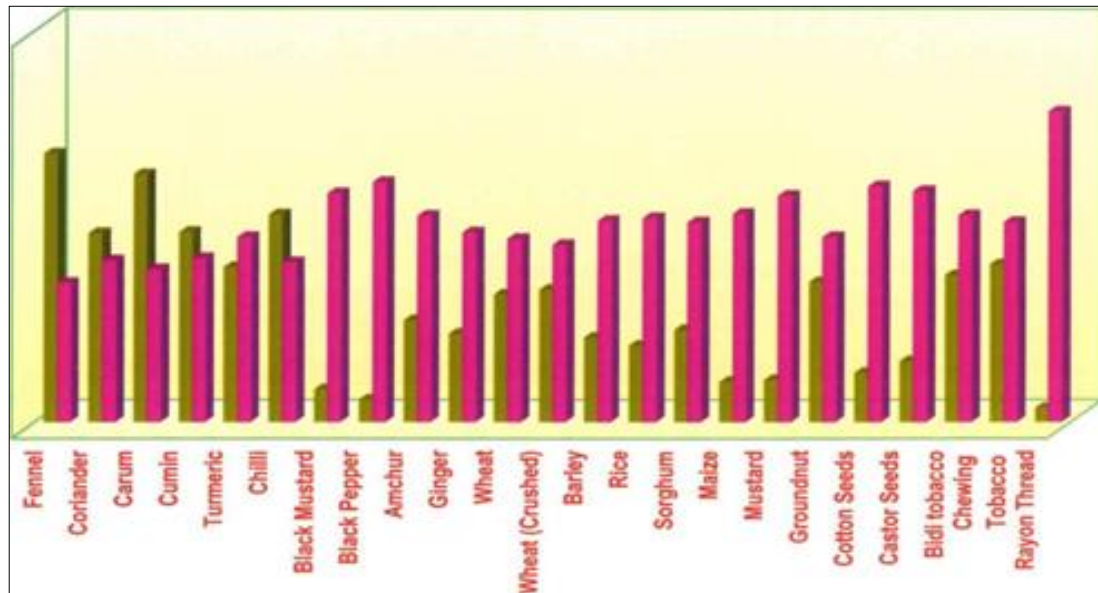
In chewing tobacco and bidi tobacco the adult emergence was 40.25 and 37.50 percent on chewing tobacco and bidi tobacco, respectively, whereas, developmental period was longer when insects were fed with bidi tobacco (52.77 days) as compared with that when they were reared on chewing tobacco (51.00 days). The adult weight recorded was more on chewing tobacco (0.60 mg/adult) and less on bidi tobacco (0.58 mg/adult) showing there by that chewing tobacco was a better food for *L. serricornis*. Whereas, when *L. serricornis* was reared on rayon thread, the adult emergence was very poor (only 3.50 percent) with longer developmental period (79.33 days). The adult weight was also less (0.35 mg/adult). In 1988 Kismali and Goktay observed that the relative suitability of tobacco to *L. serricornis* depends on type. They reported that on tobacco powder and leaves the mean developmental period was 65.55 and 68.42 days respectively which indicates that tobacco powder was more suitable for development than leaves whereas according to Steffan in 1982 <sup>[22]</sup> *L. serricornis* which though polyphagous is most commonly associated with cured tobacco leaves has been introduced in old world from the new world with tobacco. The result of present finding showed that growth and development of *L. serricornis* is largely depend upon the host foods these findings are also reported by various researchers like El-Halfway and Nakhla in 1973 and Singh and Prasad in 2001 <sup>[21]</sup>.

**Table 1:** Percent adult emergence, mean developmental period, weight and Growth Rate Index of *L. serricornis* on different host foods of *L. serricornis* on different host foods

S. No.	Host Food	Percent adult emergence	Mean developmental period days	Weight Per Adult	Growth Rate Index
(A)	Spices				
1.	Fennel	68.50 (55.86)	35.50	0.85	2.394
2.	Coriander	48.25 (43.99)	41.25	0.65	1.575
3.	Carum	63.25 (52.68)	39.00	0.78	2.00
4.	Cumin	48.50 (44.14)	41.80	0.49	1.172
5.	Turmeric	39.50(38.93)	47.20	0.68	1.440
6.	Chilli	53.00 (46.72)	40.75	0.82	2.012
7.	Black Mustard	8.25 (16.65)	58.33	0.38	0.651
8.	Black Pepper	5.75 (13.76)	61.25	0.36	0.587
9.	Amchur	26.00 (30.64)	52.66	0.45	0.854
10.	Ginger	22.50 (28.30)	48.40	0.44	0.909
(B)	Cereals				
11.	Wheat	32.50 (34.75)	46.75	0.50	1.069
12.	Wheat (Crushed)	33.75 (35.51)	45.25	0.53	1.171
13.	Barley	21.50 (27.61)	51.40	0.41	0.797
14.	Rice	19.50 (26.19)	52.10	0.39	0.748
15.	Sorghum	23.50 (28.95)	51.00	0.43	0.843
16.	Maize	10.25 (18.64)	53.20	0.38	0.714
(C)	Oil Seeds				
17.	Mustard	10.75 (19.09)	57.80	0.41	0.709

18.	Groundnut	35.75 (36.71)	47.25	0.70	1.481
19.	Cotton Seeds	12.50 (20.64)	60.20	0.49	0.813
20.	Castor Seeds	15.50 (23.15)	59.00	0.43	0.728
(D)	Tobacco				
21.	Bidi tobacco	37.50 (37.75)	52.77	0.58	1.099
22.	Chewing tobacco	40.25 (39.37)	51.00	0.60	1.176
(E)23.	Rayon Thread	3.50 (10.68)	79.33	0.30	0.441
	SEm	0.72	0.84	0.40	0.02
	CV%	4.58	3.40	4.30	8.98
	CD at 5%	2.05	2.39	0.05	0.08

Figures In Parenthesis Are Arc Sin Values.



100  
80  
60  
40  
20

Fig 1: Percent adult emergence and mean developmental period of *L. serricorne* on different host foods



Fig 2: Growth Rate Index of *L. serricorne* on different host foods

**Effect of temperature and humidity on the growth of *L. serricorne***

Five different temperature ranges included in the test were 21+1, 26+1, 31+1, 36+1 and 41+1 °C with relative humidity (RH) ranges were 35±5, 55±5, 75±5 and 95±5 percent to

check the humidity in combination with different temperatures on the *L. serricorne* growth. The opinions were documented for percent adult appearance and mean developmental period. These findings were also supported by Hodek in 1973 who revealed that that the activity of

insects and developmental rate depended on ambient temperature.

When temperature was constant (21+1<sup>0</sup>C) along with RH of 55±5 and 75±5 percent adult emergence of *L. serricornae* was 17.75, 21.50, respectively. (Table 2) where as there is no growth was seen when RH was changed to 35±5 and 95±5 percent along with the growth index was 0.409 and 0.333 at 75±5 and 55±5 percent RH, respectively. Similarly, when temperature was setted at 26+1<sup>0</sup>C adult emergence ranged from 48.50 to 58.40 percent (Table 3). Maximum percent adult emergence was noted at 55±5 percent RH after 75±5 and 35±5 percent RH. At 35±5 percent RH the percent adult development was expressively fewer than that recorded at 55±5 and 75±5 percent RH. Correspondingly, mean developmental period was also more at 35±5 percent RH. No insect development was observed at combination of 95±5 percent RH and 26±1<sup>0</sup>C. In table 4 it was shown that at 31±1<sup>0</sup>C *L. serricornae* was initiate to breed and multiply at all four relative humidity levels. The extreme adult emergence was seen at 75±5 percent RH followed by 55±5, 95±5 and 35±5 percent RH. The adult rise at 35±5 and 95±5 percent RH was expressively higher than the development seen at 55±5 and 75±5 percent RH levels whereas mean developmental period at this temperature was least at 75±5 percent RH followed by 55±5, 95±5 and 35±5 percent RH. Similarly, at 36±1<sup>0</sup>C temperature no adult emergence was recorded at 35±5 and 95±5 percent RH levels (Table 5). In 1965 Howe also reported that for *L. serricornae* the minimum temperature for the development is 21<sup>0</sup>C and at this temperature he also observed mean developmental period of 69.6 days at 70% RH which is in relative with current study whereas in 1976 Fletcher and Long [7] also reported that there is slow development of *L. serricornae* at low temperatures. However, in 1973 Fletcher with his colleagues preferred the temperature range of 25-30<sup>0</sup>C as optimum temperature for development of *L. serricornae*.

**Table 2:** Effect of Relative Humidity on the Developmental Period and Adult Emergence of *L. serricornae* at 21±5<sup>0</sup>C

S. No	RH (%) (±5 <sup>0</sup> )	Percent Adult Emergence	Mean Developmental Period (Days)	Growth Index
1.	35	0.00 (4.05)	0.00	0.00
2.	55	17.75 (24.89)	53.25	0.333
3.	75	21.50 (27.61)	52.50	0.409
4.	95	0.00 (4.05)	0.00	0.00
	SEm	0.389	0.401	0.010
	CV%	5.145	3.039	10.797
	CD at 5%	1.201	1.238	0.30

Figures in Parenthests Are Arc Sin Values.

**Table 3:** Effect of Relative Humidity on the Developmental Period and Adult Emergence of *L. serricornae* at 26±1<sup>0</sup>C

S. No	RH (%) (±5 <sup>0</sup> )	Percent Adult Emergence	Mean Developmental Period (Days)	Growth Index
1.	35	48.50 (44.14)	50.00	0.624
2.	55	58.50 (49.89)	47.50	1.232
3.	75	56.75 (48.88)	47.16	1.194
4.	95	0.00 (4.05)	0.00	0.00
	SEm	0.50	0.64	0.01
	CV%	2.97	3.56	3.80
	CD at 5%	1.56	1.98	0.04

Figures in Parenthests Are Arc Sin Values.

**Table 4:** Effect of Relative Humidity on the Developmental Period and Adult Emergence of *L. serricornae* at 31±1<sup>0</sup>C

S. No	RH (%) (±5 <sup>0</sup> )	Percent Adult Emergence	Mean Developmental Period (Days)	Growth Index
1.	35	40.50 (39.52)	44.00	0.921
2.	55	59.50 (50.47)	38.25	1.556
3.	75	68.50 (55.86)	36.00	1.905
4.	95	46.00 (42.70)	43.50	1.058
	SEm	0.45	0.76	0.03
	CV%	1.93	3.76	5.65
	CD at 5%	1.40	2.34	0.11

Figures in Parenthests Are Arc Sin Values.

**Table 5:** Effect of Relative Humidity on the Developmental Period and Adult Emergence of *L. serricornae* at 36±1<sup>0</sup>C

S. No	RH (%) (±5 <sup>0</sup> )	Percent Adult Emergence	Mean Developmental Period (Days)	Growth Index
1.	35	0.00 (4.05)	0.00	0.00
2.	55	21.15 (27.60)	51.00	0.422
3.	75	24.25 (29.49)	49.75	0.487
4.	95	0.00 (4.05)	0.00	0.00
	SEm	0.46	0.62	0.01
	CV%	5.68	4.96	13.05
	CD at 5%	1.40	1.92	0.04

Figures in Parenthests Are Arc Sin Values.

**Conclusion**

*L. serricornae* is reported as a major pest of spices. The fennel, carum, chilli, coriander and cumin exhibited more suitability as host for this pest. On these spices it has short life span and high degree of reproductive capacity. These spices constitute the bulk of spices which are handled, stored and consumed very widely and have more chances of infestation by this insect pest during storage. Present study shows that damaged grains are more susceptible to *L. serricornae* infestation than the whole grains. Healthy seeds adequately defended against the pests, but that when seeds are damaged before or after harvest, they become vulnerable moisture content and are easily infested by *L. serricornae*. The optimum conditions for the development of *L. serricornae* are 31±1<sup>0</sup>C temperature and 75±5 percent relative humidity Hence, the large-scale handling of spices and other foods is restricted in dry areas, which are not optimum for development and restricts the infestation.

**References**

1. Ali AD, Donia AR, El-Sawaf SK, Sawaf SK. The influence of natural food on the development and reproductive rate of *Lasioderma serricornae* Fab. (Coleoptera: Anobiidae). Zeitschrift fur Angewandte Entomologie,1972;72(2):212-220.
2. Al-Khazraji HI, Ahmed RF, Al-Jorany RS. Effect of feeding treatment with some extracts of black pepper on some biological aspects of cotton Leaf Worm. The Iraqi Journal of Agricultural Sciences,2016;47(3):856-864.
3. Allotey J, Unanaowo IE. Aspects of the biology of *Lasioderma serricornae* (F.) on selected food media under tropical conditions. Insect sci. and its Applic,1993;14(5):595-601.
4. Arbogast RT, Kendra PE, Chini SR. *Lasioderma serricornae* (Coleoptera: Anobiidae): spatial relationship between trap catch and distance from an infested product. Florida Entomologist,2003;86(4):437-444.

5. Ashworth JR. The biology of *Lasioderma serricornes*. Journal of Stored Products Research,1993;29(4):291-303.
6. Chaudhry MQ, Bell HA, Savvidou N, MacNicol AD. Effect of low temperatures on the rate of respiration and uptake of phosphine in different life stages of the cigarette beetle *Lasioderma serricornes* (F.) . J. Stored Prod. Res,2004;40:125-1.
7. Fletcher L We, Garrett LC, Childs DP. The ovipositional response of the cigarette beetle to temperature and to selected odors. Proceedings of the second International working conference on stored Product Entomology, September,1979:10-16, 1978, Nigeria, 1979, 350-357.
8. Hori M. Repellency of essential oils against the cigarette beetle, *Lasioderma serricornes* (Fabricius) (Coleoptera: Anobiidae) . Appl. Entomol. Zool,2003;38:467-473.
9. Howe RW. A laboratory study of the cigarette beetle, *L. serricornes* (F.) (Col. Anobiidae) with a critical review of the literature on its biology. Bull. Ent. Res,1957;48:9-56.
10. Jacob S. Host food preference of the cigarette beetle *Lasioderma serricornes* F. to few stored spices. Plant Protection Bulletin Faridabad,1992;44(3):16-17.
11. Jahromi MG, Pourmirza AA, Safaralizadeh MH. Repellent effect of sirinol (garlic emulsion) against *Lasioderma serricornes* (Coleoptera: Anobiidae) and *Tribolium castaneum* (Coleoptera: Tenebrionidae) by three laboratory methods. African Journal of Biotechnology,2012;11(2):280-288.
12. Jemâa JMB, Tersim N, Khouja ML. Composition and repellent efficacy of essential oil from *Laurus nobilis* against adults of the cigarette beetle *Lasioderma serricornes* (Coleoptera: Anobiidae). Tunisian Journal of Plant Protection,2011;6(1):29-41.
13. Jha AN, Yadav TD. Developmental response of 28 spices to *Lasioderma serricornes* (Fab.) and *Stegobium Paniceum* (Linn.) Indian. J. Ent,1994;56:111-113.
14. Kamal W, Ahmad S, Saeed M, Rehman A, Zada H, Latif A, et al. *In vitro* repellency evaluation of selected botanical extracts against cigarette beetle, *Lasioderma serricornes*. Pure and Applied Biology,2019;8(1):208-214.
15. Kellouche A, Soltani N, Kreiter S, Auger J, Arnold I, Kreiter P. Biological activity of four vegetable oils on *Callosobruchus maculatus* (Fabricius) (Coleoptera: Bruchidae). Redia,2004;87:39-47.
16. MB Isman. "Plant essential oils as green pesticides for pest and disease management,"ACS Symposium,2004;887:41-51.
17. Mahroof RM, Phillips TW. Life history parameters of the cigarette beetle, *Lasioderma serricornes* (F.) as influenced by food resources. J Stored Prod Res,2008a;44:219-226.
18. Nerio LS, Olivero-Verbel J, Elena Stashenko E. Repellent activity of essential oils: A review. Bioresource Technology,2010;101:372-378.
19. Sachan GC, Chandel SK. Susceptibility of some groundnut varieties to *Lasioderma serricornes* (Fabricius) Ind. J. Ent,1991;53(4):559-563.
20. Shahrabani SM, Shaymaa H, AL-Obaidy. Biology of cigarette beetle *Lasioderma serricornes* (F.) (Coleoptera: Anobiidae) on Baker's Yeast *Saccharomyces cerevisiae*". International Journal of Plant Research, 2020, 20(1).
21. Singh S, Prasad SK. Development of *L. serricornes* on seeds of some rapeseed and mustard varieties/species, Indian J.Ent,2001;63(1):92-95.
22. Steffan JR. The insects found in the mummy of Ramases II Annales-de-la-societe-Entomologique de France,1982;18 (4):531-537.
23. TW Phillips, JE Throne. "Biorational approaches to managing stored-product insects," Annual Review of Entomology,2010;55:375-397.
24. Yadav TD, Tanwar PK. Egg collection and rearing device of *Lasioderma serricornes* (Fabricius) Anobiidae: Coleoptera. Bull. Grain Tech,1986;24:110-113.
25. Yadav TD, Tanwar RK. Induced oviposition technique in rearing of *L. serricornes* (Fabricius). Annals Agril. Res,1986;7(2):222-226.
26. You CX, Wang Y, Zhang WJ, Yang K, Wu Y, Geng Z, et al. Chemical constituents and biological activities of the Purple *Perilla* essential oil against *Lasioderma serricornes*. Ind. Crop. Prod,2014;61:331-337.
27. ZL Liu, SH Ho. "Bioactivity of the essential oil extracted from *Evodia rutaecarpa* Hook f. et Thomas against the grain storage insects, *Sitophilus zeamais* Motsch. and *Tribolium castaneum* (Herbst)," Journal of Stored Products Research,1999;35(4):317-328.
28. Zhang WJ, Yang K, You CX, Wang CF, Geng ZF, Su Y, et al. Contact toxicity and repellency of the essential oil from *Mentha haplocalyx* Briq. against *Lasioderma serricornes*. Chem. Biodivers,2015;12:832-839.