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Development of Cigarette Beetle [*Lasioderma Serricorne* (Coleoptera :Anobiidae)] on Spice Plants and Wheat Flour

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ABSTRACT

In this study, the development of *Lasioderma serricorne* (F.) (Coleoptera: Anobiidae) was investigated on five different foods (*Mentha piperita, Thymus vulgaris, Salvia officinalis, Rosmarinus, officinalis* and flour). Trials were carried out at a temperature of 28±2°C and 70-75% relative humidity. Effects of foods on development adult longevity and egg hatching ratio of *Lasioderma serricorne* were investigated. As a result, all of the *Lasioderma serricorne* larvae left on the *Rosmarinus officinalis* plant have not completed their development and died. The shortest larval development time was in flour (37.35 days) and the longest in *Mentha piperita* (62.96 days). The shortest Pupal development time was seen in S*alvia officinalis* (4 days), while the longest was seen in *Thymus vulgaris* (4,42 days). *Mentha piperita* (10,50 days) had the shortest adult longevity and was the longest flour (15,5 days). When the egg development time was examined, it was seen that the shortest time was in *Thymus vulgarris* (5,42 days) and the longest time was in flour (5,97 days). The rate of larvae that completed its development was highest in flour (92%) and lowest in *Salvia officinalis* (5%). The rate of pupae that completed its development was highest in flour (80,30%) and lowest in *Salvia officinalis* (37.50%). In the percentages of hatched eggs, it was observed that the lowest opening was in thyme with 56.27% and the highest opening was in flour with 88.89 %.

1. Introduction

Cigarette beetle, which is a polyphagous pest, can cause economic damage in many crops grown. Some products such as tobacco and tobacco products, medicinal and aromatic plants (dried herbs, spices, herbal teas, herbariums, dried fruits), flours, cereals, coffee varieties, cocoa, rice, dates, dog food etc. are listed among the hosts of the pest (Cabrera 2002). Especially in warehouse conditions, all these products are under the pressure of *Lasioderma serricorne*. *L. serricorne* on the contaminated product can cause direct by feeding and indirect damage. As a result of intensive feeding on products, they cause weight, seed losses and commercial value. In addition to feeding damage, the presence of dead insects, residues from different life stages such as cast skins or pupal cases, and frass become contaminants in commodities and render them undesirable for human consumption.

In heavy contamination, the host products are completely destroyed. Therefore, if the necessary precautions are not taken, it causes harmful significant economic losses (Da Silva et al 2018).

Life cycle and biological parameters of *L. serricorne* have been investigated in the past under different temperature and relative humidity conditions, generally using flour, tobacco, wheat or yeast as food sources (Jones, 1913; Powell, 1931; Howe, 1957; Mahroof & Phillips, 2008; Kathirvel et al, 2019). Kısmalı & Göktay (1988) reported that the incubation period of eggs which were laid by adults developed on leaf and ground tobaccos were 7.94 and 7.12 days and the larva development time were 50.05 and 52.03 days, respectively. Jones (1913) stated that the average time for the egg development was 6 d, the larval stage was 50 d, and the pupal stage was 12.5 d, when tobacco served as larval food. Powell (1931) determined the length of the life cycle of *L. serricorne* under several controlled temperature and humidity conditions using yeast or tobacco as nutrients. Completion of the life cycle required 18–20 d longer in tobacco than in yeast, for example, at 28 1C and 75% r.h. the development time was 36 d in yeast and 55 d in tobacco. Completion of the life cycle required 18–20 d longer in tobacco than in yeast, for example, at 28°C and

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75% relative humidity. The development time was 36 d in yeast and 55 d in tobacco. Howe (1957) studied the developmental time using wheat as larval food under different temperature and relative humidity conditions. Development times ranged from 5.3 to 20.4 d for eggs 18.2 to 101 d for larvae, 6.4 to 25.9 d for pupae, and 18 to 46 d for adults. Kısmalı & Göktay (1988) reported that the incubation period of eggs which were laid by adults developed on leaf and ground tobaccos were 7.94 and 7.12 days and the larva development time were 50.05 and 52.03 days, respectively.

L. serricorne, which is a polyphagous pest, causes damage to many products, especially tobacco. LeCato (1978) stated the time required for development of *L. serricorne* in 19 different spices and the fresh body weights of beetles that emerged from each spice. Among the 19 spices evaluated, paprika (*C. annuum* L.) and cayenne pepper (*Capsicum annuum* L. var. *glabriusculum*) were the most suitable foods for the development of *L. serricorne*. Dimetry et al. (2004) compared six spices and concluded that coriander seeds (*Coriander sativum* L.) were the most favorable host for oviposition. In a recent study to evaluate the variation in responses of male and female *L. serricorne* to various nutrients, products containing wheat, two varieties of tobacco, *Capsicum* spp. and processed almond elicited significantly higher attractive responses by female *L. serricorne* than male beetles (Mahroof and Phillips, 2007). Various studies on this pest have been done before (Allotey & Unanaowo 1993; Ashworth 1993; Atabay et al 2013; Suneethamma 2016; Amoah & Mahroof 2018; Edde 2019; Abd El-Ghany & Abd El-Aziz 2021). However, although there are medicinal and aromatic plants among its hosts, it has been determined that there are very limited studies on this subject (LeCato 1978; Dimetry 2004; Mahroof & Phillips, 2008; Naveena 2019; Kathirvel et al, 2019; El-Fouly et al 2021). In this study, it was aimed to determine the adult longevity, the hatching time and the hatching rate of the eggs, the effects of the development times of larvae and pupae of *L. serricorne* fed on mint, thyme, sage and rosemary plants, which are among the important spice and medicinal-aromatic plants of our country.

2. Materials and Methods

Cultures of *L. serricorne*, were maintained in the laboratory of the Plant Protection Department (Faculty of Agriculture of Selcuk University) and grown at a temperature of 28±2°C and humidity of 70-75%. They were reared in 1 liter glass jars by mixing flour and wheat as food.

As food in the experiments; mint (*Mentha piperita*), thyme (*Thymus vulgaris*), rosemary (*Rosmarinus officinalis*), sage (*Salvia officinalis*) and flour were used. The plants were ground into smaller pieces and used in the experiments.

The effect of foods on the development times of Lasioderma serricorne larvae

One-day-old larvae were used in the experiment. Mint, thyme, rosamary, sage and flour were placed at the bottom of 2 cm diameter plastic tubes for feeding the larvae. The mouths of the tubes were covered with gauze and placed in the incubator. Each foods source consisted of 4 replications and 25 larvae were used for each repetition. A total of 100 larvae were used for a single food. All studies were carried out in an incubator at 28 ± 2°C and 70-75% RH. Starting from the day of establishment of the experiment, all larvae were checked daily until they turned into pupae. The date of pupae was recorded.

The effect of foods on the development times Lasioderma serricorne pupae

Larvae that became pupa after daily controls were separated from other larvae. It was transferred to another plastic tube. The separated 1-day-old pupae were noted with the date of their pupae. For each pupa, the time elapsed between the first appearance of the pupa and the date of adult was determined as the duration of the pupal stage

The effect of foods on the adult longevity of Lasioderma serricorne

Three Cigarette beetles (2 male and 1 female) that become adults on the same day were taken from 4 replications of a single food source and a new replication was formed. A total of 10 replications were created from these 3 adults (2 male and 1 female). The day taken from the first day of adult emergence was recorded on each of the plastic tubes. The plastic tubes were checked periodically to observe the adult and the date of death is recorded.

The effect of foods on the hatching time and hatch rate of Lasioderma serricorne eggs

The effects of foods on the opening time of the eggs were carried out in parallel with the studies conducted to determine the adult longevity. It was checked everyday whether the female individual lays eggs or not. Eggs laid in the tubes were counted under a stereomicroscope. It was determined whether the larvae hatched. In addition, the hathching period of the eggs (day) was recorded.

The effect of foods on larval development rates

The larvae were checked from the first day they hatched, until they turned into pupae. Contents of the tubes were emptied onto a black filter paper and observed daily for live and died larvae. The larval development rate study for each food sources was conducted a total of 100 larvae (4 replications for each food and 25 larvae in each replication).

The effect of foods on pupal development rates

The methods used in this experiment were the same as those described for larvae survival ratio. The pupa development rates was found from 100 larvae that completed their development in a healthy way and became adults.

Statistical analyses

The research results were evaluated with analysis of variance (ANOVA) and t-test. According to this analysis,

the mean values of the application, which showed a statistically significant difference, were grouped according to the Duncan test. SPSS 21.0 software (SPSS Inc., Chicago, IL, USA) program was used in the statistical assessment of the data.

3. Results and Discussion

The effect of foods on the development times of Lasioderma serricorne larvae

It was determined that development of *L. serricorne* larvae on rosemary could not complete. For this reason, the effects of other foods (mint, thyme, sage and flour) used in the experiment on the development of the larvae were compared, except for rosemary. Larval development took the longest time in mint (62.96 days), followed by two other medicinal-spice plants, sage (54.77 days) and thyme (49.71 days), respectively. Flour, on the other hand, came after all spice plants (37,35 days) (Table 1).

Among the foods applied, it can be said that the most suitable food for the development of *L. serricorne* larvae is "flour". This faster development could be because of the balanced and essential nutrients present in the wheat. Kısmalı and Göktay (1988) reported that there could be differences in the developmental periods of *L. serricorne* larvae fed on leaf and powder tobacco. While the development period of the larvae fed on powder tobacco was determined as 50.05 days, the development period of the larvae fed on leaf tobacco was determined as 52.03 days. Mahroof and Phillips (2008) revealed that the development of *L. serricorne*, which is fed with seven different foods, in flour (46 days) is shorter than in other foods. El-Fouly et al (2021) stated that the wheat germ was the best preferred food kind for the larval period since the larvae spent the shortest periods (15.36 days). Fenugreek and Chamomile were the less preferred foods of the larval period where was the longest periods 30.55 and 27.09 days, respectively. Therefore, it was concluded that the developmental period of *L. serricorne* larvae was affected by the foods and previous studies also support this result.

Table 1
Development times of *Lasioderma serricorne* larvae grown on different foods.

Foods	Larval development times (days)		
	Min.	Max.	Mean ± SE
Mint	34.00	77.20	62.96 ± 10.03 a *
Thyme	42.75	55.66	49.71 ± 3.02 ab
Sage	48.00	60.00	54.77 ± 3.55 ab
Flour	35.72	39.61	37.35 ± 0.84 b

*Values in a column followed by different letters are significantly different (P<0.05)

The effect of foods on the development times of Lasioderma serricorne pupae

It was determined that the development time of pupae developed on different foods was not statistically different (Table 2).

Since *L. serricorne* larvae could not complete their development on rosemary, pupa formation was not observed on this food. When the development time of the pupae of *L. serricorne* is examined, it is seen that the shortest pupal period is in sage (4 days), and the longest in thyme (4.42 days) (Table 2).

The effect of all foods on pupal development times was limited, and the difference was not statistically significant. In a study conducted by Bozan (1968), it was reported that the development times of the pupae consisting of *L. serricorne* larvae fed on wheat flour, tobacco dust and corn flour were close to each other (8.8 days). El-Halfawy and Nakhla (1976) stated that there was no difference in the development time of *L. serricorne* pupae fed on wheat flour and dry onion at 30°C temperature and 75% RH conditions.

Table 2
Pupal period of *Lasioderma serricorne* grown on different foods

Foods	Pupal period (days)		
	Min	Max.	Mean ± SE
Mint	4.0	4.20	4.05 ± 0.05 a*
Thyme	4.10	4.66	4.42 ± 0.13 a
Sage	3.00	5.00	4.00 ± 0.58 a
Flour	3.89	4.10	4.01 ± 0.46 a

*Values in a column followed by different letters are significantly different (P<0.05)

Similarly, Kısmalı and Göktay (1988) reported that there was no difference in the development of the pupae formed by *L. serricorne* larvae fed on leaf and powder tobacco. When the previous studies are considered as a whole, it can be concluded that the pupal period of *L. serricorne* does not change according to the foods.

The effect of foods on the adult longevity of Lasioderma serricorne

The effect of the foods used in the study on the adult longevity was not statistically significant. The longest adult longevity was recorded for beetles that were reared on flour (15.50 days). This followed by *L. serricorne* adults fed with sage (14.30 days), thyme (13.10 days) and mint (10.50 days), respectively (Table 3). Bozan (1968) stated that different foods have no effect on adult longevity.

Although there was no difference between the mean of adult longevity, all spice plants used as food in the experiment caused a partial decrease in adult longevity (Table 3).

Table 3
Adult longevity of *Lasioderma serricorne* grown on different foods.

Foods	Adult longevity (days)		
	Min	Max.	Mean ± SE
Mint	1.00	18.00	10.50 ± 1.78 a*
Thyme	7.00	20.00	13.10 ± 1.29 a
Sage	14.00	17.00	14.30 ± 1.50 a
Flour	11.00	19.00	15.5 ± 0.79 a

*Values in a column followed by different letters are significantly different (P<0.05)

The effect of foods on the hatch time and hatch rates of Lasioderma serricorne eggs

When the average **hatching time** of the eggs laid by adult females fed with different foods were compared; it was seen that there weren't differences according to foods. However, since adult females fed with mint and sage did not lay any eggs, it was observed not to be any naturally hatch eggs (Table 4). When the thyme and flour on which eggs left were compared, it was seen that the average hatch time of the eggs were extremely close to each other. While the egg hatch time in thyme was 5.97 days, it was determined as 5.42 days in flour. The egg hatch times in flour and thyme were statistically in the same group. There was no statistically significant difference between the hatch times of the eggs in the foods in which eggs were laid. Some researchers reported that there were no significant differences in the hatch times of eggs observed for different foods (Kısmalı and Göktay 1988; Mahroof and Phillips 2008).

Table 4
The hatch time of eggs laid of *Lasioderma serricorne* grown on different foods

	The hatch time of eggs (days)		
Food	Min	Max	Mean ± SE
Thyme	5.80	6.25	5.97 ± 0.14 a
Flour	3.00	6.50	5.42 ± 0.43 a

*Values in a column followed by different letters are significantly different (P<0.05)

In addition to the opening hatch times of the eggs laid by the adult females, the hatch ratio of the eggs (%) were also calculated. However, since only the eggs left on flour and thyme were opened, the data of these two foods were evaluated. It was determined that the difference of the hatch ratios of the eggs was related with the foods (Table 5).

Sivik et al. (1957) and Naavena et al. (2019) reported that the hatching percentage was 68.00 % in tobacco and 76.75 % in turmeric powder, respectively.

Table 5
The hatch rates of eggs laid of *Lasioderma serricorne* grown on different foods

	The egg hatch ratio (%)		The mean opening rates (%)
Foods	Min	Max	Mean ± SE
Thyme	44.44	71.42	56.27 ± 7.96 a*
Flour	66.66	100	88.89 ± 11.11 b

*Values in a column followed by different letters are significantly different (P<0.05)

The effect of foods on larval development rates of Lasioderma serricorne

When the development rate of larvae fed on different food were compared; It was seen that there was a significant difference between the means and this difference was statistically significant (Table 6). The highest pupation rate with 92% was observed in the larvae that fed on flour, it was followed by thyme (63%).

In addition, it was determined that these two foods were in the same group statistically.

Mahroof and Phillips (2008) stated that the larval development ratio according to the foods contained in their research was significantly different. In addition, they stated that the highest larval development ratio was in wheat flour with 92%.

Table 6
Larval development rates of *Lasioderma serricorne* grown on different foods.

	The larval development rate (%)		
Foods	Min	Max	Mean ± SE
Mint	4.00	32.00	18.00 ± 5.77 b*
Thyme	44.00	88.00	63.00 ± 9.29 a
Sage	0.00	8.00	5.00 ± 1.91 b
Flour	84.00	100.00	92.00 ± 9.37 a

*Values in a column followed by different letters are significantly different (P<0.05)

The effect of foods on pupal development rates

When the pupal development rates of *Lasioderma serricorne* larvae fed with different foods were compared; the highest healthy pupal development rate was in the pupae consisting of larvae fed on flour (80.3%). The lowest pupal development rate was found in sage (37.5%). These differences between the means were found to be statistically significant (Table 7).

Table 7
Pupal development rates of *Lasioderma serricorne* grown on different foods.

	Pupal development rates (%)		
Foods	Min	Max	Mean ± SE
Mint	25.00	100.00	60.63 ± 17.63 a*
Thyme	57.14	85.71	67.25 ± 6.32 a
Sage	0.00	100.00	37.50 ± 23.94 b
Flour	67.00	92.00	80.30 ± 5.50 a

*Values in a column followed by different letters are significantly different (P<0.05)

As with the larval development period and egg trials, the rate of pupa formation from larvae was also negatively affected, especially by sage and mint.

This is in agreement with Kısmalı and Göktay (1988) and Levi et al. (2014) who reported the food affects the healthy pupa formation rate of the larvae.

On the other hand, it is known that spice plants show great variation in terms of the active ingredients they contain. (Smigielski et al. 2018; Fernández-Sestelo and Carrillo 2020) Therefore, it was concluded that there was a great difference in the rate of transition of larvae to pupae depending on the spice plants used in the study. There are many studies in parallel with this results (LeCato 1978; Kim et al. 2003; Lü and Shi 2012; Pino et al. 2013). Therefore, when compared to flour; the fact that spices used as foods adversely affect the development of *L. serricorne* adults, larvae and pupae, in general, and the large variation among the spice plants included in the experiment in terms of their effects on development reveals this may be a result of the difference in the contents of spice plants.

In the study, it was determined that the plants used as food affected the development of *L. serricorne* at a significant level. Our results clearly showed Rosemary cannot be ranked within the food host sequence of *L. serricorne*. Further we confirmed that sage and mint would also be a food in which *L. serricorne* could be found by coincidence, but could not reproduce. It was concluded that the thyme was included in the host sequence of the pest. Therefore, among the spice plants included in the experiment, *L. serricorne* may cause a problem only in thyme (and partially mint), therefore it can be recommended to take precautions especially in terms of Cigarette beetle damage in stored thyme. *L. serricorne* failed to show growth on dried rosemary (and partly sage). Considering the previous studies with different plants, it was concluded that it may be beneficial to test this plant against pests (in terms of insecticidal, repellent or fumigant effect).

If mass production of *L. serricorne* is desired under laboratory conditions, it is recommended to reproduce it in flour. Knowledge of such host use features will be valuable in further research into host selection by *L. serricorne* and may help in the development of pest management systems for this serious pest.

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