STUDY ON THE BIOLOGY OF CIGARETTE BEETLE, *LASIODERMA SERRICORNE* (F.) AND ITS DAMAGE ASSESEMENT IN DIFFERENT SPICES

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CERTIFICATE

This is to certify that thesis entitled, "STUDY ON THE BIOLOGY OF CIGARETTE BEETLE, LESIODERMA SERRICORNE (F.) AND ITS DAMAGE ASSESSMENT IN DIFFERENT SPICES" submitted to the DEPARTMENT OF ENTOMOLOGY, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (M.S.) in ENTOMOLOGY embodies the result of a piece of bona fide research work carried out by ANTARA CHAKMA, Registration No. 13-05764 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated: December, 2014

Place: Dhaka, Bangladesh

……………………………………

Professor Dr. Mohammed Ali
Supervisor

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STUDY ON THE BIOLOGY OF CIGARETTE BEETLE, *LESIODERMA SERRICORNE* (F.) AND ITS DAMAGE ASSESSMENT IN DIFFERENT SPICES

ABSTRACT

Two experiments were conducted to study the biology of cigarette beetle, *Lesioderma serricorne* (F.) and its damage assessment in different spices in the laboratory of the department of Entomology, Sher-e-Bangla Agricultural University, Dhaka-1207 during March to July, 2015. Experiments were laid out in a Completely Randomized Design (CRD). In the study of biology, it was revealed that the adult female laid 112-160 eggs with an average of 138.80 eggs and the ovipositional period, incubation period, larval period, pupal period and adult longevity of Cigarette beetle were 4.00 ± 0.02 days, 6.67 ± 0.03 days, 14.00 ± 0.09 days, 8.33 ± 0.03 days and 9.67 ± 0.05 days, respectively. fenugreek (Methi), coriander (Dhania), cumin (Jira), fennel (Mouri), celery (Rhadhuni), carom (Ajowan) and Dried red chilli were used as experimental materials in the second experiment. The experiment concerning damage assesment of the above spices by cigarette beetle, indicated that the adult longivity, larval and pupal duration and adult emergence of cigarette beetle was varied in different spices. The study revealed that the percent infestation was highest in cumin 25.67 %, 66.43% and 100% at 1st, 2nd and 3rd generations, respectively and no infestation occured in celery (Radhuni) and carom (Ajowan) spices.

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LIST OF ABBREVIATIONS

Full wo	viation
and others	*et al.*
Co-efficient of Variation	CV
Completely Randomized Design	CRD
Gram	g
Id est	i.e.,
Journal	*j.*
Least significant difference	LSD
Videlicet	Viz.,

CHAPTER I

INTRODUCTION

Spices are used for flavors, color, aroma and preservation of food or beverage (Anonymous, 1996). It may be derived from many parts of plant, bark, buds, flowers, leaves, rhizomes, seeds etc. or the entire plant top. Spices serve as important condiments in culinary. They play a significant role in the treatment of several physiological disorders in humans because of their therapeutic properties. Spices are consumed in small quantities in every day diet of humans. A Bangladeshi cannot think a meal without use of spice. They have been used in all categories of food industry involving meat, fish, vegetable products, bakery products and fast foods.

Insect infestation on stored spices is a serious problem throughout the world. There are approximately 20 species of insects attacking in stored spices (Kumar *et al.*, 2014), such as red flour beetle (*Tribolium casteneum*), cigarette beetle (*Lasioderma serricorne*), spider beetle (*Ptinus tectus*), confused flour beetle (*Tribolium confusum*), khapra beetle (*Trogoderma granarium*), drugstore beetle (*Stegobium paniceum*). Among these species cigarette beetle, *L. serricorne* is the serious pest of several stored commodities and it belongs to the family Anobiidae under the order Coleoptera. The Cigarette beetle (Coleoptera: Anobiidae), is a pest of stored medicinal and aromatic plants.

Generally, mortality of each stage increased with an increase of temperature and exposure time (Abdelghany *et al.,* 2010).

They contaminate more food than they consume and most people find the contaminated products unfit for consumption. Insects within an infested package begin multiplying and can spread to other stored food or food debris. All stages (egg, larva, pupa and adult) may be present simultaneously in infested product. Beside its main host tobacco and cigarettes, it has also been recorded on turmeric, ginger, castor beans, wheat, coconut meal, pepper, cardamom, mustard, chilli, fennel, cumin and opium leaves (Ayyar, 1934; Chatterjii, 1963; Gahukar, 1975; Hussain and Khan, 1966; Samuel *et al.*, 1984 and Sharma, 2007).

Adult of cigarette beetles are quite small, have a rounded, oval shape and the head is often concealed by the pronotum when the beetle is viewed from above. The elytra are covered with fine hairs. When disturbed, they often pull in their legs, tuck their head and lay motionless. They prefer to reside in dark or dimly lit cracks, nooks and crevices but become active and fly readily in bright, open areas, probably in an attempt to find refuge. They are most active at dusk and will continue activity through the night. Adults do not feed but will drink liquids. Only larvae cause serious damage. Older larvae are white, scarab-like and hairy. The hair is longer and the head is evenly rounded dorsally with a dark marking with a convex boundary that extends halfway up the frons. An arolium is also present and extends beyond the middle of the claw on each tarsus.

Larval feeding inside and outside the seeds caused an appreciable amount of damage. It produces cavities within infested seed and causes reduction in seed weight and quality. Pupation takes by one to three weeks. Heavily infested seeds spread bad smells and become less attractive for consumption.

As cigarette beetle, *L. serricorne* is one of the serious damaging pests of stored spices, the present work was undertaken with a view to studying the biology of cigarette beetle, *L. serricorne* and it's damage assessment in different spices.

The objectives of this research work were:

- to study on the biology of cigarette beetle, *L. serricorne* on suji
- to determine the extent of damage of spices caused by cigarette beetle, *L. serricorne*

CHAPTER II

REVIEW OF LITERATURE

Spices are aromatic vegetable product used as a flavoring or condiment. The term was formerly applied also to pungent or aromatic foods (e.g., gingerbread and currants), to ingredients of incense or perfume (e.g., myrrh) and to embalming agents. Modern usage tends to limit the term to flavorings used in food or drinks, although many spices have additional commercial uses, e.g., as ingredients of medicines, perfumes, incense, and soaps. Insect pests cause heavy seed losses in storage, particularly in tropical and sub-tropical countries (Aitken, 1975). The efficient control and removal of stored pests from food commodities have long been the goals of entomologists throughout the worlds because insect infestation is the most serious problem of stored products. Losses due to insect infestation are the most serious problem of seeds in storage, particularly, in developing countries like Bangladesh. A search in the literature revealed that the biology of cigarette beetle most varied with environmental conditions, seasons and types of spices. Information about the biology of cigarette beetle on different spices is not available in Bangladesh perspective. However, some literatures on such studies relevant to the present study available through literature and CD-ROM search have been reviewed here in brief under the following sub-headings:

Krishna *et al.* (2013) observed that damage and reproduction potential of *Lesioderma serricorne* on some seed spice crops, *viz.,* cumin, coriander, fennel, ajowan and dill in different storage condition. The losses were maximum in fennel seed (58.02%) and minimum in dill seed (39.0%).

On the other hand, Mahroof & Phillips (2008) revealed that in a addition to feeding damage, the presence of dead insects, cast skins, pupal cases or frass become contaminants in the infested products, rendering them unsuitable for human consumption.

2.1: Origin and distribution of cigarette beetle (*Lesioderma serrricorne*)

This species was first described in North America by Fabricius in 1792 (Powell, 1931), and was first found infesting tobacco in Paris in 1848 (Runner, 1919).The cigarette beetle is pan-tropical but can be found worldwide, especially wherever dried tobacco in the form of leaves, cigars, cigarettes, or chewing tobacco is stored. It is also a commonly encountered stored-product pest in the home and has long been associated with humans. It is believed that the cigarette beetle originated in Egypt because their carcasses have been found in Egyptian tombs (Ashworth, 1993; Jacobs, 1998; Lyon, 1991).

2.2: Host of cigarette beetle

L. serricorne is a well known pest of stored tobacco (Cotton, 1989) and dried processed plant material. Substrates that have been reported as breeding materials or food for *L. serricorne* include tobacco seed, dried figs, dried roots of various kinds, pressed yeast, dried dates, starch, bran, belladonna, dried fish, pyrethrum powder, dried cotton, cotton seed, dog food, almonds, furniture stuffing, and bookbinders' paste (Runner 1919; Singh *et al.*, 1977; Yokoyama and Mackey, 1987). It has also been recorded in a very large number of processed products from ground grain, pulses and beans, spices, dried fruit and vegetables and yeast.

Howe (1957) in his extensive study on the biology and literature survey of *Lasioderma sericorne* recorded a list of hosts including bamboo, beans, biscuits, cassava, chickpea, cocoa, coffee beans, copra, coriander, cotton seed both before and after harvesting, cotton seed meal, atta, cumin, dates, dried banana, dried cabbage, dried carrot, drugs, flaxtow, flour, ginger, grain groundnut, herbs, herbaceous specimens, insecticides containing pyrethrum, juniper seed, liquorice root, nut meg, raisins, rhubarb, rice, seeds of bauhinia, yeast, tobacco, dried fish, fish meal, meat meal, leather and stored wax of cocos and caronda were infested with this beetle.

Padmavathamma and Rao (1989) recorded the stored spice of *Carum copticum* as a new host of *Lasioderma serricorne* in Andhra Pradesh, India causing severe damage.

2.3: Biology of cigarette beetle

Mating: Males and females have more than one mate. Mating occurs within 2-3 days after adult emergence. Males remain responsive to females after previous mating. Females normally mate with 2 males, and males normally mate at least 6 times (Ashworth, 1993; Papadopoulou, 2006). Mating System is polygamous.

Oviposition: Females lay up to about 100 eggs. The eggs of *L. serricorne* are white in color, 0.4 to 0.5 mm long and 0.2 mm wide (Jones, 1913). Each egg weighs approximately 8.4 µg and has a waxy shell which protects the egg from desiccation and hatch by 6 to 10 days in warm weather. The larva eats the egg shell at the time of hatching (Ashworth, 1993). The eggs become dull in color before hatching. Surface of the egg is smooth, without sculpture except at the end portion of egg from which the larva emerges (Runner, 1919).

Larval period: Ashworth (1993) stated that the first instar is less than 1 mm long and covered with fine hairs. The larvae go through four larval instars before pupation, and the weight ranges from 2.5 to 5.0 mg. Runner (1919) reported that the first instar is 0.55 to1.4 mm long and yellowish white in color. The second instar is about 3 mm long and yellowish white, and the last instar is 4 mm long, and body is yellowish white, set entirely with long, yellowish brown hairs. Newly hatched larvae move away from light and are extremely active (Ashworth, 1993). These tiny larvae are able to infest packaged food by entering through small holes (Runner, 1919). The older larvae are less active but are still capable of wandering considerable and remain negatively phototropic. Larvae are scarabaei form in shape, i.e., when at rest, bodies curl into a “C” shape. The larvae stop feeding and build cell when they are fully grown, and the formation of this cell is influenced by the food substrate. Disturbance may cause old larvae to give up a partly-made cell and build new cells or even cause them to form naked pupae (Howe, 1957).

They tend to penetrate deeply into loosely packed commodities. Insect activity ceases when the temperature falls below 19.5ºC (Runner, 1919) and the beetle overwinters in the larval stage (Ashworth, 1993). Development of larvae stops when the temperature falls below 17ºC and above 42ºC (Howe, 1957).

Pupal period: Pupa is uniformly white when first formed, and is 3.5 mm long and 1.7 mm wide. Pupal period is 7-21 days. Tips of elytra reach the fourth segment of the abdomen. Metathoracic legs are formed under the elytra. The head is curved beneath pronotum. The ultimate portion of the abdomen is paired with lateral protuberances (Runner, 1919).

Phillips *et al.,* (2000) reported that, in the three food sources containing *Capsicum* spp. the survival rate ranged from 30% to 40%. The egg, larval, and pupal development times varied from 3 to 5, 38 to 92 and 4 to 18 d, respectively, among food sources.

Adult emergence: Cigarette beetles are quite small, measuring about 2 to 3 mm and are reddish brown. They have a rounded, oval shape and the head is often concealed by the pronotum when the beetle is viewed from above. The elytra are covered with fine hairs. When disturbed, they often pull in their legs, tuck their head and lay motionless. They prefer to reside in dark or dimly lit cracks, nooks and crevices but become active and fly readily in bright, open areas, probably in an attempt to find refuge. They are most active at dusk and will continue activity through the night. Adults do not feed but will drink liquids.

2.4: Nature and extent of damage

Both adults and larvae cause damage to stored products (LeCato and Flaherty, 1973), but the damage done by larvae is more serious (Bousquet, 1990). In Australian conditions adults are short-lived and feed little (Rees, 2004).

Damage is caused by *L. serricorne* usually by reducing weight and decreasing in quality. A single insect only causes a few milligrams of weight loss, whereas populations measured by millions of *L. serricorne* individuals can bring considerable weight loss. Stored products are holed and contaminated with cocoons and frass when infested by *L. serricorne*. In cigar and cigarettes the holes destroy the product, and holes spoil the sack or package. Infestation of cereal grains and of seeds of beans and other plants could adversely affect germination as the germ is attacked (Howe, 1957).

Malhotra (2007) reported that about 17 to 25 percent losses are caused by insects, moulds, rodents etc. to different spices during storage. These losses are caused by converting seed into powder form.

2.5: Effect of environment on pest survival

Larval activity of the cigarette beetle ceases when the temperature falls below 15°C (59°F) and these larvae can remain dormant for many months and may over-winter in this stage in cool climates.

Howe (1957) staded that the developmental period is affected by both humidity and temperature as well as type and availability of food.

Lefkovitch & Currie (1963) reported that food shortages prolong development and reduces survival of the immature stages and also reduces the weight of the resulting adults. Larvae will eat eggs and pupae in the absence of other food sources.

Ashworth (1993) concluded that the minimal temperature for development was about 18°C, but oviposition has been recorded at 15°C. All stages are killed at 2.2°C for 16 days or -3.8°C for 7 days but eggs may survive shorter periods of exposure.

2.6: Factors regulating loss of grain in storage

2.6.1: Biotic factors

Both biotic and abiotic factors are responsible for the loss of stored seeds in storage. The major biotic factors influencing seeds loss during storage are insects, moulds, birds and rats.

2.6.2: Abiotic factors

Abiotic factors including temperature, humidity and type of storage, all affect environmental conditions in storage. High temperature causes deterioration, while low temperature is good for storage. High temperature accelerates the respiration of seeds, which produces carbon dioxide, heat and water, conditions favorable for spoilage, while decreasing humidity is good for storage for any crop. Generally the colder and drier surrounding of the environment is better for storage seeds. The conditions with 30% relative humidity, temperature bellow 59^{o} F (15^{o}C) and darkness are the three factor for optimal seed storage. Light stimulate and support the germination process of the seeds and storage in darkness helps keeping the pre-germination process in the seed at a low level.

Hagstrum and Milliken (1988) studied the development period of 9 species of coleoptera attacking stored products in relation to temperature, moisture & diet and stated that at most temperature, the order of relative influence of these factors on development was temperature, moisture and diet. However, moisture and diet influenced larval development more than temperature.

Zhang and Wang (1996) carried out an ecological study on a laboratory population of cigarette bettle, *L. serricorne* under the treatment combination of six levels of temperature (20.3^{0}C, 23.9^{0}C, 27.7^{0}C, 32.2^{0}C, 33.7^{0}C, 35.9^{0}C) and three levels of relative humidity (51.3%-55.0%, 75.5%-76.0%, 83.8%-85.0%). They reported that the optimum temperature and relative humidity were 30^{0}C-34^{0}C and 70-85 percent respectively for the growth and development of this pest and the temperature higher than 36^{0}C and relative humidity less than 51% had an adverse influence on its survival.

According to Abdelghany *et al.*, (2010), mortality of each stage generally increased with an increase of temperature and exposure time. Heat tolerance for different stages from highest to lowest was young larvae, old larvae, eggs, adult, and pupae. The mortality after 7 h at 42^0C for young larvae, old larvae, eggs, adults, and pupae, respectively, were 16 ± 5, 31 ± 6, 48 ± 3, 63 ± 8, and 86 ± 2% (mean ± SEM). Similar trends for stage specific mortality were seen with the lethal time for 90% mortality (LT_{90}) at 42°C; 773, 144, 12, and 11 h for old larvae, eggs, adults, and pupa, respectively. Mortality was too low with young larvae to estimate LT_{90}. The LT_{90} for young larvae at 42, 45, 50, 55, and 60°C was 25, 20, 3.9, 0.18 h, and 0.08 h, respectively.

2.7: Storage structure for protection of stored spice seed

Local storage structures which are commonly used in rural India and Bangladesh fail to maintain the optimum flavor of spices and also fail to provide complete seeds protection from insects. In general, these structures are not moisture proof. The moisture content is high in stored spices seed which facilitates insect multiplication. The longer the storage period, higher is the insect infestation.

The type of storage plays a fundamental role in storage efficiency. Spices seed should be kept in tightly sealed container .Climate conditions, seeds conditions at storage, seeds and pest control practices all contribute to the rate of loss caused by insects. As these factors interact, it is difficult to isolate them or identify one factor, which has a direct influence on loss. Average statistics for loss, whether for store types, areas, or quantities of seeds stored are inconclusive. An average figure for loss for a region or a country holds no significance unless a decision regarding a new system of storage, or new pest control techniques adopted. Nevertheless average loss figures are always sought.

CHAPTER III

MATERIALS AND METHODS

Experiment 1: Study on the biology of cigarette beetle, *Lesioderma serricorne* (F.) on suji in the laboratory

The study was conducted in the laboratory of the Department of Entomology of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from March to July, 2015. The biology of *L. serricorne* was studied on suji, which was collected from SAU market.

3.1.1 Test insect collection

Adults of cigarette beetle along with the infested spices were collected from the laboratory under the Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka.

3.1.2 Stock culture of cigarette beetle, *L. serricorne*

The collected insects were maintained in the laboratory of Entomology Department, Sher-e-Bangla Agricultural University, Dhaka. Different stages of *L. serricorne* were reared in a container with coriander in the laboratory. For the study of adults were sort out from infested coriander seeds (Plate 01) and then transferred to another plastic container and released in test tube with the help of aspirator (Plate 02).

Plate 01. Stock culture of *L. serrricorne* in coriander seeds

Plate 02. Aspirator for the collection of cigarette beetle, *L. serricorne*

3.1.3 Collection of eggs for the study of biology: For collection of eggs, 10 pairs of newly emerged cigarette beetle were released in 10 test tubes separately and the top of the test tube was covered by net.

After 24 to 48 hours the beetle were removed from the test tube and the eggs were gently collected from the bottom part of test tube and data were recorded.

Plate 03. Each test tube with one pair of cigarette beetle *L. serricorne* kept for egg laying

3.1.4 Biology of *L. serricorne*

Eggs were transferred on pieces of white paper in petri dishes for hatching. After hatching without exuviae, only the newly hatched larvae of *L. serricorne* were transferred in petri dishes containing suji. The morphological characteristics of the larvae (Plate 04) and pupae (Plate 05) were studied and recorded during the period of larval and pupal develpomant respectively. Different growth and development stages of *L. serricorne* such as larval period, pupal period and adult longevity were recorded during the study (Plate

06). The incubation period was measured by time interval between egg laying and larval hatching.

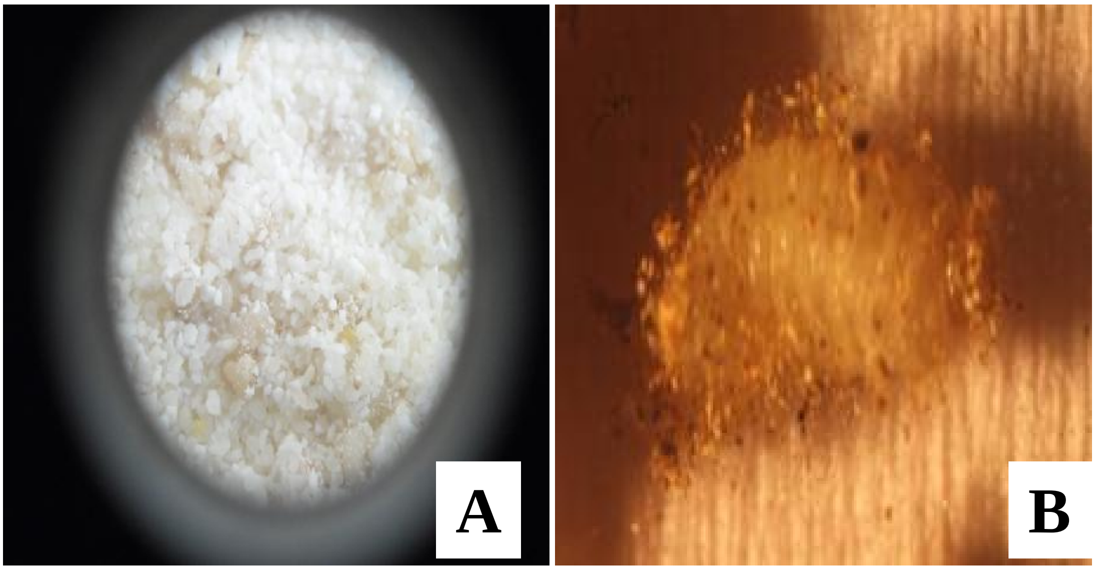


Plate 04. Infested Suji with larvae (A) of cigarette beetle *L.serricorne* during the study of biology in laboratory and microscopic view of larva (B)

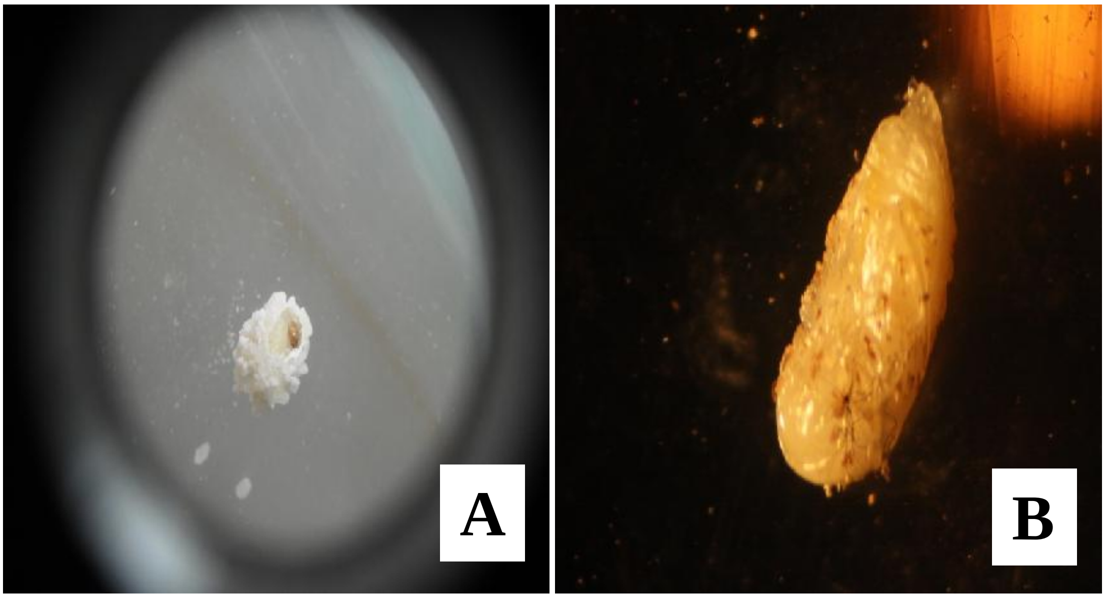


Plate 05. Pupa of cigarette beetle *L. serricorne* in chamber on suji (A) during the study of biology in laboratory and microscopic view of pupa (B)

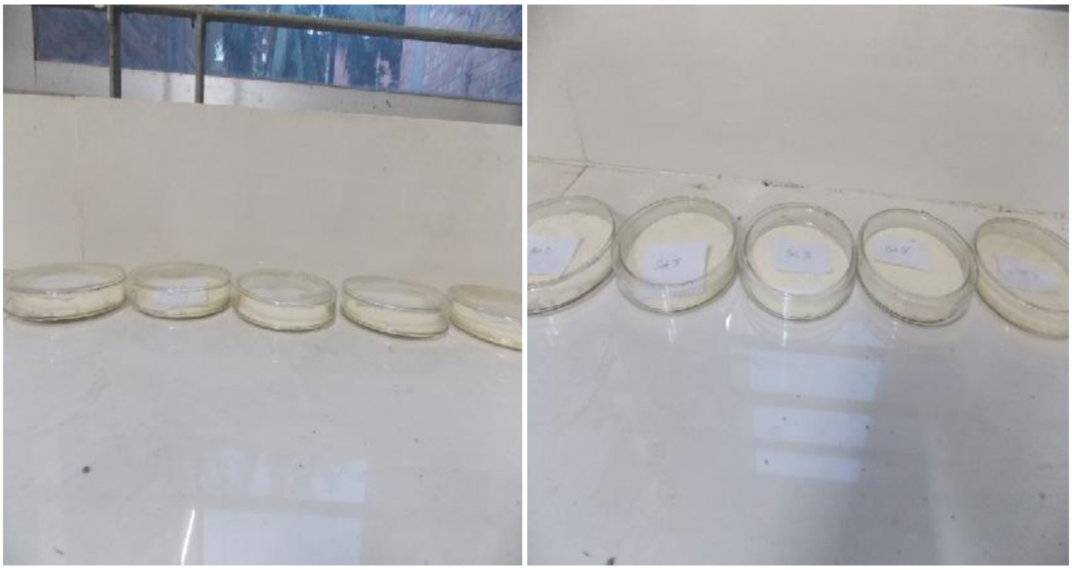


Plate 06. Study of the biology of cigarette beetle *L. serricorne* on suji in laboratory

3.1.5 Design of the experiment

The experiment was laid out in CRD (Completely randomized design) with 5 replications.

3.1.6 Data recorded: Data were recorded on the following parameters

- no. of laid eggs
- incubation period
- larval period
- larval mortality
- pupal period
- pupal mortality
- adult emergence

Experiment 2: Damage assessment in different spices caused by cigarette beetle

The experiment was conducted to study the extent of damages in different spices inflicted by cigarette beetle during the period from March to July, 2015. A brief description of the experimental site, experimental design, data collection and analysis of different parameters have been explained under the following sub-headings:

3.2.1 Preparation of test materials

Spices were collected from Krishi market, Dhaka in March 2015 to carry out the study. The seeds were cleaned, dried and sorted out from damage unhealthy seeds and stored in large size poly bag with airtight condition to keep free from the insects and microorganisms.

3.2.2 Collection of cigarette beetle

The process of collection was described similar to that in 3.1.1 – 3.1.3 of the experiment 01.

3.2.3 Experimental design and layout

The experiment was laid out in the ambient condition of laboratory and laid out in CRD (Completely randomized design).

3.2.4 Data recorded: The data were recorded on different parameters

- number of dead insects at 6, 10, 14, 18, 22, 26 and 30 days
- number of adult emergence
- status of seeds in 1st, 2nd and 3rd generation by weight
- weight loss of different spices

3.2.5 Experimental material

Ten gm of different spices fenugreek (Methi), coriander (Dhania), cumin (Jira), fennel (Mouri), celery (Radhuni), carom(Ajowan) and dry chili were used as experimental material in each plastic container 5 pairs of cigarette beetle were related to assess the damage percentage (Plate 7).

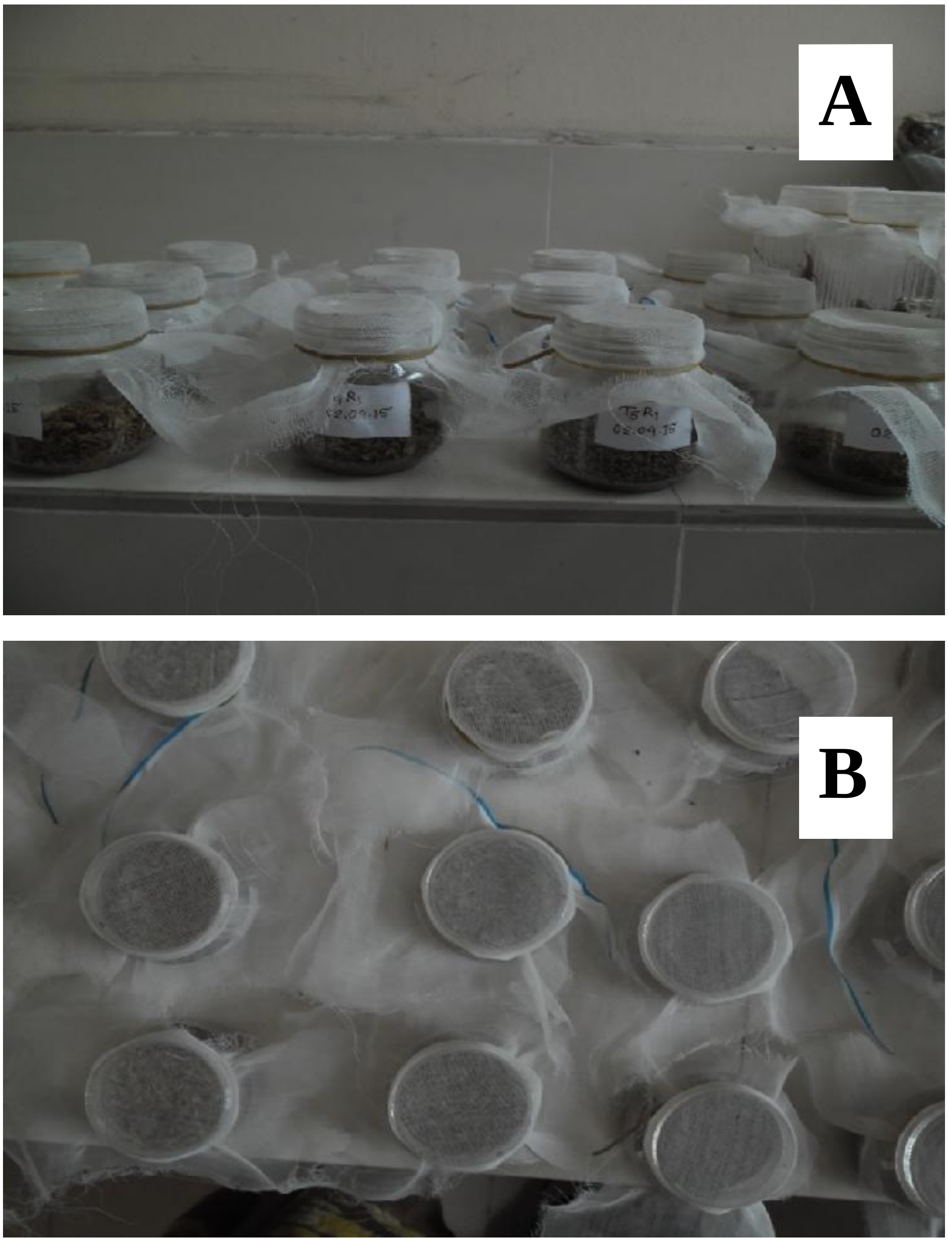


Plate 07. Experimental set up with different spices to determine the damage assessment by cigarette beetle

3.2.5.1 Fenugreek (Radhuni)

Trigonella foenum-graecum seeds (Plate 08) collected from its annual plant in the family Fabaceae, with leaves consisting of three small obovate to oblong leaflets. It is cultivated worldwide as a semiarid crop, and its seeds are common ingredient in dishes from the Indian Subcontinent in South Asia.

Plate 08. Healthy fenugreek spices seeds

Uses

Fenugreek is used as a herb (dried or fresh leaves), spice (seeds), and vegetable (fresh leaves, sprouts, and microgreens). Sotolon is the chemical responsible for fenugreek's distinctive sweet smell. Fresh fenugreek leaves are an ingredient in some Indian curries.

3.2.5.2 Coriander (Dhania)

Coriandrum sativum seeds (Plate 09) also known as cilantro or Chinese parsley or dhania (Bangali), is an annual herb in the family Apiaceae.

Coriander is native to regions spanning from southern Europe and North Africa to southwestern Asia. It is a soft plant growing upto 50 cm tall. The leaves are variable in shape, broadly lobed at the base of the plant, and slender and feathery on the flowering stems. The flowers are borne in small umbels, white or very pale pink, asymmetrical, with the petals pointing away from the centre of the umbel longer (5–6 mm or 0.20–0.24 in) than those pointing toward it (only 1–3 mm long). The fruit is a globular, dry schizocarp 3–5 mm in diameter. Although sometimes eaten alone, the seeds are often used as a spice or an added ingredient in other foods.

Plate 09. Healthy coriander spices seeds

Uses

All parts of the plant are edible, but the fresh leaves and the dried seeds are the parts most traditionally used for cooking. Coriander is common in South Asian, Southeast Asian, Indian, Middle Eastern, Caucasian, Central Asian, Mediterranean, Tex-Mex, Chinese, African and Scandinavian cuisine. Coriander, like many spices, contains phytochemicals which may delay or prevent the spoilage of food seasoned with this spice.

3.2.5.3 Cumin (Jira)

Cumin seeds (Plate 10) are used as a spice for their distinctive flavour and aroma. It is globally popular and an essential flavouring in many cuisines, particularly South Asian, Northern African and Latin American cuisines.

Plate 10: Healthy cumin spices seeds

Uses

In Sanskrit, cumin helps in digestion and in the Ayurvedic system, dried cumin seeds are used for medicinal purposes. It is used internally and sometimes for external applications also. It enhances the appetite, taste perception, digestion, vision, strength, and lactation. It is used in the treatment of fever, loss of appetite, diarrhea, vomiting, abdominal distension, edema and puerperal disorders.

3.2.5.4 Fennel (Mouri)

Fennel (*Foeniculum vulgare*) seeds (Plate 11) is a flowering plant species in the family of Apiaceae or Umbelliferae. It is a hardy, perennial herb with yellow flowers and feathery leaves. It is indigenous to the shores of the Mediterranean but has become widely naturalized in many parts of the world, especially on dry soils near the sea-coast and on riverbanks.

Plat 11. Healthy fennel spices seeds

Uses

It is a highly aromatic and flavorful herb with culinary and medicinal uses and, along with the similar-tasting anise, is one of the primary ingredients of absinthe. Florence fennel or finocchio is a selection with a swollen, bulb-like stem base that is used as a vegetable.

Fennel is used as a food plant by the larvae of some Lepidoptera species including the mouse moth and the anise swallowtail.

3.2.5.5 Celery (Radhuni)

Celery (*Apium graveolens*) is a cultivated plant, in the family Apiaceae. Celery leaves are pinnate to bipinnate with rhombic leaflets and the flowers are creamy-white. The seeds are broad ovoid to globose (Plate 12).

Plate 12. Healthy celery spices seeds

Uses

Celery is used around the world as a vegetable for the crisp petiole (leaf stalk). The leaves are strongly flavoured and are used less often, either as a flavouring in soups and stews or as a dried herb. The use of celery seed as a spice and also in pills for relieving pain as described by Aulus Cornelius Celsus around AD 30. Celery seeds contain a compound, 3-*n*-butylphthalide, that has been demonstrated to lower blood pressure in rats.

3.2.5.6 Carom (Ajowan)

Carom, *Trachyspermum ammi* (seeds) (Plate 13) is an annual herb in the family Apiaceae. It originated in the eastern Mediterranean, possibly Egypt, and spread up to India from the Near East. The small fruit pods are pale brown and have an oval shape, resembling caraway and cumin. It has a bitter and pungent taste, with a flavor similar to anise and oregano.

Uses

The fruit pods are rarely eaten raw; they are commonly dry-roasted or fried in ghee, clarified butter. This allows the spice to develop a more subtle and complex aroma.

Plate 13. Healthy carom spices seeds

3.2.5.7 Dried red chilli

Dried red chilli ,*Capsicum annuam* (Plate 14) is an *Evergreen shrub* in the family Verbenaceae. It is also known as red sage, wild sage, shrub verbena,yellow sage etc.

Plate 14. Healthy dried red chillies

Uses

Red (Ripe) chillies are used to impart pungency to the food and it's also used to repellent insects. The powder is used as condiment in every Indian household.

3.2.6 Adult mortality and new emergence

Ten gm of insect free different tested spices were taken into each plastic container separately. Then 5 pairs of newly emerged adult beetle were released carefully into each container. Insect mortality was recorded at 4 days intervals up to 30 days. The container were observed from outside to examine death of released beetle. The mortality of the adult was recorded from methi, coriander, cumin, fennel, celery, carom seeds and dried red chilli.

The adult mortality was recorded and converted into percent.

$$\text{Per cent of mortality} = \frac{\text{No. of dead insects}}{\text{Total no. of insects}} \times 100$$

After 28 – 35 days, new adults started emerging from those spices. The counting of emerged adult beetle was made by opening the net. After beginning, few beetle came out from the plastic container at first and the rest of them came out after shaking of container gently.

3.2.7 Extent of damage and weight loss of different spices

The final weight of seeds was taken to obtain weight loss. Sieving and winnowing was done to clean the seeds. The clean seeds except those having holes in each container were weighted separately. The weight losses of seeds were found out by subtracting the final weight from the initial weight (10 g). The weight losses were converted into percentage of weight loss of seeds. The percentage of weight loss was calculated as follows:

$$\text{\% Infestation (by weight)} = \frac{\text{Weight of infested seeds}}{\text{Total weight of seeds}} \times 100$$

$$\text{\% Weight loss due to infestation} = \frac{\text{Initial weight of seeds} - \text{Final weight of seeds}}{\text{Initial weight of seeds}} \times 100$$

3.2.8 Statistical Analysis

The observed data were statistically analyzed following Completely Randomized Design (CRD). Mean values were separated by Duncan's Multiple Range Test (DMRT) (Duncan, 1951). All statistical analysis were done through a package program namely MSTAT-C computer package.

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study on biology of Cigarette beetle, *Lesioderma serricorne* and it's damage assessment on different spices in the laboratory. The results have been presented and discussed with possible interpretations under the following headings and sub headings:

4.1 Biology of cigarette beetle, *L. serricorne* on suji in laboratory

4.1.1 Mating and oviposition

Males and females have more than one mate. Mating occurs within 2-3 days after adult emergence. The adult female of *L. serricorne* beetle laid 112-160 eggs with an average of 138.80 eggs throughout a period of up to 4 days (Table 1). The eggs of *L. serricorne* are white in color and become dull in color before hatching. According to Phillips *et. al.,* (2000), the highest fecundity (52.4±4.8 eggs/female) was observed in wheat flour, whereas the lowest fecundity (5.8±0.8 eggs/female) was observed in cigar tobacco.

4.1.2 Developmental period of different life stages

An average oviposition and incubation period were 4.00 ± 0.02 and 6.67 ± 0.03 days, respectively on suji in laboratory condition. The newly hatched larva is yellowish white with a light brown head. Total 14.00 ± 0.09 and 8.33 ± 0.03

Table 1. Day specific fecundity in terms of laid eggs of cigarette beetle, *L. serricorne* on suji in laboratory condition

Insect	Number of laid eggs				Total number of eggs
	1st day	2nd day	3rd day	4th day	
1st pair	25	28	31	28	112
2nd pair	39	38	37	40	154
3rd pair	43	37	39	41	160
4th pair	31	26	36	35	128
5th pair	36	37	33	28	134
6th pair	28	33	38	34	133
7th pair	36	41	39	36	146
8th pair	37	39	41	35	147
9th pair	33	30	38	35	136
10th pair	36	33	28	41	138
Average	34.40	33.80	35.30	35.30	138.80

Table 2. Development period of different life stages of cigarette beetle, *L. serricorne* on suji in laboratory condition

Development stages	Duration (days)	Statistics
Oviposition period	4.00 ± 0.02	P<0.012
Incubation period	6.67 ± 0.03	P<0.001
Larval period	14.00 ± 0.09	P<0.013
Pupal period	8.33 ± 0.03	P<0.010
Adult longevity	9.67 ± 0.05	P<0.001

days, were required for larval stage and pupal stage respectively. Adult longevity of Cigarette beetle, *L. serricorne* was 9.67 ± 0.05 (Table 2).

Ashworth (1993) reported that, each egg weighs approximately 8.4 µg and has a waxy shell which protects the egg from desiccation and hatch in 6 to 10 days in warm weather. The larva eats the egg shell at the time of hatching.

Hill (1990) concluded that larval development on a good diet takes 17-30 days, pupation takes 3-10 days and is followed by a pre-emergence maturation period of 3-10 days. Adult lives for 2-6 weeks.

4.1.3 Newly hatched larvae

At 1st, 2nd, 3rd and 4th day the number of newly hatched larvae were 22-35, 22-36, 23-33 and 21-38, respectively. The total highest number of larvae hatched in Set-II (140) and the total lowest number (92) of larvae hatched in Set-I with an average number of larvae hatched (116.00) throughout a period of up to 4 days (Table 3) & (Figure 1).

Table 3. Day specific fecundity in terms of newly hatched larvae of cigarette beetle, *L. serricorne* on suji in laboratory condition

Set or Replication	Number of newly hatched larvae				Total number of larvae
	1st day	2nd day	3rd day	4th day	
Set-I	22	22	23	25	92
Set-II	35	36	32	37	140
Set-III	34	34	33	38	139
Set-IV	24	22	31	26	103
Set-V	27	29	29	21	106
Average	28.40	28.60	29.60	29.40	116.00

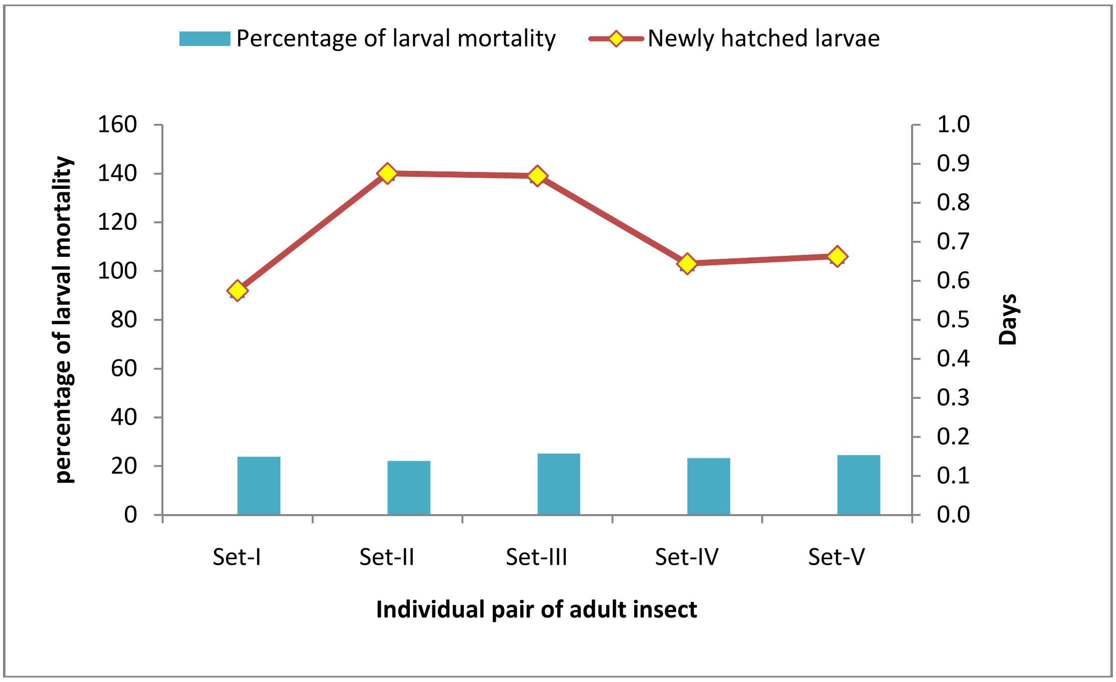


Fig. 1. Larval mortality of cigarette beetle, *L. serricorne* on suji at different days during the study period

4.1.4 Larval and pupal mortality of cigarette beetle, *L. serricorne* at different days during the study period

Larval mortality

The highest percentage (25.17%) of larval mortality was observed from set-III, whereas the lowest percentage (22.14%) of larval mortality was observed from set-II (Figure 2), with total average number of larval mortality 25.60 (Appendix i).

Pupal mortality

The highest percentage (28.75%) of pupal mortality was observed from set-V, whereas the lowest percentage (18.98%) of pupal mortality was observed from set-IV (Figure 2), with total average number of pupal mortality 21.60 (Appendix ii).

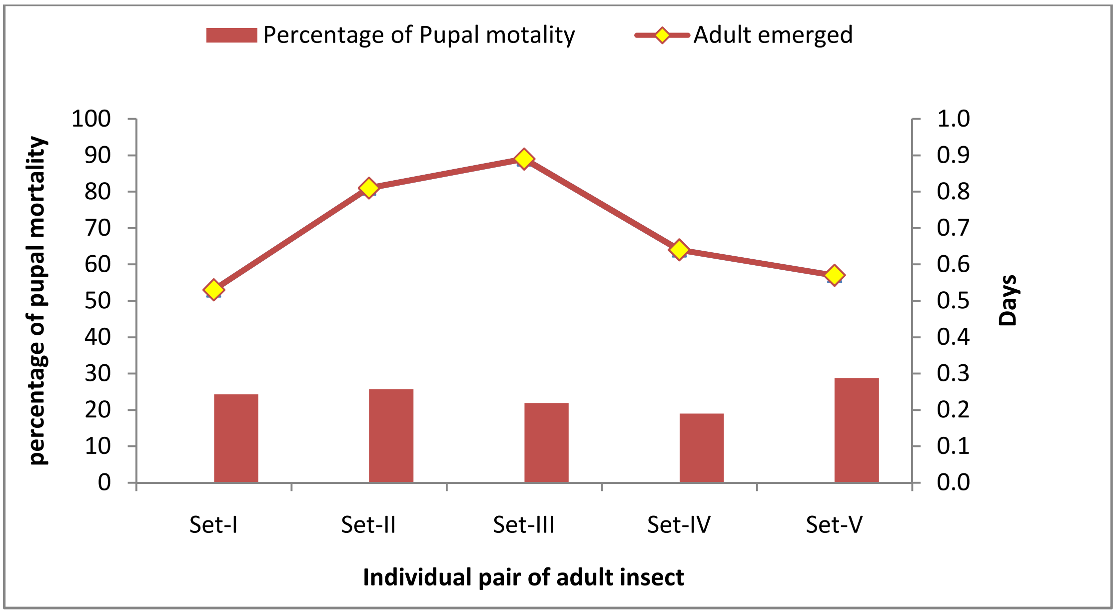


Fig. 2. Pupal mortality of cigarette beetle, *L. serricorne* at different days during the study period

4.1.5

At 1st, 2nd, 3rd and 4th day the number of newly formed pupae were 16-29, 17-28, 19-27 and 16-30, respectively. The total highest number of pupae

Table 4. Day specific fecundity in terms of newly formed pupae of cigarette Beetle, *L. serricorne* on suji in laboratory condition

Set or Replication	Number of newly formed pupae				Total number of pupae
	1st day	2nd day	3rd day	4th day	
Set-I	18	17	19	16	70
Set-II	26	28	27	28	109
Set-III	29	28	27	30	114
Set-IV	16	17	25	21	79
Set-V	19	21	23	17	80
Average	21.60	22.20	24.20	22.40	90.40

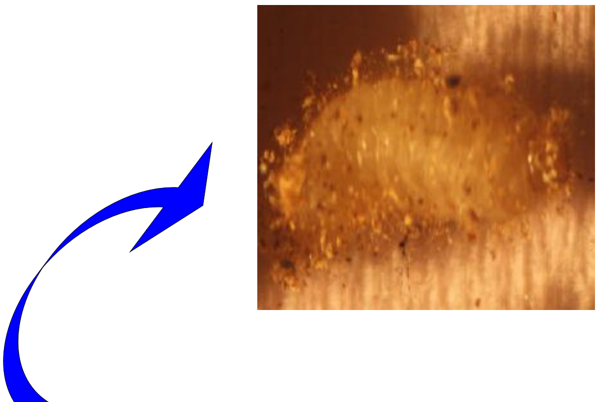
formed in Set-III (114) and the total lowest number (70) of pupae formed in Set-I with an average number of pupae formed (90.40) throughout a period of up to 4 days (Table 4).

4.1.6 Newly adult emergence

At 1st, 2nd, 3rd and 4th day the number of newly emerged adults were 10-21, 12-22, 14-23 and 12-23, respectively. The total highest number of adults emerged in Set-III (89) and the total lowest number (53) of adults emerged in Set-I with an average number of adults emerged (68.80) throughout a period of up to 4 days on suji in laboratory condition (Table 5).

Table 5. Day specific fecundity in terms of newly emerged adults of cigarette Beetle, *L. serricorne* on suji in laboratory condition

Set or Replication	Number of newly emerged adults				Total number of adults
	1st day	2nd day	3rd day	4th day	
Set-I	15	12	14	12	53
Set-II	19	21	19	22	81
Set-III	21	22	23	23	89
Set-IV	12	15	19	18	64
Set-V	10	17	17	13	57
Average	15.40	17.40	18.40	17.60	68.80



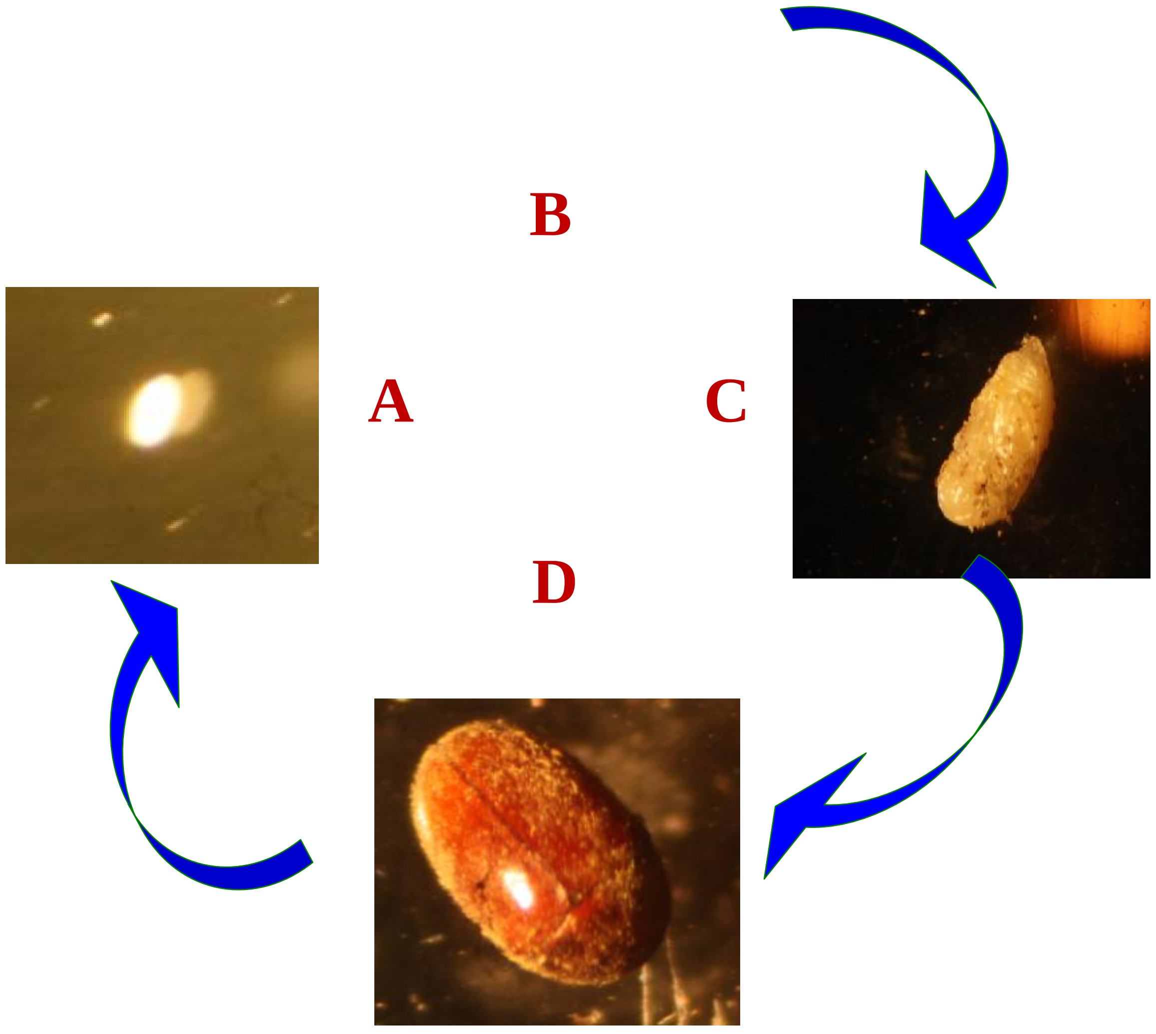


Plate 15. Life cycle of cigarette Beetle, (*Lasioderma serricorne*), A. Egg, B. Larva, C. Pupa and D. Adult

4.2 Damage assessment in different spices caused by cigarette beetle, *L. serricorne*

4.2.1 Number of dead insects

Insect mortality or number of cumulative dead insects showed statistically different in different spices in stored condition after 6, 10 and 14, 18, 22, 26 and 30 days of observation (Table 6).

After 6 days of observations, the highest number of dead insects (2.00) was recorded in carom (Ajowan), whereas the lowest number of dead insect (1.33) was observed in celery (Radhuni) but same number of dead insect (1.67) was recorded in fenugreek (Methi), coriander (Dhania), cumin (Jira), fennel (Mouri), carom (Ajowan) and dried red chilli. But no significant difference observed among them.

After 10 days of observations, the highest number of dead insects (3.67) was recorded in fenugreek (Methi) which was statistically identical (2.00) with that of cumin (Jira), fennel (Mouri), carom (Ajowan) and dried red chilli. But the lowest (1.33) numbrt of dead insect was observed in celery (Radhuni) which closely followed by (1.67) coriander (Dhania) (Table 6).

After 14 days of observations, the highest number of dead insects (3.00) was recorded in carom (Ajowan) which was statistically identical (2.33) with that of dried red chilli, whereas the lowest (1.33) dead insect was observed in cumin (Jira) which closely followed by (1.67) fenugreek (Methi), coriander (Dhania) and fennel (Mouri) (Table 6).

After 18 days of observations, the highest number of dead insects (2.67) was recorded in carom (Ajowan) which was closely followed by (2.33) in cumin

(Jira), whereas the lowest (0.67) dead insect was observed in coriander (Dhania) which followed by (1.00) fenugreek (Methi) (Table 6).

After 22 days of observations, the highest number of dead insects (2.00) was recorded in carom (Ajowan) which was followed by (1.33) in fenugreek (Methi), celery (Radhuni), dried red chilli, whereas the lowest (0.67) dead insect was observed in fennel (Mouri) which was followed by (1.00) coriander (Dhania) and cumin (Jira) (Table 6).

After 26 days of observations, the highest number of dead insects (2.33) was recorded in coriander (Dhania)) which was followed by (2.00) in fennel (Mouri) whereas the lowest (0.67) number dead insect was observed in fenugreek (Methi), which was followed by (1.00) cumin (Jira) and no dead insect was found in dried red chilli (Table 6).

Table 6. Number of dead insects of cigarette beetle, *L. serricorne* in different spices in laboratory in condition

Different spices	Number of dead insect						
	6 days	10days	14days	18days	22days	26days	30days
Fenugreek (Methi)	1.67	3.67 a	1.67 bc	1.00 c	1.33 ab	0.67 bc	0.00
Coriander (Dhania)	1.67	1.67 b	1.67 bc	0.67 c	1.00 b	2.33 a	1.33
Cumin (Jira)	1.67	2.00 b	1.33 c	2.33 a	1.00 b	1.00 abc	0.67
Fennel (Mouri)	1.67	2.00 b	1.67 bc	1.33 bc	0.67 b	2.00 ab	0.67
Celery (Radhuni)	1.33	1.33 b	2.00 bc	2.00 ab	1.33 ab	1.67 ab	1.00
Carom (Ajowan)	2.00	2.00 b	3.00 a	2.67 a	2.00 a	1.67 ab	1.15
Dried red chilli	1.67	2.00 b	2.33 ab	0.854	1.33 ab	0.00 c	0.00
LSD(0.01)	--	0.662	0.854	0.854	0.763	1.378	-
Level of Significance	NS	0.01	0.01	0.01	0.05	0.01	NS
CV(%)	12.07	8.04	14.99	10.14	15.25	9.01	12.20

In a column means having similar letter are statistically identical and those having dissimilar letter differ significantly as per 0.01 level of probability and numeric data represents the mean value of 4 replications.

After 30 days of observations, the highest number of dead insects (1.33) was recorded in coriander (Dhania), whereas the lowest (0.67) number of dead insect was observed in fennel (Mouri) and cumin (Jira), but no significant difference observed among different spices. There was no dead insect seen in fenugreek (Methi) and dried red chilli (Table 6).

Data revealed the survival rate of cigarette beetle, *L. serricorne* was highest in dried red chilli (Table 6).

4.2.2 Adult emergence

In 1st, 2nd and 3rd generation no adults emerged in celery (Radhuni) and carom (Ajowan) seeds. At 1st and 2nd generations the highest number of adults were recorded in cumin (Jira) seeds (109.00 and 250.33, respectively) which was followed by coriander seeds (56.00 and 172.33, respectively) and the lowest adult emerged in fenugreek (Methi) seeds (4.00 and 2.33, respectively) which was statistically identical to that of dried red chilli (7.33 and 11.00, respectively). At 3rd generation the highest number of adults emerged in coriander (Dhania) seeds (59.33) which was followed by cumin (Jira) seeds (26.67) and fennel (Mouri) (25.67) seeds and the lowest number of adults were recorded in fenugreek (Methi) seeds (0.33) which was statistically identical to that of dried red chilli (3.00), whereas no adults emergence were recorded in radhuni and ajowan seeds (Table 7).

Table 7. Effect of different spices for adult emerged of cigarette beetle, *L. serricorne* at 1st, 2nd and 3rd generation in stored conditions

Different spices	Adult emerged at		
	1st generation	2nd generation	3rd generation
Fenugreek (Methi)	4.00de	2.33d	0.33d
Coriander (Dhaniya)	56.00b	172.33b	59.33a
Cumin (Jira)	109.00a	250.33a	26.67b
Fennel (Mouri)	38.33c	97.33c	25.67b
Celery (Radhuni)	0.00e	0.00e	0.00e
Caron (Ajowan)	0.00e	0.00e	0.00e
Dried red chilli	7.33d	11.00d	3.00c
LSD(0.01)	5.156	18.38	2.147
Level of Significance	0.01	0.01	0.01
CV(%)	9.60	13.78	8.40

In a column means having similar letter are statistically identical and those having dissimilar letter differ significantly as per 0.01 level of probability and numeric data represents the mean value of 4 replications.

4.2.3 Status of different spices in 1st, 2nd and 3rd generation by weight

Study of 1st generation of *L. serricorne*

Status of spices in terms of healthy, infested and % infestation showed statistically significant variation (Table 8 to Table 9) in assessing damage assess in different stored spices caused by *L. serricorne*.

In 1st generation, the highest weight of healthy spices (10.00 g) were recorded in celery (radhuni) and in carom (Ajowan), which were closely followed by methi (9.84 g) which as statiscally identical to that of other spices. The lowest weight was observed in jira (7.43 g) which was statistically identical to that of dhania (8.20 g) seeds. In case of infested seeds, there were no infested seeds were recorded from radhuni and ajowan spices seeds, which were statistically different from that of other spices seeds. The highest weight of infested spices seeds were observed in jira (2.57 g) which were statistically identical to that of dhania (1.80 g) and mouri (1.00 g) seeds. The lowest weight of infested seeds were recorded in methi (0.16 g) which was closely followed by dried red chilli (0.93 g). The highest percent infestation was recorded from jira (25.67 %) seeds which were statistically similar to that of dhania (18.00 %) seeds while no percent of infestation was recorded in radhuni and ajowan seeds (Table 8).

Table 8. Effect of different spices on percent infestation and total weight of seeds caused by cigarette beetle, *L. serricorne* in stored condition at 1st generation

Different spices	Total weight of spices		Infestation%
	Healthy(g)	Infested(g)	
Fenugreek(Methi)	9.84 a	0.16 d	1.57 d
Coriander(Dhaniya)	8.20 c	1.80 b	18.00 b
Cumin(Jira)	7.43 d	2.57 a	25.67 a
Fennel(Mouri)	9.00 b	1.00 c	10.00 c
Celery(Radhuni)	10.00 a	0.00 d	0.00 d
Caron(Joyan)	10.00 a	0.00 d	0.00 d
Dried red chilli	9.07 b	0.93 c	9.33 c
LSD(0.01)	0.207	0.207	2.075
Level of Significance	0.01	0.01	0.01
CV(%)	5.31	12.85	12.85

In a column means having similar letter are statistically identical and those having dissimilar letter differ significantly as per 0.01 level of probability and numeric data represents the mean value of 4 replications.

Study of 2nd generation of *L. serricorne*: In 2nd generation, the highest weight of healthy spices (10.00 g) were recorded in celery (radhuni) and in carom (Ajowan), which were followed by methi (9.66 g) and statiscally identical to that of other spices. The lowest weight was observed in jira (2.50 g) which was statistically identical to that of dhania (4.03 g) seeds. There were no infested seeds recorded from radhuni and ajowan spices seeds respectively, which were statistically different from all other spices seeds. The highest weight of infested spices seeds were observed in jira (4.93 g) which were statistically identical

Plate 16. Infested cumin (jira) spices seeds after infestation by cigarette beetle (A) and infested cumin (jira) spices seeds with larvae (B)

to that of dhania (4.17 g). The lowest weight of infested seeds was recorded in methi (0.19 g) which was followed by dried red chilli (1.10 g). The highest percent infestation was recorded from jira (66.43 %) seeds which were statistically identical to that of dhania (50.86 %) seeds while no percent of infestation was recorded in radhuni and ajowan seeds (Table 9).

Table 9. Effect of different spices on percent infestation and total weight of seed caused by cigarette beetle, *L. serricorne* in stored condition at 2nd generation

Different spices	Total weight of spices		Infestation%
	Healthy(g)	Infested(g)	
Fenugreek(Methi)	9.66 a	0.19 e	1.90 e
Coriander(Dhaniya)	4.03 d	4.17 b	50.86 b
Cumin(Jira)	2.50 e	4.93 a	66.43 a
Fennel(Mouri)	6.83 c	2.17 c	24.07 c
Celery(Radhuni)	10.00 a	0.00 e	0.00 e
Caron(Ajowan)	10.00 a	0.00 e	0.00 e
Dried red chilli	7.97 b	1.10 d	12.14 d
LSD(0.01)	0.583	0.505	6.898
Level of Significance	0.01	0.01	0.01
CV(%)	4.58	16.08	17.74

In a column means having similar letter are statistically identical and those having dissimilar letter differ significantly as per 0.01 level of probability and numeric data represents the mean value of 4 replications.

Plate 17. Infested fennel (Mouri) spices seeds after infestation by cigarette beetle (A) and infested fennel (Mouri) spices seeds with larvae (B)

Study of 3rd generation of *l. serricorne*

At 3rd generation, the highest weight of healthy spices (10.00 g) were recorded in celery (radhuni) and in carom (Ajowan), respectively, which were closely followed by methi (9.46 g) and whereas no healthy seeds were recorded from dhania, jira and mouri seeds.

Table 10. Effect of different spices for adult emerged of cigarette beetle, *L. serricorne* in stored condition at 3rd generation by weight basis

Different spices	Total weight of spices		Infestation%
	Healthy(g)	Infested(g)	
Fenugreek(Methi)	9.46 b	0.20 e	2.07 c
Coriander(Dhaniya)	0.00 d	4.53 b	100.00 a
Cumin(Jira)	0.00 d	5.43 a	100.00 a
Fennel(Mouri)	0.00 d	2.43 c	100.00 a
Celery(Radhuni)	10.00 a	0.00 e	0.00 d
Caron(Ajowan)	10.00 a	0.00 e	0.00 d
Dried red chilli	6.73 c	1.23 d	15.51 b
LSD(0.01)	0.222	0.411	1.507 b
Level of Significance	0.01	0.01	0.01
CV(%)	5.43	11.87	3.90

In a column means having similar letter are statistically identical and those having dissimilar letter differ significantly as per 0.01 level of probability and numeric data represents the mean value of 4 replications.

sNo percent of infestation were obtained in radhuni and ajowan seeds, whereas the highest (100.00%) infestation were found from dhaniya, jira and mouri seeds, respectively and the lowest (2.07%) infestation was recorded in methi seeds which was followed by dried red chilli (15.51) (Table 10).

Plate 18. Infested coriander (Dhania) spices seeds after infestation by cigarette beetle

Plate 19. Infested fennel (Mouri) spices seeds after infestation by cigarette beetle

Plate 20. Infested dried red chilli spices after infestation by cigarette beetle

4.2.4 Weight loss of different spices

The highest weight loss (25.7%) was observed in cumin (Jira) and the lowest weight loss (1.6%) was observed in fenugreek (Methi) caused by Cigarette beetle, *L. serricorne* at 1st generation.

Table 11. Weight loss of different spices caused by cigarette beetle, *L. serricorne* at 1st ,2nd and 3rd generation in stored conditions

Different spices	Percentage of weight loss at		
	1st generation	2nd generation	3rd generation
Fenugreek (Methi)	1.6d	3.4de	5.4c
Coriander (Dhaniya)	18b	59.7b	100a
Cumin (Jira)	25.7a	75a	100a
Fennel (Mouri)	10c	31.7c	100a
Celery (Radhuni)	0.00e	0.00e	0.00d
Caron (Ajowan)	0.00e	0.00e	0.00d
Dried red chilli	9.3c	20.3d	32.7b
LSD (0.01)	5.156	15.38	21.47
Level of Significance	0.01	0.01	0.01
CV(%)	5.43	11.87	3.90

In a column means having similar letter are statistically identical and those having dissimilar letter differ significantly as per 0.01 level of probability and numeric data represents the mean value of 4 replications.

At 2nd generation the highest weight loss (59.7%) was recorded in coriander (Dhania) and the lowest weight loss (3.4%) was recorded in Fenugreek (Methi). At 3rd generation the highest weight loss (100%) were observed in coriander (Dhania), cumin (Jira) and fennl (Mouri), respectively. The insect generations developed on the spice seeds and the loss increased with the number of generations consistently. But no weight loss occurs in celery (Radhuni) and in carom (Ajowan) spices in generations 1st, 2nd and 3rd (Table 11).

CHAPTER V

SUMMARY AND CONCLUSION

Two experiment were conducted in the laboratory of the Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from March to July, 2015 to study on the biology of Cigarette beetle, *L. serricorne* and its damage assessment in different spices. Fenugreek (Methi), coriander (Dhania), cumin (Jira), fennel (Mouri), celery (Radhuni), carom (Ajowan) and dried red chilli were used as experimental materials.

Experiment-1: Biology of cigarette beetle, *L. serricorne* on suji in laboratory

Mating occurs within 2-3 days after adult emergence. The adult female beetle laid 112-160 eggs with an average of 138.80 eggs throughout a period of up to 4 days. An average oviposition and incubation period were 4.00 ± 0.02 and 6.67 ± 0.03 days, respectively on suji in laboratory condition. Total 14.00 ± 0.09 and 8.33 ± 0.03 days, were required for larval stage and pupal stage respectively. Adult longevity of cigarette Beetle, *L. serricorne* was 9.67 ± 0.05.

At 1st, 2nd, 3rd and 4th day of emergence the number of newly emerged larvae were 22-35, 22-36, 23-33 and 21-38 respectively, with an average number of larvae emerged (116.00) throughout a period of up to 4 days.

At 1st, 2nd, 3rd and 4th day the number of newly formed pupae were 16-29, 17-28, 19-27 and 16-30 respectively, with an average number of pupae formed (90.40) throughout a period of up to 4 days.

At 1st, 2nd, 3rd and 4th day the number of newly emerged adults were 10-21, 12-22, 14-23 and 12-23 respectively. The total highest number of adults emerged in Set-III (89) and the total lowest number (53) of adults emerged in Set-I with an average number of adults emerged (68.80) throughout a period of up to 4 days from suji in laboratory condition.

Experiment-2: Damage assessment of cigarette beetle, *L. serricorne* beetle in different stored spices

Insect mortality (cumulative no. of dead insects) showed statistically different result in various tested spices in stored condition after 6, 10 and 14, 18, 22, 26 and 30 days of observation.

After 6 days of observations, the highest number of dead insects (2.00) were recorded in carom (Ajowan), whereas the lowest number of dead insect (1.33) was observed in celery (Radhuni) but same number of dead insect (1.67) were recorded in fenugreek (Methi), coriander (Dhania), cumin (Jira), fennel (Mouri), carom (Ajowan) and dried red chilli respectively, but no significant difference was observed among them (different spices).

After 10 days of observations, the highest number of dead insects (3.67) were recorded in fenugreek (Methi), the lowest (1.33) number of dead insect were counted in celery (Radhuni) which closely followed by coriander (Dhania) (1.67).

After 14 days of observations, the highest number of dead insects (3.00) were recorded in carom (Ajowan), whereas the lowest number of dead insects were observed in cumin (Jira) (1.33) which closely followed by fenugreek (Methi), coriander (Dhania) and fennel (Mouri) (1.67).

After 18 days of observations, the highest number of dead insects (2.67) were recorded in carom (Ajowan), whereas the lowest (0.67) dead insect were observed in coriander (Dhania) which closely followed by fenugreek (Methi) (1.00).

After 22 days of observations, the highest number of dead insects (2.00) were recorded in carom (Ajowan), whereas the lowest number of dead insects were observed in fennel (Mouri) (0.67).

After 26 days of observations, the highest number of dead insects (2.33) were recorded in coriander (Dhania), whereas the lowest number of dead insect were observed in fenugreek (Methi) (0.67).

After 30 days of observations, the highest number of dead insects (1.33) were recorded in coriander (Dhania), whereas the lowest (0.67) number of dead insects were in fennel (Mouri) and cumin (Jira), but no significant difference observed among them after 30 days. No insect was found dead incase in fenugreek (Methi) and dried red chilli.

At 1st and 2nd generations the highest number of adults were recorded in cumin (Jira) seeds (109.00 and 250.33, respectively) and the lowest adult emerged in fenugreek (Methi) seeds (4.00 and 2.33, respectively).

At 3rd generation the highest number of adults emerged in coriander (Dhania) seeds (59.33) and the lowest numbers of adults were recorded in fenugreek (Methi) seeds (0.33), whereas no adults emergence were recorded in radhuni and ajowan seeds.

Statistically significant variation of healthy, infested & rate of infestation was recorded in different spices.

In 1st generation, the highest weight of healthy spices were recorded in celery (radhuni) and in carom (Ajowan) (10.00 g). The lowest weight was observed in jira (7.43 g) which was statistically identical with dhania (8.20 g) seeds. There were no infested seeds recorded from radhuni and ajowan spices seeds. The highest weight of infested spices seeds was observed in jira (2.57 g) and the lowest weight of infested was in methi (0.16 g). The highest seed infestation was recorded from jira (25.67 %) which were statistically similar to dhania (18.00 %) seeds while no infestation was recorded in radhuni and ajowan seeds.

In 2nd generation on weight basis, the highest weight of healthy spices (10.00 g) was recorded in celery (radhuni) and in carom (Ajowan). But the lowest was observed in jira (2.50 g). There were no infested seeds were recorded from radhuni and ajowan spices, whereas the highest weight of infested spices seeds was observed in jira (4.93 g) and the lowest was recorded in methi (0.19 g) which was closely followed by dried red chilli (1.10 g). The rate of highest infestation was recorded from jira (66.43 %) seeds, while no infestation was recorded in radhuni and ajowan seeds.

At 3rd generation, the highest weight of healthy spices (10.00 g) was recorded in celery (radhuni) and in carom (ajowan) (10.00 g), which were closely followed by methi (9.46 g) and whereas no healthy seeds were recorded from dhania, jira and mouri. There were no infestation obtained in radhuni and ajowan seeds, whereas the highest (100.00%) infestation was recorded each from dhania, jira and mouri seeds. The lowest (2.07%) infestation was recorded in methi seeds which was followed by dried red chilli (15.51).

CONCLUSION

The cigarette beetle, *L. serricorne* is one of the most serious pests of different stored spices at post harvest stage. The beetle develops through egg, four to six larval instars, pupa, pre-pupa and adult stages. The duration of beetle development stage duration were 14.00 ± 0.09 and 8.33 ± 0.03 days for larval stage and pupal stage, respectively. Adult longevity of this was 9.67 ± 0.05 days. Considering the adult mortality, adult emergence, weight of healthy and infested spices and percent infestation, it was revealed that the highest damage occurs in cumin (jira) but no damage observed in celery (Radhuni), carom (Ajowan) spices. Information on the biology and pattern of host use *L. serricorne* may help to explain how various stored commodities are affected by this species and may help to develop appropriate pest management strategies for this insect pest.

Recommendation:

Considering the present results, further studies in the following areas may be suggested:

- study needs to be conducted in different season for identify environmental factors influencing their growth and development and
- to study the control measures using non-chemical approaches.

CHAPTER VI

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APPENDICES

Appendix I: Day specific mortality of larvae of Cigarette Beetle, *Lasioderma serricorne* on suji in laboratory condition

Set or Replication	Morality of larvae				Total mortality of larvae	Percentage of larval mortality
	1st day	2nd day	3rd day	4th day		
Set-I	4	5	4	9	22	23.91
Set-II	9	8	5	9	31	22.14
Set-III	5	6	6	8	25	25.17
Set-IV	8	5	6	5	24	23.30
Set-V	8	8	6	4	26	24.52
Average	6.80	6.40	5.40	7.00	25.60	

Appendix II: Day specific mortality of pupae of Cigarette Beetle, *Lasioderma serricorne* on suji in laboratory condition

Set or Replication	Morality of pupae				Total mortality of pupae	Percent of pupal mortality
	1st day	2nd day	3rd day	4th day		
Set-I	3	5	5	4	17	24.28
Set-II	7	7	8	6	28	25.68
Set-III	8	6	4	7	25	21.92
Set-IV	4	2	6	3	15	18.98
Set-V	9	4	6	4	23	28.75
Average	6.20	4.80	5.80	4.80	21.60	