

## ACKNOWLEDGEMENT

*Accomplishment of this thesis is the result of benevolence of almighty, teachers, and my parents.*

*At the very outset, I feel elated to express sincere thanks and profound sense of gratitude to my chairman of advisory committee, **Dr. C.V. Rama Rao**, Scientist (Entomology), Post Harvest Technology Centre, Agricultural College, Bapatla for his stupendous, splendid and stimulating guidance, constructive criticism, valuable suggestions and steady encouragement throughout the course of investigation and preparation of dissertation. I acknowledge all his contributions more gratefully.*

*I feel it as my privilege in expressing my respectable regards to **Dr. P. Arjuna Rao**, Professor and Head, Department of Entomology and member of my advisory committee for his valuable suggestions, scholarly guidance and meticulous attention during the course of study.*

*I am extremely thankful to **Dr. V. Srinivasa Rao**, Assistant Professor, Department of Mathematics and Statistics and member of my advisory committee for his valuable guidance during the preparation of thesis work.*

*I profusely thank all the staff members Department of Entomology, **Dr. V. Rama Subba Rao**, Professor; **Dr. V. Devaprasad**, Professor; **Dr. P. V. Krishnayya**, Associate professor; **Dr. P. Rajashekhar**, Associate professor; **Dr. T. Madumathi**, Assistant professor and **Dr. G. Ramachandra Rao**, Assistant professor for their amenable guidance and co-operation during my post graduation study.*

*I am highly thankful to **Dr. Sivala Kumar** Principal Scientist (Agril. Engg), P.H.T. Centre, Agricultural College, for affording all the facilities to carryout the experiments.*

*I am equally thankful to **Dr. K. Sri Ramamurthy** Senior Scientist (Biochemistry), **Dr. Ch. V. V. Sathyanarayana** (AP &FE), Scientist Department of Agricultural Engineering for their co-operation at all times in the course of research.*

*Words fail me in expressing my affection and gratitude for my beloved Grand father Late **Mariswamy**, Grand mother **Mahadevamma**, parents*

**Sri R. M. Shivaprasad** and **Smt Rathna**, Sister **Sowmya** without whose love, care and encouragement I would not have come to this level.

My heartfelt gratitude and love to my beloved uncle and friend **Dr. R. M. Shivaprakash** and aunt **Smt Chandrakala** and crazy kid **Sushma** for their love, affection and encouragement rendered during my stay in this college.

Words cannot express my deepest sense of affection on my dearest friends and classmates **Vishwa, Battu, Murali, Bala, Rajesh, Venu, Sabitha, Tulasi** and **Madhuri** for their matchless caring and help.

I would like to acknowledge the constant assistance provided by my seniors **Dr. M. S. V. Chalam, Seetharam, Seshamahalakshmi, Surekhadevi** ; Juniors **Chinna, Sathyanarayana, Jeevan, Sreekanth, Ravindra, Suresh, Kumar, Prasenjit, Venkateswari, Aruna Sri, and Dharma Prasad**.

Though I cannot be unmindful of the innumerable friends and classmates who rendered assistance of hundred kinds, I apologize others for making the list so small including only **Arvind, Garjappa, Gaurav, Aski, Acharya, Basavaraj, Kanu, Vivek** and **Vishwadeep**.

I am at loss of words to express my love to my UG friends **Niri, Nataraj, Megha, Nagaraj, Malli**; Childhood friends **Murthy, Mahesh** and **Viji** and my cousins **Vicky, Shashi, Pradee** and **Vinay**.

I owe my sincere thanks to Indian Council of Agricultural Research (**ICAR**) for nominting me to Acharya N.G. Ranga Agricultural University for the PG studies.

A word of appreciation goes to **Sri Ch. Mallikharjuna Rao** and **Mr. Ch. Parameswara Rao, Eswar Digital**s, Bapatla for neat typing of the thesis manuscript.

Place : Bapatla

Date :

(SANDEEP.R.S.)

## LIST OF TABLES

Sl.No	Title	Page No.
1	Biology of <i>Caryedon serratus</i> on groundnut pods under laboratory conditions.	
2	Morphometrics of different life stages of <i>C. serratus</i> .	
3	Effect of plant products (powders) against oviposition of <i>C. serratus</i> in stored groundnut pods.	
4	Effect of plant products (powders) on pod damage by <i>C. serratus</i> in stored groundnut pods.	
5	Effect of plant products (oils) on oviposition of <i>C. serratus</i> on groundnut pods.	
6	Effect of plant products (oils) on pod damage by <i>C. serratus</i> on groundnut pods.	
7	Effect of plant products (powders) on the germination of groundnut.	
8	Effect of plant products (oils) on the germination of groundnut.	
9	Effect of plant products (powders) on the moisture content of groundnut pods during the storage.	
10	Effect of plant products (oils) on the moisture content of groundnut pods during the storage.	

## LIST OF FIGURES

Sl.No	Figures	Page No.
1	Effect of plant products (powders) against oviposition of <i>C. serratus</i> in stored groundnut pods.	
2	Effect of plant products (powders) on pod damage by <i>C. serratus</i> in stored groundnut pods.	
3	Effect of plant products (oils) on oviposition of <i>C. serratus</i> on groundnut pods.	
4	Effect of plant products (oils) on pod damage by <i>C. serratus</i> on groundnut pods.	

## LIST OF PLATES

Sl.No	Title	Page No.
1	One kg capacity gunny bag used for groundnut storage	
2	Cage used for storage of groundnut pods treated with plant products	
3	Eggs laid by <i>C. serratus</i> on groundnut pods	
4	Fully grown larva of <i>C. serratus</i>	
5	<i>C. serratus</i> feeding inside the groundnut kernel	
6	Groundnut kernels damaged by <i>C. serratus</i>	
7	Exit holes made by mature larva of <i>C. serratus</i> on groundnut pods	
8	Pupal cases of <i>C. serratus</i>	
9	Groundnut pod borer ( <i>C. serratus</i> ) adult	

## LIST OF SYMBOLS AND ABBREVIATIONS USED IN THE THESIS

%	per cent
&	and
@	at the rate of
CD	critical difference
DAT	Days after treatment
<i>et al.,</i>	and others
etc	et cetera
Fig	Figure
gm	gram
<i>i.e.,</i>	that is
kg	Kilogram
ml	milliliter
No.	number
°C	Degree celsius
ppm	Parts per million
RH	Relative humidity
S.Ed	Standard error of mean
<i>viz</i>	namely
Sig.	Significant
NS	Non significant
ha	hectare

Name of the Author : **SANDEEP R.S.**  
Title of the thesis : **Biology and management of  
groundnut pod borer *Caryedon  
serratus* (Olivier) in groundnut pods**  
Degree to which it is submitted : **M.Sc. (Ag.)**  
Discipline : **Entomology**  
Faculty : **AGRICULTURE**  
Major advisor : **C.V. Rama Rao**  
University : **ACHARYA N.G. RANGA  
AGRICULTURAL UNIVERSITY**  
Year of submission : **2005**

---

## **ABSTRACT**

The present investigations were undertaken to study the biology of *Caryedon serratus* (Olivier) on groundnut pods and the relative efficacy of some plant products under laboratory conditions at Post Harvest Technology Center, Agricultural College, Bapatla during the year 2004-2005.

The Pre-oviposition and oviposition periods of *C. serratus* ranged from 1.04 to 2.41 days and 3 to 16 days, respectively. The egg, larval and pupal periods ranged from 3 to 9, 19 to 38, 9 to 34 days with an average of 6.25, 31.21, 26.55 days, respectively. The fecundity of female ranged from 15 to 85 eggs with an average of 35.44 eggs/female.

The adult longevity and total life cycle ranged from 19 to 30 and 43 to 70 days with an average of 19.62 and 57.16 days, respectively.

The average length of egg, larva, pupa and adult was 1.00 mm, 7.28 mm, 6.93 mm and 6.22 mm, respectively, whereas the average breadth of the respective life stages was 0.71 mm, 2.61 mm, 2.80 mm and 2.81 mm, respectively.

The study on relative efficacy of some grain protectants *i.e.* neem kernel powder, *Acorus calamus* rhizome powder, karanja seed powder *Lantana camara* leaf powder, *Ocimum canum* leaf powder and eucalyptus leaf powder each at 1% concentration (mixed with groundnut pods), neem oil, karanja oil, mustard oil, castor oil, sesamum oil and citronella oil each at 1% concentration (gunny bag treatment) and proven check deltamethrin @ 0.02% concentration revealed that *A. calamus* rhizome powder was effective in controlling oviposition and pod damage by *C. serratus* upto 150 and 180 days, respectively. The *L. camara* leaf powder was effective upto 30 and 120 days after treatment in restricting oviposition and pod damage, respectively. The *O. canum* leaf powder recorded 25.94 and 26.30 per cent pods with eggs and pod damage, respectively and gave protection upto 120 days after treatment. Karanja seed powder controlled oviposition upto 30 days and pod damage upto 90 days where as neem kernel powder recorded 76.23 and 63.48 per cent pods with eggs and pod damage, respectively at 180 days after treatment. The least effective was eucalyptus leaf powder.

Among the oils tested by treating the gunny bags, neem oil and castor oil protected groundnut pods upto 180 days after treatment with zero per cent pods with eggs and zero per cent pod damage by *C. serratus*.

Citronella oil provided protection against oviposition upto 120 days and controlled pod damage upto 150 days after treatment. It was followed by Karanja oil and the least effective was sesamum oil.

Deltamethrin a proven check controlled oviposition and pod damage by *C. serratus* upto 180 days after treatment. Besides, this the plant products and plant oils did not affect the germination of groundnut kernels.

# CHAPTER - I

## INTRODUCTION

Groundnut (*Arachis hypogaea* L.), an annual legume crop is the third major oilseed of the world and is produced in subtropical and tropical regions. It is the world's fifth most important source of edible oil and vegetable protein. It contains 44 to 56 per cent oil and is rich source of minerals (phosphorus, calcium, magnesium, and potassium) and vitamins (E, K and B group) (Dwivedi and Nigam, 2003).

In India the crop occupies an area of 5998 thousand ha with a production of 8180 thousand tonnes and with a productivity of 1364 Kg/ha. In Andhra Pradesh, it occupies an area of 1493 thousand ha with a total production of 986 thousand tonnes and with a productivity of 660 Kg/ha (CMIE, 2004).

Generally, farmers store groundnut for a longer period for seed purpose and sell the pod whenever they get higher prices. In storage groundnut is susceptible to the attack of many insect pests. Twenty four insect species have been recorded on stored groundnut among which the groundnut pod borer *Caryedon serratus* (Olivier), rust-red flour beetle *Tribolium castaneum* Herbst and rice moth *Corcyra cephalonica* Stainton. are the major pests (Singh and Ansari, 1991).

The bruchid, *C. serratus* (Olivier) is a major cosmopolitan pest of groundnut and is the only species that can penetrate intact pods to infest

the kernels. This pest is reported to attack groundnut pods and cause considerable damage to stored groundnut at farm, godowns and oil mills.

*C. serratus* has a wide host range, which includes *Tamarindus indicus* (Shivalingaswamy, 1987), *Acacia nilotica*, *Acacia tortolis*, and *Prosopis cineria* (Singal and Toky, 1988), *Pongamia pinnata* (Singal and Toky, 1989), *Bauhinia variegata* (Nilson and Johnson 1992), and *Cassia moschata* (Romero and Johnson, 2002).

*C. serratus* causes heavy loss in quality and quantity of stored groundnut. The pest caused 20 per cent loss over a period of five months of storage of groundnut pods in Andhra Pradesh (Dick 1987a). The extent of damage of bruchid was recorded as 77.1 per cent in pods by Kumari *et al.* (2002) and 50 to 70 per cent by Devi and Rao (2000).

Malathion resistance has been recorded in *Tribolium castaneum* Herbst, *Cadra cautella* (walker), *Plodia interpunctella* (Hubner) by Zettler (1982), phosphine resistance by Zettler *et al.* (1989), malathion and dichlorovos resistance in *Tribolium castaneum* by Halliday *et al.* (1988) in stored peanut. Apart from this insecticidal residues are also reported in stored products.

The need for alternatives to chemical measures for the protection of stored products is strongly felt after the discovery of insect resistance to fumigants, chemical insecticides and pesticidal residues in the stored products.

In the competitive world trade we have to maintain quality in agricultural commodities in terms of pest infestation and pesticide contamination. The pesticidal properties of many plants have been known for a long time and natural pesticides based on plant extracts such as rotenone, nicotine and pyrethrum have been commonly used in pest control during the earlier period. The plants with pesticidal properties can be exploited for control of pests as an alternative to chemical pesticides to overcome above problems. Hence there is need for identification and large scale production of natural pesticides based on crude or purified extracts. Keeping this in mind a detailed study was undertaken to evaluate some of the plant products, which are known to have insecticidal properties to control groundnut pod borer at Post Harvest Technology Centre, Agricultural college campus, Bapatla during 2004-2005.

The objectives of the study are as follows *viz.*,

1. Study of biology of *Caryedon serratus* (Olivier) in laboratory conditions.
2. Management of the groundnut pod borer with
  - I. Plant powders
  - II. Edible and non edible oils

## CHAPTER - II

### REVIEW OF LITERATURE

Available literature regarding the present study on *Caryedon serratus* (Olivier) is categorized and presented under different heads as follows.

#### 2.1 DISTRIBUTION OF *C. serratus* AND ITS HOST RANGE

The groundnut seed beetle *C. serratus* (Olivier) is a bruchid of African origin, well known as primary storage pest of unshelled groundnut (*Arachis hypogaea* L.) and tamarind (*Tamarindus indica* L.) (Davey, 1958). The geographical distribution and host range of *C. serratus* are reviewed below.

Davey (1958) reported that *C. serratus* breeds on the seeds of common tree legumes viz., *T. indica*, *Cassia* sp., *Acacia* sp. and groundnut.

Prevett (1966) cited *T. indica* and two species of *Pilostigma* as primary host of *C. serratus* in northern Nigeria. *C. serratus* had been traced out from a fruit pod of *P. thonnigi* collected in Uganda (Prevett 1967).

Mittal and khanna (1967) reported *C. serratus* as an important pest of stored fruit of tamarind in Rajasthan, Madhya Pradesh, and Uttar Pradesh. Mittal (1969) recorded *C. serratus* as a minor pest of stored groundnuts in Gujarat.

*C. serratus* was described as multibrooded pest of stored *T. indica* (Pajni and Mann 1979).

Conway (1983) recorded *C. serratus* on stored unshelled groundnuts and in tamarind pods. Hideux (1984) recorded the development and reproduction of the bruchid *Caryedon pallidus* on seeds of *Cassia torra* in Senegal.

Johnson (1986) revealed the establishment of *C. serratus* in South America and has also presented record of bruchid from Mexico, where it was reared on the seeds of its primary food plant, tamarind.

Pratap (1987) reported the infestation of *C. gonagra* on *Acacia tortilis*. *C. serratus* was recorded to be the most important pest of stored groundnuts in Congo and it was also reported that outbreaks of *C. serratus* usually originated from residual off season populations in village store houses and also from the populations developing in the pods of a wild plant *Pilostigma thonnigi* (Matakot *et al.*, 1987).

The bruchid, *C. serratus* has been identified as the potential pest of stored groundnuts in India (Wightman *et al.*, 1987). The larvae and pupae of *C. serratus* were collected from seeds of *Acacia nilotica*, *Acacia tortilis* and *Prosopis cineraria*, which had been collected from the field in India (Singal and Toky, 1988).

Kingsolver (1992) reported *C. serratus* from Florida and described it as a tropicopolitan tramp species associated with the tree *T. indica*.

The infestation of *C. serratus* in the ornamental plant *Bauhinia variegata* was recorded for the first time in Mexico by Nilson and Johnson (1992).

Calderon (1994) investigated the possibility of *C. serratus* developing in local groundnut in Israel. Delobel (1995) described *C. serratus* as a pest of stored groundnuts in Senegal, Congo and Asia. It was also reported in parts of the American tropics in the seeds of tamarind and ornamental *Bauhinia sp.*

Mucunguzi (1995) recorded *Acacia* seed infested by bruchids and *C. serratus* was found even in small seeds of *Acacia gerrardii*.

Satya and Jindal (1996) cited *C. serratus* as a major pest on pods and seeds of *Acacia nilotica* in Thar desert of India. Halle (1999) reported that eggs of *C. serratus* were found on *T. indica* and *Acacia farnesiana* whereas eggs were not found on other alternative hosts like *Albizia lebbek* Benth, *Pongamia pinnata* L. and *Cassia tora* L. He has also reported the distribution of *C. serratus* in Dharwad, Gadag and Haveri districts of Karnataka.

*Cassia moschata* was reported to be the new host of *C. serratus* in Guerrero, Mexico (Romero and Johnson, 2002).

Carry over of bruchid *C. serratus* was recorded from field to store through seeds of *Acacia nilotica* in India (Singal and Toky 1990). The shift of *C. serratus* from wild *Caesalpinaceae* to groundnut took place in West Africa (Delobel, 1995).

Rangarao and Mohan (2000) reported the possibility of cross infestation of *C. serratus* from tamarind trees to groundnut fields and stores.

## **2.2 ECONOMIC IMPORTANCE OF *C. serratus***

Seed loss of 20 per cent over a period of five months of storage of groundnut was caused by *C. serratus* in Andhra Pradesh (Dick 1987a). The total dry weight loss of kernels was approximately 20 per cent and *C. serratus* was responsible for almost all the damage (Dick 1987b).

Venugopalreddy (1990) reported that bruchids's attack in stored groundnut kernels resulted in heavy loss upto 87 per cent.

Kumari *et al.* (2002) reported the extent of damage by the bruchid was 77 per cent in pods and 67.8 per cent in kernels. The weight loss due to the infestation in pods and kernels was 55.1 and 52.3 per cent, respectively. They have also reported the reduction in oil content in infested pods and kernels as 2.9 and 3.5 per cent, respectively.

## **2.3 BIOLOGY OF *C. serratus***

Since *C. serratus* was considered to be a minor pest until recently, proper attention was not given on the biology of the pest. Hence we find very scanty published notes on the biology of the pest.

### **2.3.1 Copulation**

According to Davey (1958) copulation of the beetle takes place on the surface of the heap but not in the confined spaces between the nuts.

Pajni and Mann (1979) observed the freshly emerged adult bruchids were sexually mature and mate within few hours after emergence but in most cases copulation took place after one or two days. Copulation occurred at dawn and dusk where large number of copulating pairs was observed. The copulation lasted for 25 to 40 minutes.

### **2.3.2 Oviposition**

Corby (1941) observed that the oviposition continued for 6 to 15 days with peak occurring 5 to 6 days after emergence.

Prevett (1954) observed that the females indiscriminately laid eggs one day after emergence on any substrate. Translucent white oval eggs (1 mm long and 0.5 mm width) were laid in depressions on the shell of the groundnut pods or on smooth testa of the seeds. Amaro *et al.* (1958) reported the oviposition period of the beetle as 17.4 days.

According to Pajni and Mann (1979) female beetle examines the surface of the seeds with the help of the antennae. After locating a suitable spot, female stretches out her abdomen and extrudes the tubular ovipositor, secreting a sticky fluid on which the egg was firmly glued. A female takes 2 to 3 minutes for laying an egg, and oviposition period of female bruchid extends for 6 to 10 days at temperature of 30<sup>0</sup>C and 70% R.H.

Shabbir (1988) recorded the range of pre-oviposition and oviposition periods of *C. serratus* as 2 to 8 days and 1 to 12 days with an average of 4.17 days and 6.17 days, respectively.

Studies conducted on ovipositional response of *C. serratus* on 52 plant species revealed that testa of seed are important factor, which provides stimulus for egg laying. Out of 52 tree species, seeds of 23 species were rejected for oviposition (Ahamad and Kumar, 1990).

According to Kapadia (1995) average pre-oviposition and oviposition periods of *C. serratus* are 2.00 and 23.00 days with a range of 1 to 3 days and 8 to 40 days, respectively. Ramadevi (1996) reported average pre-oviposition and oviposition period of *C. serratus* as 22 hours and 9.5 days with a range of 2 to 24 hours and 9 to 10 days, respectively.

According to Motka and Butani (1999) pre-oviposition and oviposition period of *C. serratus* varied from 1 to 3 (Av.  $1.70 \pm 0.67$  days) and 8 to 17 (Av.  $9.20 \pm 3.22$ ) days, respectively. Halle (1999) recorded pre-oviposition and oviposition period as 4.21 and 8.7 days, respectively.

### **2.3.3 Fecundity**

Amaro *et al.* (1958) reported the number of eggs laid per female as 44.52 and 24.16 at 30<sup>0</sup>C and 40<sup>0</sup>C, respectively.

Sardesai (1961) found that 20 to 50 eggs were laid per female and observed that the females from earlier generation laid more eggs than those from later indicating the unfavourable effect of breeding.

Calderon *et al.* (1967) reported the fecundity of female bruchid as 13.6 eggs where as Babji (1976) observed 25 to 30 eggs per female with an average of 4 to 11 eggs per pod and 2 to 9 eggs per kernel.

According to Pajni and Mann (1979) a single female beetle lays an average of 42 eggs under optimum conditions of 30<sup>0</sup>C and 70% R.H. The number of eggs laid by a single female was 21 to 76 with an average of 52.30 (Kapadia 1995).

Ramadevi (1996) recorded the average fecundity of the bruchid under laboratory conditions as 71.5 eggs with a range of 53 to 95 eggs.

According to Haritha (1998) fecundity of bruchid on pods ranged between 20 to 80 eggs with an average of 37.5 eggs. Motka and Butani (1999) recorded average egg laying capacity of female bruchid, ranging between 47 to 76 eggs under laboratory conditions.

#### **2.3.4 Duration of egg period**

The egg period of *C. serratus* was reported as 6 days, 8 to 10 days and 9 to 10 days by Corby (1941), Lepesme (1945) and Prevett (1953), respectively.

According to Babji (1976) the egg period of *C. serratus* on groundnut pods and groundnut kernels were 4 to 6 days and 4 to 5 days, respectively. Shabbir (1988) reported the average egg period of the beetle as 7.45 days with a range of 5 to 11 days.

Sontakke *et al.* (1992) recorded minimum egg duration of *C. serratus* as 5.42 days during March to May and the maximum of 14.57 days during December to February with an average duration of 9.79 days. The egg viability was minimum (22.36 per cent) during March to May and maximum (58 to 59 per cent) during September to November.

Kapadia (1995) observed average incubation period of 2.63 days with a range of 2 to 5 days. The average incubation period of eggs was recorded to be 8 days by Ramadevi (1996). Haritha (1998) reported egg period of 4.3 days on groundnut pods.

According to Motka and Butani (1999) the incubation period of *C. serratus* eggs ranged from 5 to 9 days with an average of 6.37 days.

### **2.3.5 Larval and pupal periods**

Babji (1976) recorded the larval period of *C. serratus* extending upto 20 to 22 days on groundnut pods and kernels. The pupal period lasted for 15 to 16 days on groundnut pods while it was 18 to 19 days on kernels.

According to Shabbir (1988) larval and pupal period of *C. serratus* ranged between 11 to 19 days and 25 to 35 days with an average of 15 days and 27.37 days, respectively on groundnut pods.

Sontakke *et al.* (1992) recorded minimum larval (24.45 days) and pupal period (7.53 days) during March to May and maximum larval (48.65 days) and pupal period (14.42 days) during December to February on groundnut pods.

According to Kapadia (1995) larval period of *C. serratus* ranged from 12 to 24 days with an average of 18.88 days. The pupal period averaged 12.88 days with a range of 10 to 22 days. Ramadevi (1996) found the average larval and pupal periods of *C. serratus* as 22.9 days and 15.5 days, respectively.

Haritha (1998) reported the larval and pupal period of *C. serratus* as 23.64 and 15.78 days on groundnut pods, respectively.

According to Motka and Butani (1999) larval and pupal period of *C. serratus* ranged from 5.0 to 9.0 (Av. 6.37) days and 12 to 22 (Av. 18.03) days, respectively at an average temperature of  $29.22 \pm 3.5^{\circ}\text{C}$  and  $61.62 \pm 9.87$  per cent relative humidity. Pupal period lasted for 20-32 days with mean of 28.33 days (Halle, 1999).

### **2.3.6 Longevity of adults**

Babji (1976) reported that adult beetle of *C. serratus* lived for 18 to 23 days under room temperature. It was observed that more number of adults emerged from unshelled nuts compared to shelled nuts.

Shabbir (1988) observed that female beetles of *C. serratus* lived longer than the males. The longevity of females ranged between 6 to 58 days with an average of 24.46 days while the males ranged between 6 to 61 days with an average of 23.18 days.

According to Sontakke *et al*, (1992) the adults of *C. serratus* survived for less time (15.24 days) during summer as compared to winter season (23.71 days).

Kapadia (1995) observed that female beetles of *C. serratus* live longer than males. The female and male lived for as many as 69 and 45 days, respectively.

The duration of adult stage of male and female varied from 10 to 23 (Av.  $18.4 \pm 4.03$ ) days and 17 to 33 (Av.  $25.80 \pm 4.57$ ) days, respectively (Motka and Butani, 1999). Halle (1999) observed that adult males lived for 12.9 days while females lived for 13.43 days.

### **2.3.7 Total life cycle**

Babji (1976) observed that the life cycle lasted for 40 to 43 days and 42 to 45 days on groundnut pods and kernels, respectively. Shabbir (1988) reported that the life cycle of *C. serratus* was completed in 43 to 65 days with an average of 53.01 days.

According to Sontakke *et al*, (1992) in winter season (December to February) the duration of all the stages of beetle prolonged which might be due to low temperature.

Kapadia (1995) reported that *C. serratus* completed its life cycle (egg to adult) within 82.00 days. The duration of total life cycle of *C. serratus* from egg to adult emergence was found to be 46 days (Rama devi, 1996).

Haritha (1998) observed that average total life cycle of bruchid was (45.56 days) with a range of 42 to 52 days on groundnut pods.

## **2.4 RELATIVE EFFICACY OF GRAIN PROTECTANTS**

Since the available literature on the relative efficacy of certain plant products on oviposition and pod damage by *C. serratus* (Olivier) is limited, literature pertaining to the efficacy of plant products against mortality of bruchids and other stored grain pests which shows indirect effect on oviposition and damage of grains has been reviewed in a nutshell.

### 2.4.1 Neem

Singh and Srivastava (1980) studied the efficacy of neem seed powder by mixing it with wheat grains @ 1.0, 2.5 and 5.0 parts per 100 parts against lesser grain borer, *Rhizopertha dominica* (Fab.) for 3 months and found that maximum level of protection could be afforded at 5 parts per 100 parts.

Anand *et al.* (1981) summarized the work of various workers on neem kernel powder. He has reported that neem kernel powder protected the grains in wheat storage against *R. dominica*, *Sitophilus oryzae* L. and *Trogoderma granarium* (Everts) in paddy storage and also in storage of jowar, mung and rice against general insect pests.

Gosh *et al.* (1981) recorded least per cent of damage (4.23) in powdered neem seed kernel treatment at a concentration of 1.5 parts/100 parts against pulse beetle in gram.

Neem seed powder at a concentration of 1.5 parts per 100 parts gave a mortality of 79.54 per cent, which was next to malathion with a mortality rate of 85.69 at 0.15 parts per 100 parts against *Callosobruchus chinensis* Linn. in blackgram (Mathur *et al.*, 1985).

Agarwal *et al.* (1988) summarized the works of various workers on neem and reported that neem kernel powder at 1 to 2 % level is effective for 8 to 11 months against pulse beetles.

Chiranjeevi (1991) indicated that 100 per cent protection was obtained against *C. chinensis* of greengram treated with *Acacia nilotica* seed powder at 1 parts per 100 parts.

Mishra *et al.* (1992) screened some indigenous plant powders and found that neem seed powder was statistically better than other treatments followed by citrus peel and neem leaf powder application in control of *S. oryzae*. Neem kernel powder at a concentration of 5% protects wheat seed during storage from the attack of lesser grain borer, *R. dominica* (Patel *et al.*, 1993).

Damaged pods percentage was 4 and 0 in groundnut pods treated with neem kernel powder @ 10 and 25 g/kg against *Corcyra cephalonica* Staint (Senguttuvan *et al.*, 1995).

Jood *et al.* (1996) reported neem kernel powder @ 1% concentration completely prevented the damage of *T. granarium* on sorghum.

Sharma (1999) studied the efficacy of neem products against storage pests in maize and found that neem seed kernel powder @ 4% and neem leaf powder @ 5% protected maize for five months against *Sitophilus zeamais*, *S. oryzae* and *R. dominica*.

Neem kernel powder (5%) was effective upto 150 days after treatment with 70 per cent mortality of *S. oryzae* on maize (Hanumantharao, 2003).

#### 2.4.2 Sweet flag

Pandey *et al.* (1976) found the treatments containing 1 and 2 parts of powdered caner drupes and sweet flag rhizomes, 8 parts of sadabahar leaves, 3 and 5 parts of petroleum ether extract of garlic and neem oil per 100 parts of seed (w/w) provided complete protection upto 135 days against *C. chinensis* in gram.

Anand *et al.* (1981) summarized the works of various workers on sweetflag and reported that *Acorus calamus* root powder and root extract as a grain protectant against *Sitophilus cerealella*, *S. oryzae*, and *C. chinensis*.

According to Gosh *et al.* (1981) sweet flag rhizome powder @ concentration of 1.5 parts per 100 parts of seed caused 100 per cent mortality after 36 hours of treatment against *C. chinensis* in gram. Powder of *A. calamus* rhizomes was the most promising grain protectant against *S. oryzae*, *T. granarium* and *C. chinensis* at a lowest concentration of 1 per cent (Chander and Ahamed, 1983).

Prakash and Rao, (1986) recorded antifeedent property of plant extract of *Acorus calamus* against *Tribolium castaneum* (Herbst) and *Oryzaephilus surinamensis* (Linn.) in rice.

*Acorus calamus* at 1 % level provided complete protection in initial testing and after 2 months of storage of wheat against *C. cephalonica* (Chander and Ahamed, 1986).

Agarwal *et al.* (1988) summarized the works of various workers on natural products as protectants of pulses. At 0.1 and 0.2 per cent sweet flag was found to be effective pulse protectant for 3 to 6 months against pulse beetles.

*Acorus calamus* rhizome powder treated seeds of greengram recorded nil grain damage by *C. chinensis* at a concentration of 1.5 per cent (Chiranjeevi, 1991). Sweet flag (*Acorus calamus*) rhizome powder at the rate of 2% w/w gave complete kill of adults of *S. oryzae* and *Sitophilus granarius* in wheat with 7 days of exposure (Panneru *et al.*, 1997).

Ramarao and Sarangi (1998) studied the efficacy of 5 grain protectants *viz.*, sweet flag rhizome powder, turmeric rhizome powder, neem kernel powder, bel leaf powder and lantana leaf powder against *S. oryzae* and found that sweet flag rhizome powder both at 3% and 5% concentrations remained effective for 90 days.

Chandan *et al.* (2001) studied the effect of rhizome extract of sweet flag, *Acorus calamus* on the larval and adult form of *T. castaneum* and found that *A. calamus* showed a definite phagodeterrent activity on the pest.

According to Hanumantharao (2003) sweet flag rhizome powder @ 5% remained effective for 180 days after treatment with 90 per cent mortality against *S. zeamais* in maize.

### **2.4.3 Karanja**

The greatest reduction in larval weight and increase in larval mortality of *O. surinamensis* and *T. castaneum* were observed with the grains treated with extracts of *Pongamia glabra*, followed by extracts of *Pongamia pinnata*, neem, *Acorus calamus* and *Cliostanthus collinus* in that order (Prakash and Rao, 1986).

Rajasekharan *et al.* (1985) reported that coating of green gram grains with extract of karanja at 0.4% and 0.6% v/v, respectively gave significant protection from *C. chinensis*.

Satpathi *et al.* (1992) reported that 20% petroleum ether extract of *Pongamia glabra* caused 71 per cent adult mortality of rice weevil at 5 days after treatment.

Kahare *et al.* (1993) reported that pungam extract showed high ovipositional deterrent in *C. chinensis* on Bengalgram. Pungam extract caused mortality of eggs of *C. chinensis* on gram (Kachare *et al.*, 1994).

Karanja seed powder remained effective upto 180 days of treatment with 70 per cent mortality of *S. oryzae* in maize (Hanumantharao, 2003).

### **2.4.4 *Lantana camara***

*Lantana camara* powder (@ 2%) and Turmeric rhizome powder (@ 2%) were nearly as effective as the other insecticides used against *S. oryzae* in stored maize (Islam *et al.*, 1989).

Chiranjeevi (1991) reported 86.4 per cent protection of greengram against *C. chinensis* with *Lantana* leaf powder @ 2%.

Saxena *et al.* (1992) indicated that the extracts of *L. camara* were positively toxic on contact and strongly antifeedant to adults of *C. chinensis*, but their ovicidal activity was not strong enough to be used for the control.

Misra (1999) reported that after 150 days of confinement the fecundity of *C. chinensis* on Bengalgram in treatments like leaf powders of lantana, tulsi and red chilli fruit powder (@ 3%) were at par with control.

Kumari *et al.* (1998) reported *L. camara* leaf powder (@ 25 gm/kg groundnut pods) had a good oviposition deterrant activity but lost effectiveness gradually after one month on *C. serratus*.

#### **2.4.5 *Ocimum canum***

Delobel and Malonga (1987) reported reduction of infestation of *C. serratus* in unshelled groundnut by 3.9, 17.6 and 18.5 per cent in bags treated with *Ocimum canum*, *Lippia multiflora* and *Eupatorium odoratum*, respectively as compared with control.

Oviposition of *C. chinensis* on cowpea seeds treated with ocimum, adalodakam, bel, thippali and castor leaves were on par with the untreated control (Jacob, 1994).

According to Rajapakse (1996) *Ocimum sanctum* and *Annona reticulata* gave 46.0 per cent and 40 per cent mortality of *Callosobruchus maculatus* L., respectively at 0.1%/50 seeds of mungbean.

Treatment with *Ocimum* dried leaf powder at a dose of 1, 2, 5 and 10 gm per 250 gm on *Acacia nilotica* and *Tamarindus indica* seeds caused growth inhibition, malformation and mortality of *C. serratus* (Murugesan *et al.*, 1998).

Misra (1999) found that fecundity of *C. chinensis* in tulasi leaf powder (at a dose of 3 parts/100 parts) treated blackgram seeds was at par with control.

#### **2.4.6 Eucalyptus**

Anand *et al.* (1981) summarized the works of various workers on use of plant products for control of stored grains. They have reported the ovicidal action of *Eclipta alba* against eggs of *Sitotroga cerealella*.

The leaves of *Eucalyptus* reduced the tuber damage by *Pthorimaea operculella* to 8 per cent compared with 26 to 39 per cent with the leaves of *Eupatorium odoratum*, *Ambrosia artemisiifolia* and *Anemone elongata* (Lal, 1988).

Agarwal *et al.* (1988) summarized the works of various workers on natural products as protectants of pulses against pulse beetles. *Eucalyptus globus* was said to have insecticidal activity and exhibited high toxicity against *C. chinensis*.

## 2.5 RELATIVE EFFICACY OF EDIBLE AND NON EDIBLE OILS

### 2.5.1 Neem oil

Sangappa (1977) studied the efficacy of different oils against the bruchid, *C. chinensis* infestation on Redgram. Neem oil gave complete protection from bruchid infestation upto a period of 161 days. Neem oil at 1.0 ml per 100 gm of seed inflicted 100 per cent egg, grub and adult mortality of *C. chinensis* on gram (Ali *et al.*, 1983).

According to Jadhav and Jadhav (1984) cent per cent mortality of *C. maculatus* eggs in gram was noticed in neem and mohwa (*Basia latifolia*) oil treatment at 0.3 %level.

According to Naik and Dumbre (1985) neem oil protected cowpea at 0.75 per cent upto five months against *C. maculatus*.

Khaire *et al.* (1987) reported neem oil to be the most toxic against *C. chinensis* at 1 per cent concentration.

Chowdhary (1992) revealed that neem oil was effective in protecting seeds of chickpea against *C. chinensis* for 12 months at different concentrations of 0.25, 0.50 and 1 ml/100 g seed.

Among the different plant oils used against pulse beetle, *C. chinensis* in pigeonpea, neem oil at 1 per cent concentration had a significant repellent action on egg laying. Also egg hatching was suppressed upto 56 days (Kachare *et al.*, 1994).

Rani *et al.* (2000) revealed that neem oil was significantly superior to all other oils by recording maximum mortality (66.50 per cent) at 1 ml/kg and was followed by rice bran oil (60.00 per cent) against *C. chinensis* infesting chickpea.

Bhujbal *et al.* (2001) studied the efficacy of 3 synthetic pyrethroids along with malathion, lindane and neem oil. They have reported that neem oil 5000 and 7500 ppm recorded cent per cent protection upto 8 weeks against *C. maculatus* in pigeonpea.

Neem, *Lawsonia inermis* and *Psoraleae carylifolia* oils at 10 ml/kg seed were effective even after 6 months of treatment, the later three were effective in controlling *C. chinensis* even after 9 months of the oil treatment to greengram (Singh and Sharma, 2003).

Neem and mehandi oils at the dose of 10 ml/kg of seed were effective even beyond 150 days after treatment against *C. chinensis* in greengram (Singh and Yadav, 2003).

Raghavani and Kapadia (2003) indicated that neem and coconut oils @ 10 ml/kg of seed (pigeonpea) provided complete control of grains against *C. maculatus* for six months.

### **2.5.2 Karanja oil**

There was no insect emergence from redgram seed treated with honge (karanja) oil applied at 1.0 per cent upto period of 319 days and emergence was very low compared with that of control even after 375 days (Sangappa, 1977).

Naik and Dumbre (1985) studied to assess the effect of some vegetable oils as surface protectants @ 0.25, 0.5, 0.75 and 1 per cent on storability of cowpea seeds against pulse beetle, *C. maculatus* and reported that karanja oil gave complete protection at 1 per cent level upto 150 days after treatment.

Oils of karanja, clove and cedar wood at doses of 25 to 100 ppm and acetone extracts of pepper provided protection to wheat grains against curculionid, *S. oryzae* and the bostrichid, *R. dominica* upto 60 days and 30 days after treatment, respectively (Singhamony *et al.*, 1986).

Khaire *et al.* (1987) tested the efficacy of ten vegetable oils as grain protectants of pigeonpea against *C. chinensis*. Of the 10 vegetable oils karanja at 1 % level were found to be most toxic to *C. chinensis*.

Khaire *et al.* (1992) studied the efficacy of 10 vegetable oils, each applied at the rates of 5, 7.5 and 10 ml/kg of grain (0.5, 0.75 and 1% v/w concentration) as grain protectants of pigeonpea against pulse beetle (*Callosobruchus chinensis* L.). Adult emergence was completely prevented by karanja oil at 0.75 and 1% levels upto 100 days.

Karanja oil @ 1% per cent showed significant repellent action against egg laying by adult bruchid (*C. chinensis*) upto 100 days after treatment. Also it suppressed egg hatching upto 56 days (Kachare *et al.*, 1994).

Negi *et al.* (1997) studied the efficacy of pongam oil on adult emergence and egg laying of *C. chinensis* on greengram @ 0.1, 0.5, 1.0, 1.5 and 2.0%. Both egg laying and adult emergence decreased with the increase in dose concentration. Singh (2003) reported karanja oil @ 8 ml/kg of pigeonpea seed proved highly effective in protecting seed upto 9 months in terms of seed damage and weight loss against *C. chinensis*.

Karanja oil @ 10 ml/kg seed of pigeonpea provided complete control of bruchid, *C. maculatus* upto four months of storage (Raghavani and Kapadia, 2003).

### **2.5.3 Mustard oil**

Minimum grain loss was noted with mustard, castor and groundnut oils at 1% level upto 100 days of treatment of pigeonpea seeds against *C. chinensis* (Khaira *et al.*, 1992).

Singal (1992) reported zero percentage damage in chickpea treated with 5 ml/kg of mustard, coconut and groundnut oils during nine months of storage against *C. chinensis*.

Singh *et al.* (1994) studied the efficacy of different vegetable oils @ 1 ml and 3 ml/kg of gram seeds. Least adult emergence of *C. chinensis* was recorded from seeds treated with mustard oil @ 1 ml/kg seed.

Singh (2003) tested the efficacy of some edible and non edible oils @ 8 ml/kg of pigeonpea seeds against *C. chinensis*. Zero per cent adult emergence was recorded in seeds treated with mustard oil upto 9 months after treatment.

The seeds of pigeonpea were treated with eight oils at different concentrations of 1.5, 5.0 and 10 ml/kg of seed to study their efficacy against *C. maculatus*. Mustard oil at higher dose gave fairly good protection of pigeonpea upto 6 months *C. serratus* (Raghavani and Kapadia, 2003).

#### **2.5.4 Castor oil**

Castor oil at 1.0 per cent dose concentration protected the seeds upto 133 days against *C. chinensis* in redgram (Sangappa, 1977). Castor oil @ 1 per cent concentration caused a mortality of 14.33 per cent of *C. maculatus* infesting cowpea (Naik and Dumbre, 1985).

Khaire *et al.* (1992) studied the efficacy of ten vegetable oils against *C. chinensis* in pigeonpea at 0.5, 0.75 and 1% v/w concentrations. No emergence of adults occurred upto 66 days in castor oil at the 0.75 and 1% treatments.

Kachare *et al.*, (1994) reported 1% concentration of castor oil showed significant repellent action for egg laying by *C. chinensis* upto 100 days after treatment. Also at 56 and 100 days castor oil was quite effective in suppressing the egg hatching.

Castor oil at 1 ml and 3 ml/kg seed was found to be best in order to check egg laying of pulse beetle on greengram (Singh *et al.*, 1994).

Refined soybean and crude castor oils were evaluated for control of infestation of *C. maculatus* (F) and *C. phaseoli* (gylenhall) in stored

chickpea. Both oils were used at 5 and 10 ml/kg of seeds. Castor oil at 5 and 10 ml/kg protected chickpea seeds from the infestation of *C. maculatus* for 60 and 150 days, and from *C. phaseoli* for 60 and 90 days respectively (Pacheco *et al.*, 1995).

Singh (2003) reported castor oil as a potent protectant of pigeonpea seed @ 8 ml/kg against *C. chinensis*. Castor oil @ 10 ml/kg of seed gave considerable protection of 96.6% upto six months against *C. maculatus* in pigeonpea (Raghavani and Kapadia, 2003).

#### **2.5.5 Sesame oil**

Sesamum oil @ 1 ml/100 gm of seed caused cent per cent mortality of *C. chinensis* in gram (Ali *et al.*, 1983).

Doharey *et al.* (1985) revealed that sesame oil at 1.0 per cent (w/w) concentration gave zero per cent seed damage of green gram against *C. chinensis* and provided protection upto 6 months.

Sesamum oil at 0.25% concentration was found to be effective against *C. chinensis* in protecting green gram seeds (Sujatha and Punnaiah, 1985).

Doharey *et al.* (1988) found that both *C. chinensis* and *C. maculatus* failed to lay eggs at 1.0 per cent concentration of sesamum oil treated green gram.

Choudhary (1992) studied the efficacy of different vegetable oils at various concentrations of 0.25, 0.50, 1.00 ml/100 g seed against *C. chinensis* in chickpea. He has reported that sesame oil effectiveness increased with an increase in dosages of oil concentrations.

Sesamum oil at 1% concentration showed repellent action for egg laying by adult bruchids of *C. chinensis* in pigeonpea up to 100 days after treatment (Kachare *et al.*, 1994).

Rajapakse and Emden (1997) revealed that all the four oils (corn, groundnut, sunflower and sesamum) significantly reduced the longevity of adults of *C. maculatus* and *C. chinensis* at 10 ml/kg of cowpea seed.

Sesamum oil at higher dose of 10 ml/kg of seed gave fairly good protection upto 6 months against *C. maculatus* in pigeonpea (Raghavani and Kapadia, 2003).

#### **2.5.6 Citronella oil**

Saraswathi and Rao (1987) studied the repellent effect of citronella oil (*Cymbopogon nardus*) on *T. castaneum*, *C. chinensis* and *Periplanata americana*. Repellency was noted upto 52 hours after treatment.

According Kumari *et al.* (1998) citronella oil @ 15 ml/kg pods gave total protection to groundnut pods by inhibiting oviposition upto 6 months against *C. serratus*.

### 2.5.7 Deltamethrin

Nawale *et al.* (1992) reported the efficacy of some synthetic pyrethroids on *C. maculatus* infesting pigeonpea seed. decamethrin @ 12.5 ppm completely inhibited hatching of eggs.

Daglish *et al.* (1993) revealed that deltamethrin applied @ 0.75-1.5 mg kg<sup>-1</sup> could control the progeny of *C. phaseoli* and *C. maculatus* for 36 weeks.

Azam *et al.* (1994) studied the efficacy of malathion and dichlorvos each at 0.05%, deltamethrin at 0.02%, Neem oil, Neemark and Repelin at 1.0% against *T. castaneum* (H), *S. oryzae* (L) and *C. maculatus*. Deltamethrin recorded 88.89 per cent mortality in case of *T. castaneum*, 68.75 per cent in case of *S. oryzae* and 55.56 per cent in case of *C. maculatus* at 4 hrs after treatments.

Deltamethrin residues from applications of 0.5, 0.75 or 1.0 ppm on wheat controlled *R. dominica* for at least 10 months. (Arthur, 1994). Hundred per cent mortality was recorded in *T. castaneum* @ 0.1 and 0.05 per cent concentration of deltamethrin (Kumar and Parikh, 1996)

Among the different insecticides and plant products tested as surface treatments of gunny bag, deltamethrin @ 5g/bag recorded the least pod damage (4%) against *C. serratus* in groundnut pods (Halle, 1999).

## CHAPTER - III

### MATERIALS AND METHODS

The studies on biology of groundnut pod borer, *Caryedon serratus* (Olivier) and the relative efficacy of some plant products (powders and oils) against the test insect were conducted at Post Harvest Technology Centre, Agricultural College campus, Bapatla during the year 2004-05. The materials used and the methods adopted to conduct the experiments have been described in the following paragraphs.

#### 3.1 MATERIALS

##### 3.1.1 Test insect

The groundnut pod borer, *Caryedon serratus* (Olivier)

[Coleoptera: Bruchidae]

The Groundnut pod borer, *C. serratus* has a wide range of hosts such as groundnut, tamarind, *Acacia sp.* etc. The beetle inflicts damage in larval stage. The test insects were obtained from the laboratory culture.

##### 3.1.2 Diet used for rearing the test insect

For the studies on biology and management of the groundnut pod borer with plant powders and plant oils, the test insects were multiplied on groundnut pods in the laboratory.

### **3.1.3 Rearing jars**

Plastic bottles of size 20 × 15 cm were used for rearing test insect.

### **3.1.4 Muslin cloth**

Muslin cloth was used to cover the open end of the rearing jars, so as to prevent the escape of the insects.

### **3.1.5 Aluminum phosphide**

Groundnut pods were thoroughly cleaned and disinfested by using aluminium phosphide 3 G tablets at the rate of 3 tablets/ton for 7 days and later they were aerated for 2 days.

### **3.1.6 Stage micrometer and ocular micrometer**

The stage and ocular micrometers were used to study the morphometrics of *C. serratus*.

### **3.1.7 Plastic tubes**

Plastic specimen tubes of 10 cm long and 2.3 cm in diameter were used in carrying out the experiments.

### **3.1.8 Maximum and minimum thermometer**

Maximum and minimum thermometers were used to record daily temperature in the laboratory.

### **3.1.9 Hygrometer**

Hygrometer was used to record daily relative humidity in the laboratory.

### **3.1.10 Autoclave**

Autoclave was used for sterilization of glass materials to prevent contamination by pathogens.

### **3.1.11 Electronic balance**

Electronic balance was used to weigh the various materials during the course of investigation.

### **3.1.12 Oven**

Electric oven with a temperature limit of 200<sup>0</sup>C was used for determination of moisture content of the groundnut pods.

### **3.1.13 Gunny bags**

Gunny bags of 1 Kg capacity were used to store groundnut pods for evaluation of the effect of different plant products.

### **3.1.14 Microscopes**

Compound binocular microscope and trinocular stereozoom microscope were used for observing various stages of the test insect to study the biology and insect morphometrics.

## **3.2 GRAIN PROTECTANTS**

The following grain protectants were used in the experiment to study their relative efficacy against the adults of *Caryedon serratus* (Olivier).

SI No.	Common name	Botanical name
1	Neem kernel powder	<i>Azadirachta indica</i> A. Juss
2	Sweet flag rhizome powder	<i>Acorus calamus</i> L.
3	Karanja seed powder	<i>Pongamia pinnata</i> L.
4	<i>Lantana camera</i> leaf powder	<i>Lantana camara</i> L.
5	Tulsi leaf powder	<i>Ocimum canum</i> L.
6.	Eucalyptus leaf powder	<i>Eucalyptus globus</i> Labill
7	Neem oil	<i>Azadirachta indica</i> A. Juss
8	Karanja oil	<i>Pongamia pinnata</i> L.
9	Mustard oil	<i>Brassica juncea</i> L.
10	Castor oil	<i>Ricinus communis</i> L.
11	Sesame oil	<i>Sesamum indicum</i> L.
12	Citronella oil	<i>Cymbopogan nardus</i> (L.) Rendle
13	Deltamethrin	-

Needles, scalpel, camel hair brush, glass marking pencil, scissors etc were also utilized for the experimental purpose.

### 3.3 METHODS ADOPTED

#### 3.3.1 Preparation of groundnut pods for the experiment

The groundnut pods were thoroughly cleaned and fumigated with aluminium phosphide @ 3 tablets/ton for 7 days to ensure that the pods were free from any internal and external infestation and then aerated for 2 days to remove phosphide residues in the pods. The pods were then ready for the experiment.

### **3.3.2 Mass culturing of test insect**

The parental culture of *C. serratus* was obtained from the godowns of groundnut oil mills located in and around Bapatla. The beetle was identified by small black markings on the elytra which completely covered the abdomen, very broad hind femur and serrated antennae (Dick, 1987a).

Twenty-five pairs of freshly emerged beetles were released into plastic jar (20 X 15 cm) containing 250 gm of groundnut pods. The mouth of the jar was covered with muslin cloth and held tight with rubber bands. Ten such jars were maintained for mass culturing of the bruchids. The adult beetles were removed after ten days and the jars were kept undisturbed till the emergence of adults. The freshly emerged adults were used in experiments.

### **3.3.3 Sexing of the test insect**

The sexing of the adult beetles was done by observing the last visible segments of the abdomen. In male the pygidium or sixth visible tergite projects downwards and was hidden by elytra. The fifth visible sternite was deeply incurved and seventh tergite projects between the fifth sternite and pygidium. In female the pygidium was seen in dorsal view projecting beyond the elytra. The fifth sternite was fully extended and the ventral surface was more or less flat. The seventh tergite was not seen in the female. [Davey, 1958]

### **3.4 BIOLOGY OF *C. serratus***

Studies on the biology of *C. serratus* were carried out under laboratory conditions on groundnut pods. One hundred grams of disinfested groundnut pods were taken in a plastic container. Ten replications were maintained and a mating pair of freshly emerged adults were released into plastic containers. The mouth of the jar was covered with muslin cloth and held with rubber bands. The pre-oviposition period was recorded in 10 female beetles by observing the beetles continuously till they start laying eggs. The eggs on the pods were counted daily and were replaced by healthy pods. The counting of eggs was continued till the adults ceased to lay the eggs.

Eggs were dark brown in colour initially and later turned to pale green and the embryo movements in the egg before hatching was observed with the help of microscope to note the egg period. Fifty eggs were observed for hatching.

The larval period was determined by placing one groundnut pod with freshly hatched single larvae separately in a small plastic tube (2.3 cm diameter). As the fully grown larva sometimes pupate outside pod or within the shell of the groundnut pod, the pods were daily split open and examined for pupae. Fifty of such larvae were observed till pupation.

The pupal period was recorded by placing fifty fresh pupae separately in small plastic tubes (2.3 cm diameter) and observed till the emergence of the adults. For recording adult longevity fifty adult beetles were observed daily until their death.

### **3.5 STUDY OF MORPHOMETRICS OF *C. serratus* (Olivier)**

The study of morphometrics of different stages of the test insect were carried out using a trinocular stereozoom microscope (Olympus, SZX – ILL K – 2000) having the minimum of 6.3 and a maximum of 57.6 magnification. The study of morphometrics was accomplished by means of stage micrometer in conjugation with ocular micrometer. Stage micrometer consisted of 3” × 1” slide on which a graduated millimeter scale is present, ocular micrometer was a diaphragm consisting a graduated scale mounted in the eye piece of a trinocular microscope.

The stage micrometer was placed over the stage of stereozoom trinocular microscope. The ocular micrometer was inserted in the eye piece of the microscope. The focus was adjusted to make stage micrometer coincide with the zero scales of both ocular and stage micrometer.

The number of graduations of coincidence on the scales of both ocular and stage micrometer was determined. The value of each ocular division with reference to stage micrometer was calibrated. The stage micrometer was removed. The different life stages *viz.*, egg, larvae, pupae and adult of *C. serratus* to be measured were focused. The number of graduations on the ocular scale, which covered the length and width of *C. serratus* life stages were observed and recorded. The length and breadth of the *C. serratus* was multiplied by calibration value of each ocular division with the number of ocular divisions that covered the length and width of different life stages was determined. Length and breadth of twenty specimens of each life stage of *C. serratus* was determined for obtaining the average measurement.

### 3.6 EVALUATION OF EFFICACY OF PLANT PRODUCTS

Groundnut pods of one kilogram was taken after carefully weighing the groundnut pods. The test concentration for powders was  $10 \text{ gm kg}^{-1}$  *i.e.*, 1% concentration. The plant powders were added to pods slowly in small amounts and were thoroughly mixed so as to obtain uniform distribution. The treated groundnut pods were filled in one Kg capacity gunny bags (Plate 1) and were kept in cage (Plate 2). The treatments were replicated thrice. The test insect *C. serratus* @ 5 pairs per each replication were released into cage.

The plant oils were tested at 1% concentration. Disinfested gunny bags were taken and were treated with edible and non-edible plant oils by spraying 1% plant oils with the help of hand sprayer. For obtaining 1% spray fluid, 10 ml of oil was mixed with a litre of acetone. To maintain uniformity in untreated control, only acetone was sprayed on gunny bags. The treated bags were dried under shade and were filled with one kilogram groundnut pods. Each treatment was replicated thrice and were kept in a cage. Test insect, *C. serratus* @ 5 pairs for each replication were released into the cage.

One untreated control and one treated control (proven check with deltamethrin @ 0.02%) samples were also maintained, similarly.

Observations were taken on oviposition, pod damage, germination and moisture content of the pods by drawing monthly samples. The monthly samples were drawn upto 6 months. To evaluate the efficacy of plant products monthly samples of 25 gm of pods were drawn from the

gunny bags of each treatment separately. The pods were observed for egg laying by the test insect carefully. The number of pods with eggs to the total number of pods in sample were observed and recorded. Pods were also observed by splitting to see the pod damage. The per cent pods with eggs and per cent pod damage were calculated. The different parameters were worked out with the following formulas.

$$1. \text{ Per cent pods with eggs} = \frac{\text{Number of pods with eggs}}{\text{Total number of pods observed}} \times 100$$

$$2. \text{ The percentage of pods damaged / per cent pod damage} = \frac{\text{Number of damaged pods}}{\text{Total number of pods observed}} \times 100$$

### 3.6.1 Determination of moisture content

The moisture content of the pods was determined on the weight basis. The samples were weighed ( $W_1$ ) and kept in hot air oven at  $100 \pm 5^\circ\text{C}$  for 24 hours and weight ( $W_2$ ) was determined. The percentage of moisture present in the pods was determined by using following formula.

$$\text{Moisture content} = \frac{W_1 - W_2}{W_1} \times 100$$

$W_1$  = weight of sample before drying

$W_2$  = weight of sample after drying

### **3.6.2 Determination of germination percentage of groundnut kernels**

Effect of plant products on seed germination was studied by conducting germination tests by paper towel method (ISTA 1966). Three hundred groundnut kernels were taken and kept in three replications (100 kernels/replication) in moisture paper towels and allowed to germinate at room temperature for 7 days. The number of germinated kernels to the total number of kernels were observed and recorded. The percentage of germination was calculated by the following formula.

$$\text{Per cent germination} = \frac{\text{Number of germinated kernels}}{\text{Total number of kernels observed}} \times 100$$

### **3.7 STATISTICAL ANALYSIS**

All the experiments were carried out in Completely Randomized Design (CRD) replicated three times and data were analysed by using Analysis of variance (ANOVA) technique. Standard error of difference was calculated for the effect of each treatment and the critical difference (CD) was also calculated to compare the mean difference among the treatments.

## **CHAPTER – IV**

### **RESULTS**

The results of the investigation carried out on the biology of *Caryedon serratus* (Olivier) and its management through plant powders, edible and non edible oils are presented in this chapter.

#### **4.1 BIOLOGY OF *C. serratus* ON GROUNDNUT PODS**

The detailed studies on the biology of *C. serratus* on groundnut pods were carried out from the month of November 2004 to January 2005. The temperature recorded during the experimental period varied between 19.33<sup>o</sup>C to 30.26<sup>o</sup>C where as the relative humidity ranged from 68.60 % to 90.91% with an average of 79.61%.

##### **4.1.1 Oviposition and fecundity**

The studies revealed that the copulation occurred on the surface of pods or in the interspaces of pods, usually one or two days after emergence. It was evident from the data (table 1) that the pre-oviposition period ranged between 1.04 to 2.41 days, with an average of 1.69 days. Generally the female laid one egg per pod and if there was shortage of pods it laid more than one egg per pod. Some times the eggs were laid indiscriminately on any surface *i.e.*, on walls of rearing jars also.

The fecundity ranged between 15 and 85 eggs/female and the highest was 85 eggs/female with an average of 35.44 eggs/female. The oviposition period ranged between 3 to 16 days and average oviposition period was recorded to be 8.44 days.

#### **4.1.2 Egg**

The freshly laid eggs were translucent, ovoid and dark brown in colour with a tough chorion (Plate 3). Prior to hatching, the first instar larva was seen in the transparent chorion. A day earlier to hatching the larva made a circular cut in the chorion and started boring into the pod of the groundnut. The eggshell after hatching looked opaque white or grey. The egg period ranged from 3 to 9 days with an average period of 6.25 days (Table 1). The length of the egg ranged between 0.95 mm to 1.08 mm with an average of 1.00 mm while the breadth of egg ranged between 0.60 mm to 0.77 mm with an average of 0.71 mm (Table 2).

#### **4.1.3 Larva**

The grub passed through four instars. The entire development of larval stage was completed inside the kernel. The newly hatched first instar larva was creamy white in colour, 'C' shaped with prominent mandibles. After completion of the embryonic development, the first instar larva bored into the pod with the help of mandibles by creating a very minute emergence hole.

After tunneling out from its egg and through the pod, the larva located a seed and penetrated the seed coat. No sign of damage was visible externally on pods and kernels. The full grown mature larva turned light pink colour before pupation (Plate 4). On opening of cotyledons larvae were observed feeding inside the kernel (Plate 5). The kernels were totally eaten by the larva in some cases (Plate 6).

The larval period ranged between 19 to 38 days with an average of 31.21 days (Table 1).

The length of larva ranged between 6.66 mm to 7.88 mm with an average of 7.28 mm and the breadth ranged between 2.24 mm to 2.82 mm with an average of 2.61 mm (Table 2).

#### **4.1.4 Pupa**

The fully mature larva emerged out through a hole made in the groundnut pod (Plate 7) and pupated outside the kernel but within the shell or protruding from the hole made by the larvae. Pupa was exarate enclosed in a white papery cocoon (Plate 8). Pupal period lasted for 9 to 34 days, with an average of 26.55 days (Table 1).

The length of the pupae ranged between 6.55 mm to 7.38 mm with an average of 6.93 mm while the breadth ranged between 2.49 mm to 2.90 mm with an average of 2.80 mm (Table 2).

#### **4.1.5 Adult**

The adults emerged from the cocoon by cutting at one end. The freshly emerged adults were pale brown in colour and within a span of one to two days they turned brown. The dark brown adult beetle possessed small black markings on the elytra with head slightly deflexed, compound eyes very large, protruding laterally (Plate 9). Antenna was serrate and 11 segmented. Fore and middle legs were similar, femora of hind legs were enlarged with a conspicuous comb of teeth. The whole body was covered with grayish white pubescence. The sexes were identified by the last

abdominal segments. In case of male the pygidium or sixth visible tergite projected downwards, so that in dorsal view it was hidden by elytra. Where as in female the pygidium was seen in dorsal view projecting beyond the elytra. The length of adult beetle ranged between 6.05 mm and 6.55 mm with an average of 6.22 mm, while the breadth ranged between 2.65 mm and 3.07 mm with an average of 2.81 mm (Table 2).

#### **4.1.6 Longevity of adult**

The adult longevity of *C. serratus* ranged from 19 to 30 days with an average of 19.62 days (Table 1).

#### **4.1.7 Total life cycle**

The total life cycle of *C. serratus* ranged between 43 to 70 days with an average of 57.16 days.

#### **4.1.8 General habits**

*C. serratus* was an active species and a strong flier too. The adult beetle remained inactive during midnights and afternoon and confined to lower layers of the pods in the culture jars. The adults showed brisk activity in early mornings and late evenings. The beetles feign death on being touched or disturbed, they retract their necks, pull the legs close to the body and stay motionless. The larvae too feign death for few seconds on disturbance. They also showed a characteristic habit of occupying empty cocoons and cavities of the used seeds with their backs facing outwards.

## **4.2 RELATIVE EFFICACY OF PLANT PRODUCTS (POWDERS) AGAINST OVIPOSITION OF *C. serratus* IN STORED GROUNDNUTS.**

The efficacy of some plant products in the form of powders on oviposition of *C. serratus* was tested. The freshly emerged one day old adult beetles were released into the cage where groundnut pods were stored in one kg capacity gunny bags. The pods with eggs were recorded at 30, 60, 90, 120, 150 and 180 days after treatments. The data are presented in table 3.

### **4.2.1 30 days after treatment**

The results in table 3 (Fig 1) revealed that after 30 days of treatment, *Acorus calamus* L. rhizome powder, *Lantana camara* L. leaf powder, *Ocimum canum* L. leaf powder, karanja seed powder, eucalyptus leaf powder each at 1% concentration and deltamethrin (@ 0.02%) were found significantly superior and effective with zero per cent pods with eggs whereas neem kernel powder resulted in 4.07 per cent pods with eggs but was on par with all the above treatments. The highest per cent pods with eggs (5.91) was recorded in untreated control but was at par with neem kernel powder.

### **4.2.2 60 days after treatment**

The results of the present experiment indicated that after 60 days of treatment, *A. calamus* rhizome powder, *O. canum* leaf powder, *L. camara* leaf powder, karanja seed powder each at 1% concentration and

deltamethrin (@ 0.02%) were found to be significantly superior treatments being on par with 0.00, 0.00, 1.73, 2.92 and 0.00 per cent pods with eggs, respectively. The next best treatment was neem kernel powder (@1%) with 9.52 per cent pods with eggs. The least effective treatment was eucalyptus leaf powder (@1%) with 14.54 per cent pods with eggs. The highest per cent of pods with eggs was 15.79 in untreated control. The treatments with neem kernel powder, eucalyptus leaf powder and untreated control were on par with each other.

#### **4.2.3 90 days after treatment.**

At 90 days after treatment deltamethrin (@ 0.02%) was on par with *A. calamus* rhizome powder, *O. canum* leaf powder and *L. camara* leaf powder with 0.00, 0.00, 0.00 and 1.89 per cent pods with eggs, respectively and all the treatments were significantly superior over other treatments. The next best treatment was karanja seed powder (@ 1%) with 16.72 per cent pods with eggs and was also significantly superior from rest of the treatments. Among the treatments eucalyptus leaf powder and neem kernel powder were on par and the least effective with 25.77 and 32.69 per cent pods with eggs, respectively. However neem kernel powder was also on par with untreated control (36.55), which recorded the highest per cent pods with eggs.

#### **4.2.4 120 days after treatment**

The results presented in the table 3 (Fig 1) indicated that *A. calamus* rhizome powder (@ 1%), *O. canum* leaf powder (@ 1%) and deltamethrin (@ 0.02%) were the best treatments without recording any

Pods with eggs, being on par and significantly superior over all the other treatments. *L. camara* leaf powder was the next best treatment which recorded 12.71 per cent pods with eggs and also significantly superior over the remaining treatments. It was followed by neem kernel powder (35.75 per cent pods with eggs) and karanja seed powder (48.54 per cent pods with eggs), being on par with each other. The eucalyptus leaf powder (@1%) treatment was found to be the least effective with 65.58 per cent pods with eggs and was on par with untreated control (62.67 per cent pods with eggs) and karanja seed powder.

#### **4.2.5 150 days after treatment**

The perusal of the data (Table 3) indicated that deltamethrin (@ 0.02%) and *A. calamus* rhizome powder (@ 1%) were the best being on par with each other with 0.00 and 3.76 per cent pods with eggs, respectively. However *A. calamus* rhizome powder was also on par with *L. camara* leaf powder, which was the next best treatment with 14.45 per cent pods with eggs. It was followed by *O. canum* leaf powder (18.57 per cent pods with eggs) and karanja seed powder (48.64 per cent pods with eggs). The eucalyptus leaf powder was the least effective treatment with 66.95 per cent pods with eggs and was on par with untreated control, which recorded 74.38 per cent pods with eggs.

#### **4.2.6 180 days after treatment**

At 180 days after treatment the proven check deltamethrin (0.00 per cent pods with eggs) was on par with *L. camara* leaf powder (17.03 per cent pods with eggs) and the two treatments were the best in recording

lowest per cent pods with eggs. However *L. camara* was in turn on par with *A. calamus*, which recorded 19.79 per cent pods with eggs and *O. canum* leaf powder with 25.95 per cent pods with eggs. Karanja seed powder and neem kernel powder recorded 46.73 and 76.23 per cent pods with eggs, respectively. Among the treatments eucalyptus leaf powder (@1%) was the least effective with 78.07 per cent pods with eggs and was on par with untreated control having 100.00 per cent pods with eggs as well as the last two treatments.

#### **4.3 RELATIVE EFFICACY OF PLANT PRODUCTS (POWDERS) ON POD DAMAGE BY *C. serratus* IN STORED GROUNDNUT.**

Efficacy of some plant products in the form of powders on pod damage caused by *C. serratus* was tested. Freshly emerged one day old adult beetles were released into the cage where groundnut pods were stored in one kg capacity gunny bags. The per cent pod damage of groundnut pods was recorded at 30, 60, 90, 120, 150 and 180 days after treatment. The data is presented in table 4.

##### **4.3.1 30 days after treatment**

The data (Table 4) revealed that no pod damage was recorded in stored groundnuts upto 30 days after treatment in all the treatments including untreated control.

#### **4.3.2 60 days after treatment**

The results revealed that after 60 days of treatment, pod damage was zero in the treatments with neem kernel powder, *A. calamus* rhizome powder, karanja seed powder, *O. canum* leaf powder and eucalyptus leaf powder each at 1% concentration and deltamethrin (@ 0.02%). Although *L. camara* leaf powder recorded 1.73 per cent pod damage it was on par with the above treatments. However all the treatments were significantly superior to untreated control which recorded 3.83 per cent pod damage at 60 days after treatment.

#### **4.3.3 90 days after treatment**

At 90 days after treatment no pod damage was recorded in the treatments with *A. calamus* rhizome powder, karanja seed powder, *L. camara* leaf powder, *O. canum* and eucalyptus leaf powder each at 1% concentration and the proven check deltamethrin (@ 0.02%) and all the above treatments were on par and significantly superior over neem kernel powder, the least effective treatment with 2.98 per cent pod damage. However all the treatments were significantly superior to control which recorded 6.72 per cent pod damage.

#### **4.3.4 120 days after treatment**

A critical examination of the data in the table 4 (Fig 2) revealed that no pod damage was recorded in the treatments with *A. calamus* rhizome powder, *L. camara* leaf powder and *O. canum* leaf powder each at 1% concentration and deltamethrin (@0.02%) and all the above treatments

were significantly superior over the remaining treatments and were at par with each other. The next best were karanja seed powder (@ 1%) with 7.33 per cent pod damage and eucalyptus leaf powder (@ 1%) with 9.88 per cent pod damage, being on par and significantly superior over neem kernel powder (@ 1%) treatment, the least effective with 19.14 per cent pod damage. Untreated control, which recorded 24.33 per cent pod damage, was on par with neem kernel powder.

#### **4.3.5 150 days after treatment**

The treatments with *A. calamus rhizome* powder (@ 1%), deltamethrin (@ 0.02%) and *L. camara* leaf powder (@ 1%) recorded a pod damage of 0.00, 0.00 and 6.03 per cent, respectively at 150 days after treatment. The above treatments were significantly superior over the remaining treatments and were at par with each other.

The *O. canum* leaf powder was the next best treatment with 11.72 per cent pod damage. The treatments with karanja seed powder (@ 1%) and neem kernel powder (@ 1%) showed a pod damage of 30.12 and 38.41 per cent, respectively and were at par with each other. The eucalyptus leaf powder (@ 1%) was the least effective treatment with 61.08 per cent pod damage and was on par with untreated control having 61.04 per cent pod damage.

#### **4.3.6 180 days after treatment**

The data at 180 days after treatment indicated that deltamethrin (@0.02%) *A. calamus* rhizome powder (@1%) and *L. camara* leaf powder (@1%) were significantly superior over all the other treatments, being on

par with 0.00, 10.95 and 12.43 per cent pod damage, respectively. The next best treatments were *O. canum* leaf powder (@ 1%) and karanja seed powder (@ 1%), which were on par with 26.30 and 51.82 per cent pod damage. Neem kernel powder (63.48 per cent pod damage) and eucalyptus leaf powder (76.64 per cent pod damage) were the least effective treatments and were on par with untreated control having 92.06 per cent pod damage.

#### **4.4 RELATIVE EFFICACY OF PLANT PRODUCTS (PLANT OILS) ON OVIPOSITION OF *C. serratus* IN GROUNDNUT PODS.**

The efficacy of certain plant oils as grain protectants on the oviposition of *C. serratus* was tested. The gunny bags of one kg capacity were treated with 1% plant oils, shade dried, filled with groundnut pods and were kept in a cage. Freshly emerged one day old adult beetles were released into the cage. The pods with eggs were recorded at 30, 60, 90, 120, 150 and 180 days after treatment. The data are presented in table 5.

##### **4.4.1 30 days after treatment**

The results in the table 5 (Fig 3) indicated that there was zero per cent pods with eggs in treatments with neem oil, mustard oil, castor oil, sesamum oil and citronella oil each at 1% concentration and the proven check deltamethrin (@ 0.02%) at 30 days after treatment. The per cent pods with eggs was 0.83 in karanja oil treatment and 2.96 in untreated control. There was no significant difference between the treatments including untreated control at 30 days after treatment.

#### **4.4.2 60 days after treatment**

The results at 60 days after treatment revealed that zero per cent pods with eggs was recorded in treatments with neem oil, castor oil, citronella oil each at 1% concentration and the proven check deltamethrin (@ 0.02%). All the treatments were significantly superior over the other treatments and were on par with each other. Mustard oil (@ 1%) and karanja oil (@ 1%) were the next best treatments with 4.61 and 7.91 per cent pods with eggs, respectively. The treatment with sesamum oil was the least effective with 18.76 per cent pods with eggs and was on par with untreated control having 20.72 per cent pods with eggs.

#### **4.4.3 90 days after treatment**

The perusal of the data in table 5 (Fig 3) revealed that per cent pods with eggs was zero in treatments with neem oil, castor oil and citronella oil each at 1% concentration and the proven check deltamethrin (@ 0.02%). These treatments were on par with each other and were significantly superior over all the other treatments.

The per cent of pods with eggs was 7.74 in mustard oil (@ 1%), which was the next best treatment. It was followed by karanja oil with 16.34 per cent pods with eggs and sesamum oil, the least effective treatment which recorded 3.43 per cent pods with eggs. All the treatments were significantly superior to untreated control, which recorded the highest per cent of pods with eggs (40.76 per cent) upto 90 days after treatment.

#### **4.4.4 120 days after treatment**

At 120 days after treatment neem oil, castor oil and citronella oil each at 1% concentration and the proven check deltamethrin (@ 0.02%) were on par with zero per cent pods with eggs and were significantly superior over all the other treatments. Mustard oil and karanja oil were the next best treatments and were on par with 21.82 and 33.73 per cent pods with eggs, respectively. Sesamum oil was the least effective treatment with 73.61 per cent pods with eggs and was on par with untreated control having 78.52 per cent pods with eggs.

#### **4.4.5 150 days after treatment**

The results in table 5 (Fig.3) revealed that neem oil (@ 1%), castor oil (@ 1%) and deltamethrin (@ 0.02%) treatments recorded no pods with eggs, while in citronella oil, it was 1.78 per cent pods with eggs. But all the above treatments were on par and significantly superior over the other treatments. The next best was mustard oil (@ 1%) treatment, which recorded 29.98 per cent pods with eggs and was followed by karanja oil treatment with 46.28 per cent pods with eggs. Sesamum oil was the least effective treatment with 80.15 per cent pods with eggs and was on par with untreated control having 83.05 per cent pods with eggs.

#### **4.4.6 180 days after treatment**

A review of the data (Table 5) at 180 days after treatment indicated that the treatments with neem oil, castor oil each at 1% concentration and deltamethrin (@ 0.02%) were significantly superior to all the other

treatments being on par with zero per cent pods with eggs. The next best treatments were mustard oil (@ 1%) and citronella oil (@ 1%) being on par with 34.98 and 46.58 per cent pods with eggs, respectively. However citronella oil was also inturn on par with karanja oil, which recorded 63.84 per cent pods with eggs. Sesamum oil was the least effective treatment with 82.85 per cent pods with eggs. However all the treatments were significantly superior to untreated control which recorded the highest of 96.94 per cent pods with eggs.

#### **4.5 RELATIVE EFFICACY OF PLANT PRODUCTS (PLANT OILS) ON POD DAMAGE BY *C. serratus* IN STORED GROUNDNUT.**

The efficacy of certain plant oils as grain protectants against the infestation by *C. serratus* was tested. The gunny bags of one kg capacity were treated with 1% plant oils separately and were shade dried, filled with groundnut pods and were kept in a cage. Freshly emerged one day old adult beetles were released into the cage. The pod damage on groundnut pods was recorded at 30, 60, 90, 120, 150 and 180 days after treatment. The data are presented in table 6.

##### **4.5.1 30 days after treatment**

The data (Table 6) collected at 30 days after treatment revealed that no pod damage was recorded in groundnut pods treated with plant oils including untreated control.

#### **4.5.2 60 days after treatment**

The data (Table 6) collected at 60 days after treatment also revealed that no pod damage was recorded in groundnut pods treated with plant oils including untreated control.

#### **4.5.3 90 days after treatment**

At 90 days after treatment all the plant oils *i.e.*, neem oil, karanja oil, mustard oil, castor oil, sesamum oil and citronella oil each at 1% concentration and the proven check deltamethrin (@ 0.02%) recorded zero per cent pod damage and were very effective in controlling pod damage upto 90 days and were significantly superior to untreated control which recorded a pod damage of 4.61 per cent.

#### **4.5.4 120 days after treatment**

The results in table 6 (Fig 4) indicated that the treatments with neem oil, castor oil and citronella oil each at 1% concentration and deltamethrin (@ 0.02%) showed zero per cent pod damage while 1.61 per cent pod damage was recorded in mustard oil (@ 1%). All the above treatments were at par and significantly superior over the other treatments. The pod damage was 6.06 per cent in karanja oil (@ 1%), which was the next best treatment. Sesamum oil was the least effective treatment with 28.61 per cent pod damage and was on par with untreated control having a pod damage of 33.85 per cent.

#### **4.5.5 150 days after treatment**

At 150 days after treatment the per cent pod damage recorded was zero in the treatments with neem oil, castor oil and citronella oil each at 1% concentration and deltamethrin (@ 0.02%). The above treatments were on par and significantly superior over the other treatments. The next best treatment was mustard oil (19.22 per cent pod damage) and was followed by karanja oil with a pod damage of 33.47 per cent. Among the treatments sesamum oil was the least effective with 67.68 per cent pod damage. However all the treatments were significantly superior to untreated control which recorded the highest (75.95 per cent) pod damage.

#### **4.5.6 180 days after treatment**

The perusal of the data in table 6 (Fig 4) revealed no pod damage in the treatments with neem oil (@ 1%), castor oil (@ 1%) and deltamethrin (@ 0.02%) treatments. The above treatments were significantly superior over the other treatments and were on par with each other. Citronella oil (10.69 per cent pod damage) was the next best treatment and was followed by mustard oil (26.59 per cent) and karanja oil (43.82 per cent pod damage). Among the treatments sesamum oil (79.55 per cent pod damage) was the least effective in reducing pod damage by *C. serratus* at 180 days after treatment. The pod damage was the highest (94.79 per cent) in untreated control. However all the treatment were significantly superior to untreated control in reducing the pod damage at 180 days after treatment.

#### **4.6 INFLUENCE OF PLANT PRODUCTS (POWDERS) ON GERMINATION OF GROUNDNUT PODS**

The data in the table 7 indicated that the germination of groundnut pods before treatment with plant powders was 96.66 per cent.

The germination percentage at 30, 60, 90, 120, 150 and 180 days after treatment ranged between 83.33 to 93.33 per cent, 90 to 100 per cent, 80 to 100 per cent, 80 to 93.33 per cent, 73.33 to 93.33 per cent and 73.33 to 86.66 per cent, respectively in all the treatments including untreated control and there was no significant difference in germination between the treatments. Hence the treatments with plant powders had no effect on germination of groundnut kernels.

#### **4.7 INFLUENCE OF EDIBLE AND NON EDIBLE OILS ON THE GERMINATION OF GROUNDNUT PODS DURING THE STORAGE**

The germination was 96.66 per cent in the groundnut pods prior to the test on the influence of different edible and non edible oils on germination of groundnut pods during the study (Table 8).

At 30, 60, 90, 120, 150 and 180 days after treatment the germination per cent ranged between 83.33 to 96.66 per cent, 83.33 to 100.00 per cent, 76.66 to 93.33 per cent, 60.00 to 96.66 per cent, 60.00 to 96.66 per cent and 80.00 to 93.33 per cent, respectively in all the treatments including untreated control and there was no significant difference in germination

among the treatments indicating that the gunny bag treatment with edible and non edible oils had no effect on the germination of groundnut kernels.

#### **4.8 INFLUENCE OF GRAIN PROTECTANTS ON MOISTURE CONTENT OF GROUNDNUT PODS**

The initial moisture content of groundnut pods before treatment with grain protectants was 8.09 per cent.

The moisture percentage at 30, 60, 90, 120, 150 and 180 days after treatment with plant powders ranged between 7.00 to 8.6 per cent, 7.52 to 8.52 per cent, 7.61 to 8.38 per cent, 6.88 to 8.00 per cent, 7.39 to 8.57 per cent and 6.94 to 8.33 per cent, respectively (Table 9) in all the treatments including untreated control.

While the moisture percentage of groundnut pods treated with plant oils at 30, 60, 90, 120, 150 and 180 days after treatment varied between 7.30 to 7.82 per cent, 7.79 to 8.21 per cent, 7.92 to 9.12 per cent, 7.05 to 8.16 per cent, 7.20 to 8.33 per cent and 8.09 to 9.11 per cent, respectively (Table 10).

**Table 1: Biology of *Caryedon serratus* on groundnut pods under laboratory conditions.**

Stage	Number studied	Duration in days	
		Average	Range
1. Egg	50	6.25	3-9
2. Larva	50	31.21	19-38
3. Pupa	50	26.55	9-34
4. Adult longevity	50	19.62	19-30
5. Total life cycle	50	57.16	43-70
6. Pre-oviposition period	10	1.69	1.04-2.41
7. Oviposition period	10	8.44	3-16
8. Fecundity	10	35.44	15-85

**Table 2: Morphometrics of different life stages of *C. serratus***

Stage	Number studied	Length (mm)		Breadth (mm)	
		Average	Range	Average	Range
1. Egg	20	1.00	0.95-1.08	0.71	0.60-0.77
2. Larva	20	7.28	6.66-7.88	2.61	2.24-2.82
3. Pupa	20	6.93	6.55-7.38	2.80	2.49-2.90
4. Adult	20	6.22	6.05-6.55	2.81	2.65-3.07

**Table 3: Effect of plant products (powders) against oviposition of *C. serratus* in stored groundnut pods.**

Sl. No	Treatment	Concentration	Pods with eggs (%)					
			30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT
1	Neem kernel powder	1%	4.07 (10.61) <sup>ab</sup>	9.52 (16.88) <sup>b</sup>	32.69 (34.82) <sup>cd</sup>	35.75 (36.72) <sup>c</sup>	45.75 (42.54) <sup>de</sup>	76.23 (65.59) <sup>d</sup>
2	<i>Acorus calamus</i> rhizome powder	1%	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	3.76 (10.20) <sup>ab</sup>	19.79 (24.60) <sup>b</sup>
3	Karanja seed powder	1%	0.00 (4.05) <sup>a</sup>	2.92 (9.17) <sup>a</sup>	16.72 (24.03) <sup>b</sup>	48.54 (44.10) <sup>cd</sup>	48.64 (44.22) <sup>e</sup>	53.01 (46.73) <sup>cd</sup>
4	<i>Lantana camara</i> leaf powder	1%	0.00 (4.05) <sup>a</sup>	1.73 (6.64) <sup>a</sup>	1.89 (6.87) <sup>a</sup>	12.71 (20.84) <sup>b</sup>	14.45 (22.25) <sup>bc</sup>	17.03 (24.22) <sup>ab</sup>
5	<i>Ocimum canum</i> leaf powder	1%	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	18.57 (25.48) <sup>c</sup>	25.94 (30.60) <sup>bc</sup>
6	Eucalyptus leaf powder	1%	0.00 (4.05) <sup>a</sup>	14.54 (22.34) <sup>b</sup>	25.77 (30.50) <sup>c</sup>	65.58 (54.17) <sup>d</sup>	66.95 (54.95) <sup>ef</sup>	78.07 (66.68) <sup>de</sup>
7	Deltamethrin	0.02%	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>
8	Control	--	5.91 (12.72) <sup>b</sup>	15.79 (22.93) <sup>b</sup>	36.55 (37.18) <sup>d</sup>	62.67 (52.68) <sup>d</sup>	74.38 (64.47) <sup>f</sup>	100.00 (90.00) <sup>e</sup>
			Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	S.Em		1.96	2.54	1.43	3.38	4.86	6.78
	C.D (P=0.05)		5.88	7.61	4.30	10.16	14.57	20.33

The values in the brackets are angular transformed values

Sig = Significant

In each column the values having common alphabet are not significant.

**Table 4: Effect of plant products (powders) on pod damage by *C. serratus* in stored groundnut pods**

Sl. No	Treatment	Concentration	Pods infested/damaged (%)					
			30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT
1	Neem kernel powder	1%	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	2.98 (9.25) <sup>b</sup>	19.14 (25.86) <sup>c</sup>	38.41 (38.19) <sup>b</sup>	63.48 (58.16) <sup>c</sup>
2	<i>Acorus calamus</i> rhizome powder	1%	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	10.95 (19.21) <sup>a</sup>
3	Karanja seed powder	1%	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	7.33 (15.48) <sup>b</sup>	30.12 (33.13) <sup>b</sup>	51.82 (46.04) <sup>bc</sup>
4	<i>Lantana camara</i> leaf powder	1%	0.00 (4.05) <sup>a</sup>	1.73 (6.64) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	6.03 (14.13) <sup>a</sup>	12.43 (20.60) <sup>a</sup>
5	<i>Ocimum canum</i> leaf powder	1%	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	11.72 (19.99) <sup>a</sup>	26.30 (30.81) <sup>b</sup>
6	Eucalyptus leaf powder	1%	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	9.88 (18.03) <sup>b</sup>	61.08 (51.54) <sup>c</sup>	76.64 (61.31) <sup>c</sup>
7	Deltamethrin	0.02%	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>
8	Control		0.00 (4.05) <sup>a</sup>	3.83 (10.28) <sup>b</sup>	6.72 (14.70) <sup>c</sup>	24.33 (29.47) <sup>c</sup>	61.04 (52.63) <sup>c</sup>	92.06 (76.60) <sup>c</sup>
			NS	Sig.	Sig.	Sig.	Sig.	Sig.
	S.Em		1.59	1.49	1.23	1.45	4.26	6.29
	C.D (P=0.05)		3.38	4.48	3.69	4.35	12.79	18.87

The values in the brackets are angular transformed values

NS= Non significant                      Sig.= Significant

In each column the values having common alphabet are not significant.

**Table 5: Effect of plant products (oils) on oviposition of *C. serratus* on groundnut pods**

Sl. No	Treatment	Concentration	Pods with eggs (%)					
			30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT
1	Neem oil	1%	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>
2	Karanja oil	1%	0.83 (5.04) <sup>a</sup>	7.91 (16.07) <sup>c</sup>	16.34 (23.72) <sup>c</sup>	33.73 (35.50) <sup>b</sup>	46.28 (42.81) <sup>c</sup>	63.84 (53.79) <sup>c</sup>
3	Mustard oil	1%	0.00 (4.05) <sup>a</sup>	4.61 (12.40) <sup>b</sup>	7.74 (16.14) <sup>b</sup>	21.82 (27.83) <sup>b</sup>	29.98 (33.19) <sup>b</sup>	34.98 (36.16) <sup>b</sup>
4	Castor oil	1%	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>
5	Sesamum oil	1%	0.00 (4.05) <sup>a</sup>	18.76 (25.51) <sup>d</sup>	33.43 (35.32) <sup>d</sup>	73.61 (64.06) <sup>c</sup>	80.15 (63.79) <sup>d</sup>	82.85 (65.80) <sup>d</sup>
6	Citronella oil	1%	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	1.78 (6.72) <sup>a</sup>	46.58 (43.58) <sup>bc</sup>
7	Deltamethrin	0.02%	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>
8	Control		2.96 (8.14) <sup>a</sup>	20.72 (27.02) <sup>d</sup>	40.76 (39.64) <sup>e</sup>	78.52 (62.52) <sup>c</sup>	83.05 (65.71) <sup>d</sup>	96.94 (84.12) <sup>e</sup>

NS      Sig.      Sig.      Sig.      Sig.      Sig.

S.Em      1.48      1.25      0.99      4.77      2.00      3.68

C.D (P=0.05)      4.46      3.76      2.99      14.32      6.02      11.05

The values in the brackets are angular transformed values

Sig = Significant      NS = Non significant

In each column the values having common alphabet are not significant.

**Table 6: Effect of plant products (oils) on pod damage by *C. serratus* on groundnut pods**

Sl. No	Treatment	Concentration	Pods infested/damaged (%)					
			30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT
1	Neem oil	1%	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>
2	Karanja oil	1%	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	6.06 (13.94) <sup>b</sup>	33.47 (35.34) <sup>c</sup>	43.82 (41.45) <sup>d</sup>
3	Mustard oil	1%	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	1.61 (6.46) <sup>a</sup>	19.22 (25.90) <sup>b</sup>	26.59 (31.04) <sup>c</sup>
4	Castor oil	1%	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>
5	Sesamum oil	1%	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	28.61 (32.12) <sup>c</sup>	67.68 (55.37) <sup>d</sup>	79.55 (63.57) <sup>e</sup>
6	Citronella oil	1%	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	10.69 (18.38) <sup>b</sup>
7	Deltamethrin	0.02%	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>
8	Control	--	0.00 (4.05) <sup>a</sup>	0.00 (4.05) <sup>a</sup>	4.61 (11.23) <sup>b</sup>	33.85 (35.57) <sup>c</sup>	75.95 (60.72) <sup>e</sup>	94.79 (82.23) <sup>f</sup>
			NS	NS	Sig.	Sig.	Sig.	Sig.
	S.Em		1.59	1.59	1.34	1.30	1.07	3.39
	C.D (P=0.05)		3.38	3.38	4.02	3.91	3.22	10.18

The values in the brackets are angular transformed values

Sig = Significant

NS = Non significant

In each column the values having common alphabet are not significant.

**Table 7: Effect of plant products (powders) on the germination of groundnut.**

Sl. NO	Treatment	Concentration	Germination (%)						
			0 DAT	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT
1	Neem kernel powder	1%	96.66 (8385)	90.00 (75.00)	90.00 (71.56)	80.00 (68.85)	90.00 (75.00)	83.33 (70.07)	80.00 (67.85)
2	<i>Acorus calamus</i> rhizome powder	1%	96.66 (8385)	93.33 (81.14)	96.66 (83.85)	83.33 (70.07)	93.33 (77.71)	93.33 (77.71)	86.66 (72.29)
3	Karanja seed powder	1%	96.66 (8385)	90.00 (91.56)	100.00 (90.00)	93.33 (77.71)	83.33 (70.07)	83.33 (70.07)	73.33 (63.92)
4	<i>Lantana camara</i> leaf powder	1%	96.66 (8385)	83.33 (66.63)	90.00 (75.00)	93.33 (77.71)	90.00 (75.00)	90.00 (75.00)	86.66 (72.29)
5	<i>Ocimum canum</i> leaf powder	1%	96.66 (8385)	86.66 (61.21)	96.66 (83.85)	83.33 (66.14)	80.00 (63.43)	80.00 (63.43)	76.66 (61.71)
6	Eucalyptus leaf powder	1%	96.66 (8385)	86.66 (61.21)	93.33 (77.71)	83.33 (66.63)	86.66 (72.78)	86.66 (72.78)	83.33 (66.14)
7	Deltamethrin	0.02%	96.66 (8385)	86.66 (72.29)	90.00 (75.00)	86.66 (72.78)	80.00 (63.43)	73.33 (59.00)	83.33 (70.07)
8	Control		96.66 (8385)	93.33 (77.71)	96.66 (83.85)	100.00 (90.00)	93.33 (77.71)	80.00 (63.92)	80.00 (63.00)
			NS.	NS.	NS.	NS.	NS.	NS.	NS.
	S.Em		8.69	6.075	5.85	7.68	7.02	7.25	8.75
	C.D (P=0.05)		8.42	18.21	17.56	23.05	21.04	21.74	26.25

The values in the brackets are angular transformed values

NS = Non significant

In each column the values having common alphabet are not significant.

**Table 8: Effect of plant products (oils) on the germination of groundnut.**

Sl. No	Treatment	Concentration	Germination (%)						
			0 DAT	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT
1	Neem oil	1%	96.66 (8385)	96.66 (83.85)	83.33 (70.77)	76.66 (66.93)	96.66 (83.85)	96.66 (83.85)	93.33 (77.71)
2	Karanja oil	1%	96.66 (8385)	83.33 (66.14)	83.33 (70.07)	90.00 (71.56)	80.00 (63.92)	73.33 (60.00)	80.00 (63.92)
3	Mustard oil	1%	96.66 (8385)	96.66 (83.85)	96.66 (83.85)	83.33 (70.07)	86.66 (72.78)	86.66 (72.78)	90.00 (75.00)
4	Castor oil	1%	96.66 (8385)	90.00 (75.00)	93.33 (77.71)	83.33 (70.07)	76.66 (61.71)	76.66 (61.71)	86.66 (72.78)
5	Sesamum oil	1%	96.66 (8385)	83.33 (66.14)	83.33 (66.14)	86.66 (72.78)	60.00 (51.93)	60.00 (51.93)	83.33 (66.14)
6	Citronella oil	1%	96.66 (8385)	96.66 (83.85)	83.33 (66.63)	90.00 (75.00)	86.66 (68.85)	86.66 (68.85)	93.33 (81.14)
7	Deltamethrin	0.02%	96.66 (8385)	96.66 (83.85)	86.66 (72.78)	90.00 (75.00)	90.00 (75.00)	90.00 (75.00)	93.33 (81.14)
8	Control		96.66 (8385)	90.00 (71.56)	100.00 (90.00)	93.33 (77.71)	90.00 (71.56)	90.00 (71.56)	80.00 (63.92)
			NS	NS	NS	NS	NS	NS	NS
	S.Em		8.69	5.33	7.33	9.21	6.52	6.93	7.00
	C.D (P=0.05)		18.42	15.98	21.99	27.63	19.56	20.77	20.99

The values in the brackets are angular transformed values

NS = Non significant

In each column the values having common alphabet are not significant.

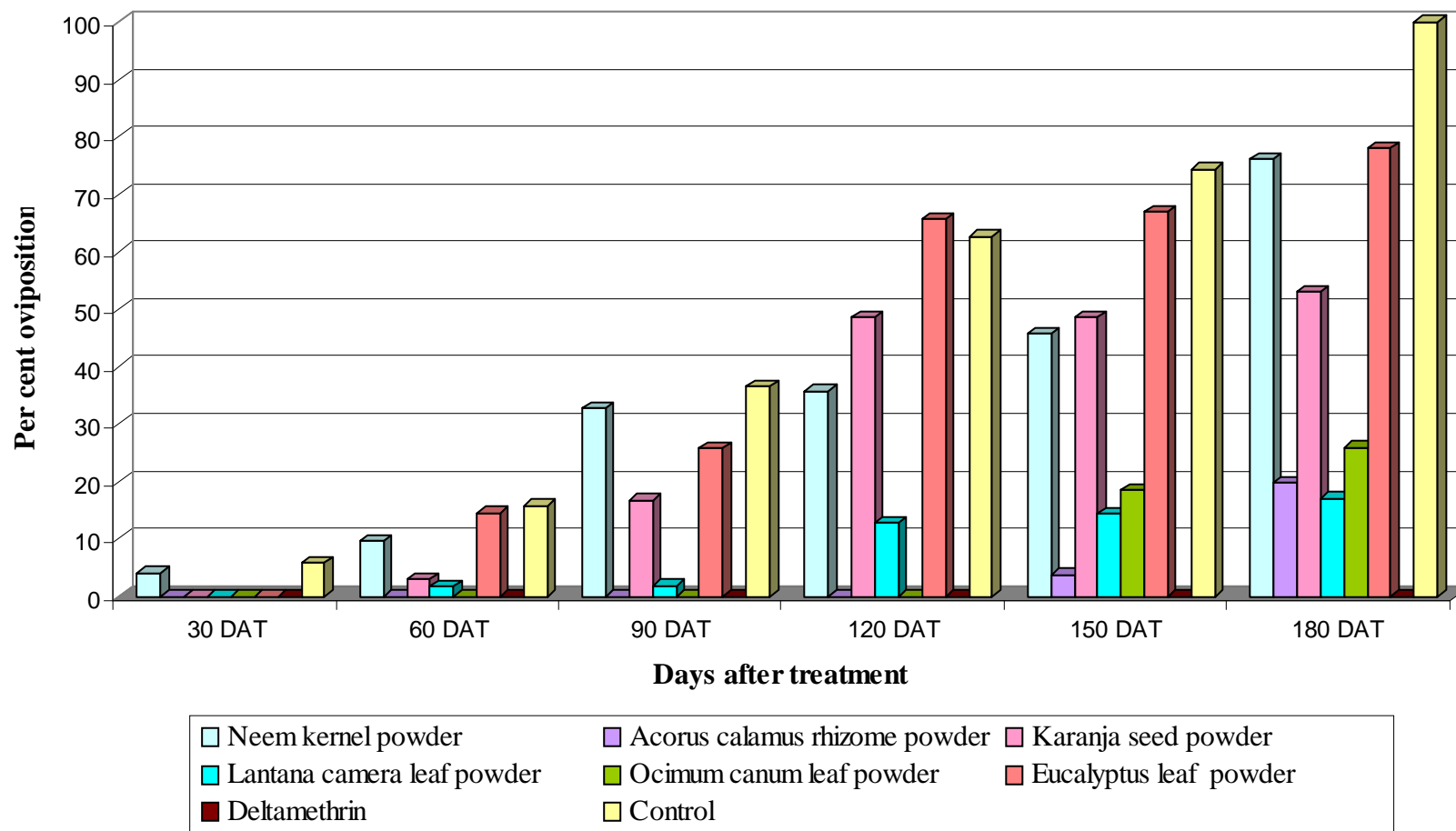
**Table 9: Effect of plant products (powders) on the moisture content of groundnut pods during the storage**

Sl. No	Treatment	% Moisture content						
		0 DAT	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT
1	Neem kernel powder	8.09	7.71	7.59	7.62	7.46	8.41	7.85
2	<i>Acorus calamus</i> rhizome powder	8.09	8.6	8.52	7.61	8.00	8.41	7.11
3	Karanja seed powder	8.09	7.26	7.52	8.27	7.21	7.96	8.33
4	<i>Lantana camara</i> leaf powder	8.09	8.40	7.64	8.21	6.88	7.45	6.94
5	<i>Ocimum canum</i> leaf powder	8.09	7.40	7.61	8.34	6.92	7.39	7.50
6	Eucalyptus leaf powder	8.09	8.13	7.53	8.17	7.02	8.57	7.95
7	Deltamethrin	8.09	7.00	7.79	8.38	7.00	7.87	6.95
8	Control	8.09	7.60	7.74	8.38	7.20	8.49	8.30

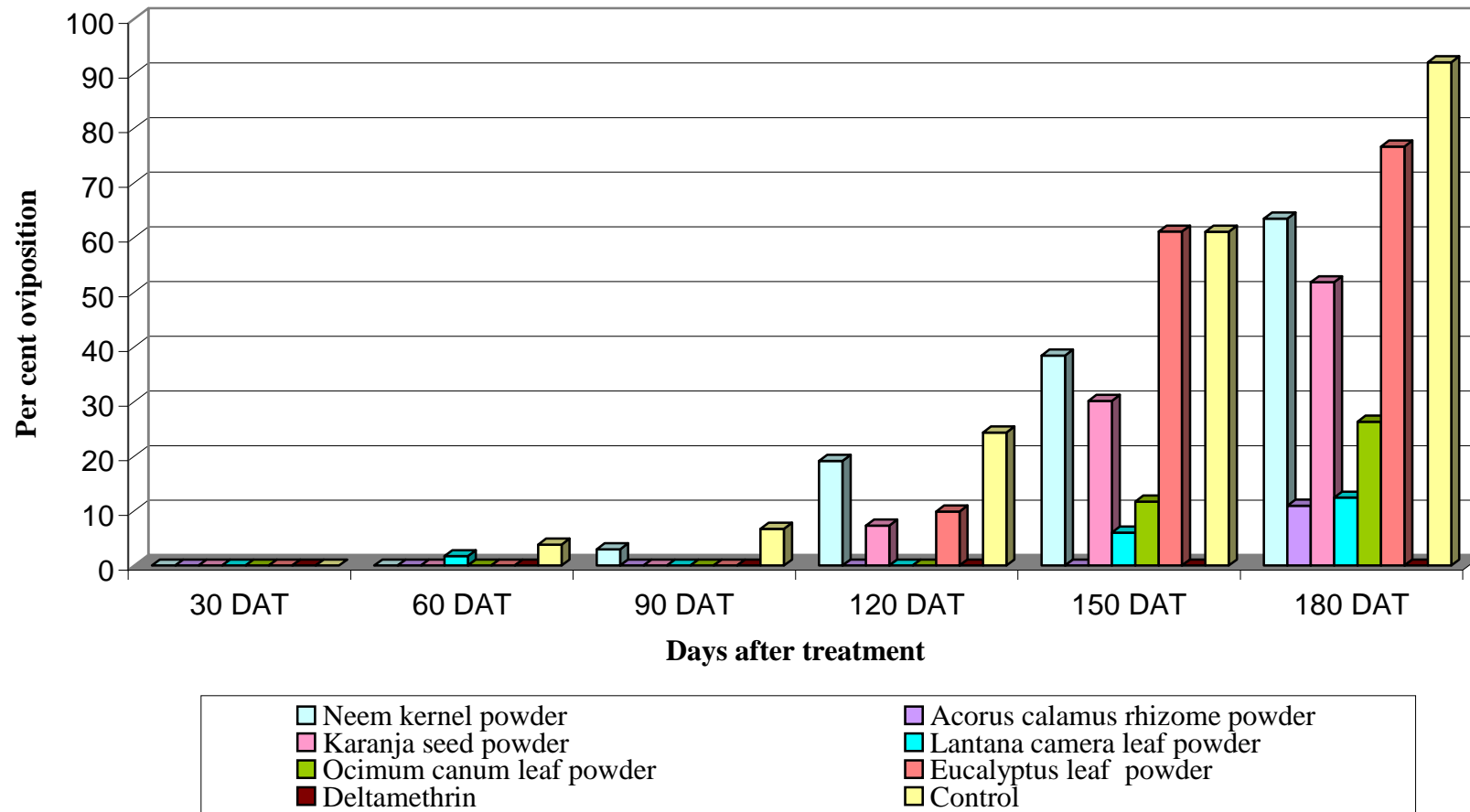
**Table 10: Effect of plant products (oils) on the moisture content of groundnut pods during the storage**

Sl. No	Treatment	% Moisture content						
		0 DAT	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT
1	Neem oil	8.09	7.60	8.03	7.92	7.18	8.31	8.36
2	Karanja oil	8.09	7.30	7.79	7.94	7.61	8.33	9.11
3	Mustard oil	8.09	7.50	8.02	8.16	7.13	8.05	8.44
4	Castor oil	8.09	7.40	7.89	8.32	7.29	7.55	8.34
5	Sesamum oil	8.09	7.54	7.89	8.12	7.79	8.16	9.09
6	Citronella oil	8.09	7.50	8.21	9.12	8.16	7.90	8.09
7	Deltamethrin	8.09	7.82	8.10	8.64	7.72	7.20	8.16
8	Control	8.09	7.53	8.02	8.40	7.05	8.05	8.92

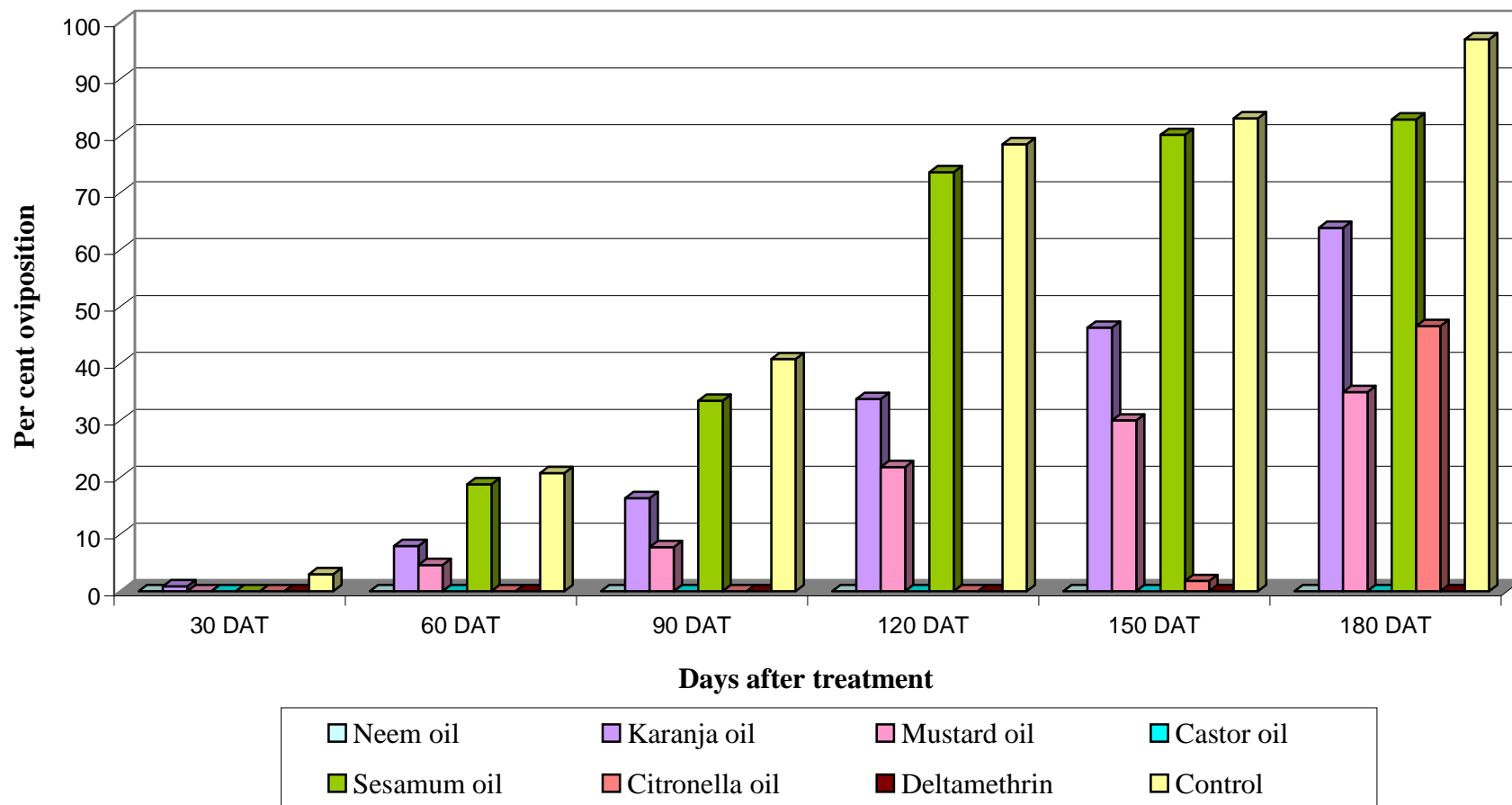
**Fig. 1 : Effect of plant products (powders) against oviposition of *C. Serratus* in stored groundnut pods.**



**Fig. 2 : Effect of plant products (powders) on pod damage by *C. serratus* in stored groundnut pods.**



**Fig. 3 : Effect of plant products (oils) on oviposition of *C. serratus* in groundnut pods.**



**Fig. 4 : Effect of plant products (oils) on pod damage by *C. serratus* in groundnut pods.**

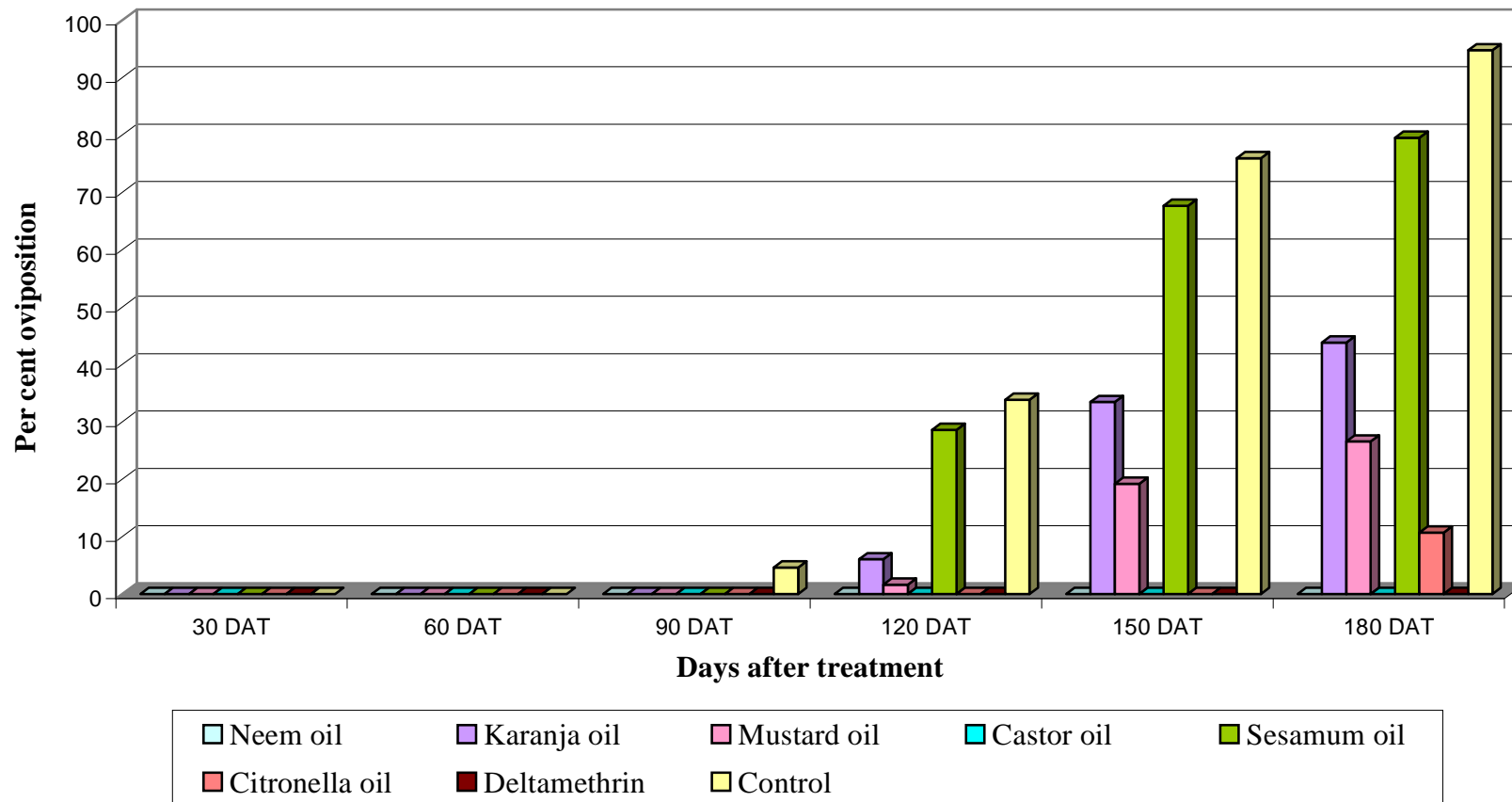




Plate 3. Eggs laid by *C. serratus* on groundnut pods

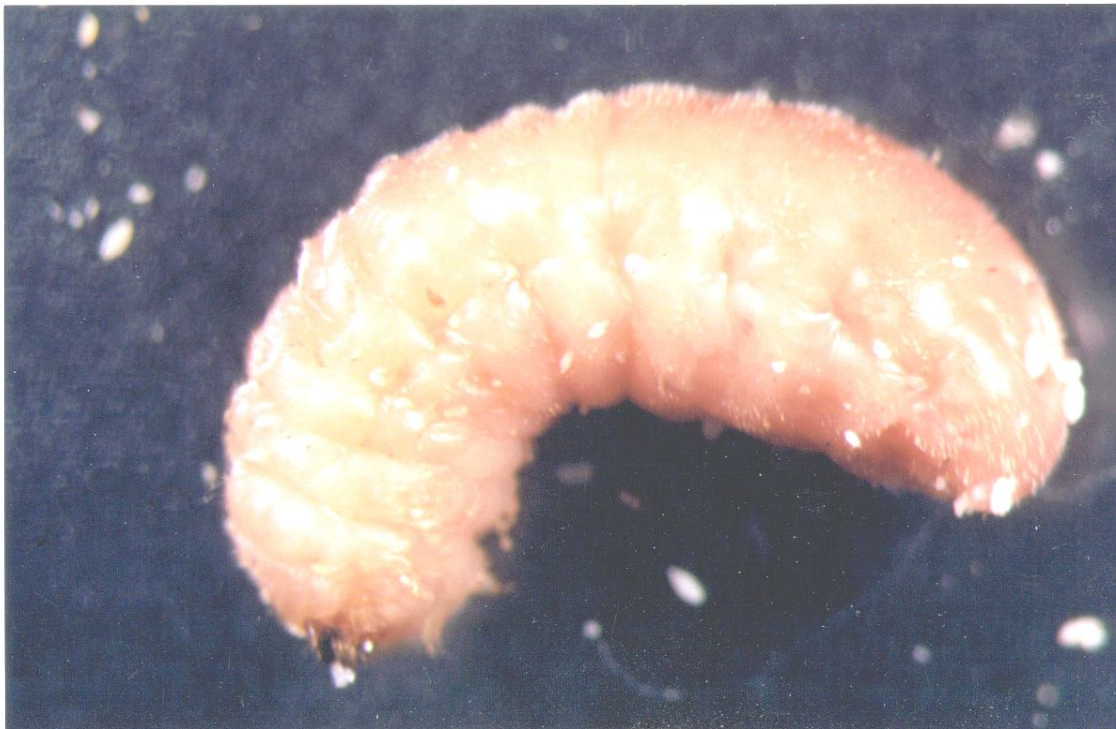


Plate 4. Fully grown larva of *C. serratus*

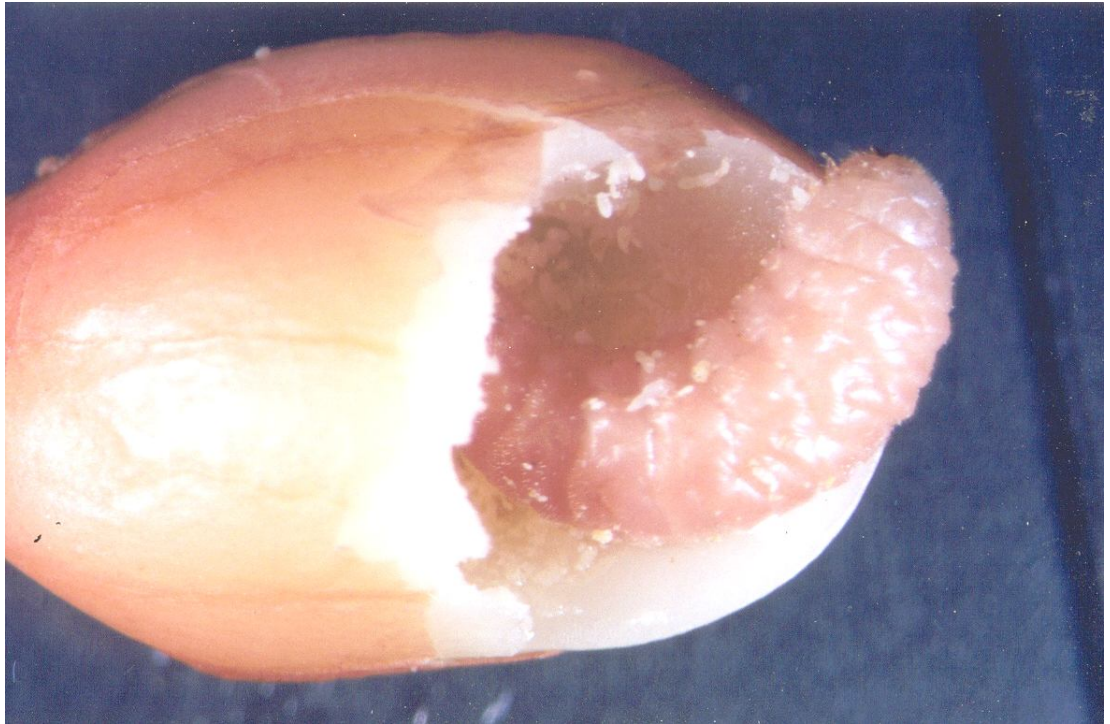


Plate 5. *C. serratus* larva feeding inside groundnut kernel

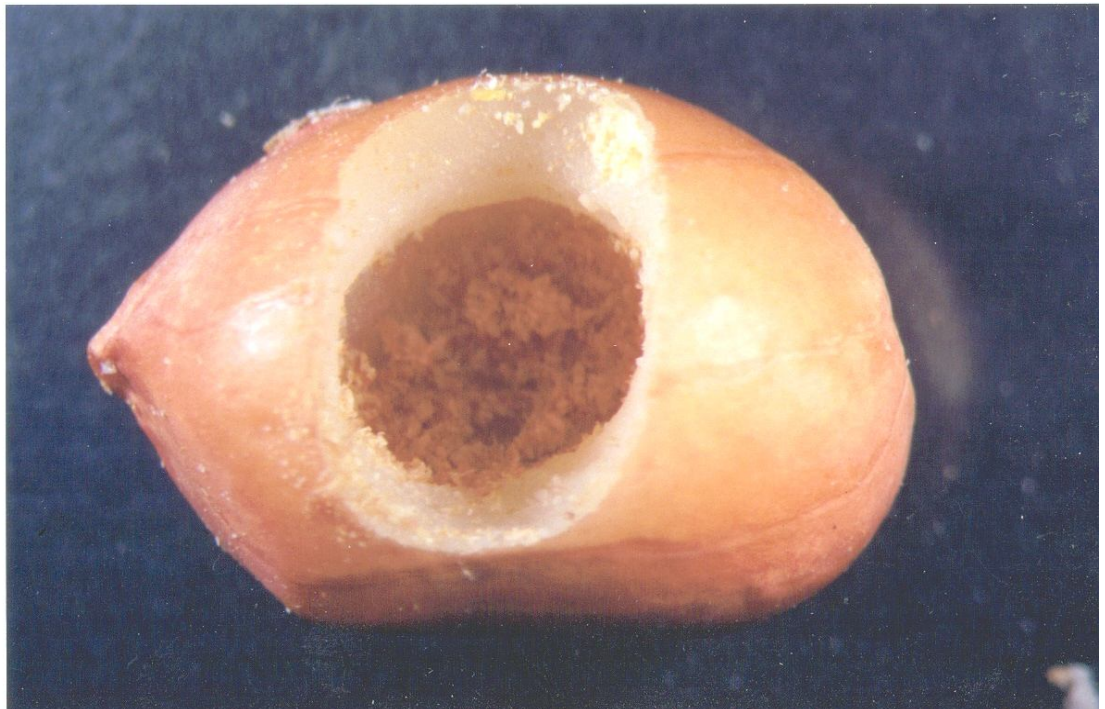


Plate 6. Groundnut kernel damaged by *C. serratus*



Plate 7. Exit holes made by mature larva of *C. serratus* on groundnut pods.

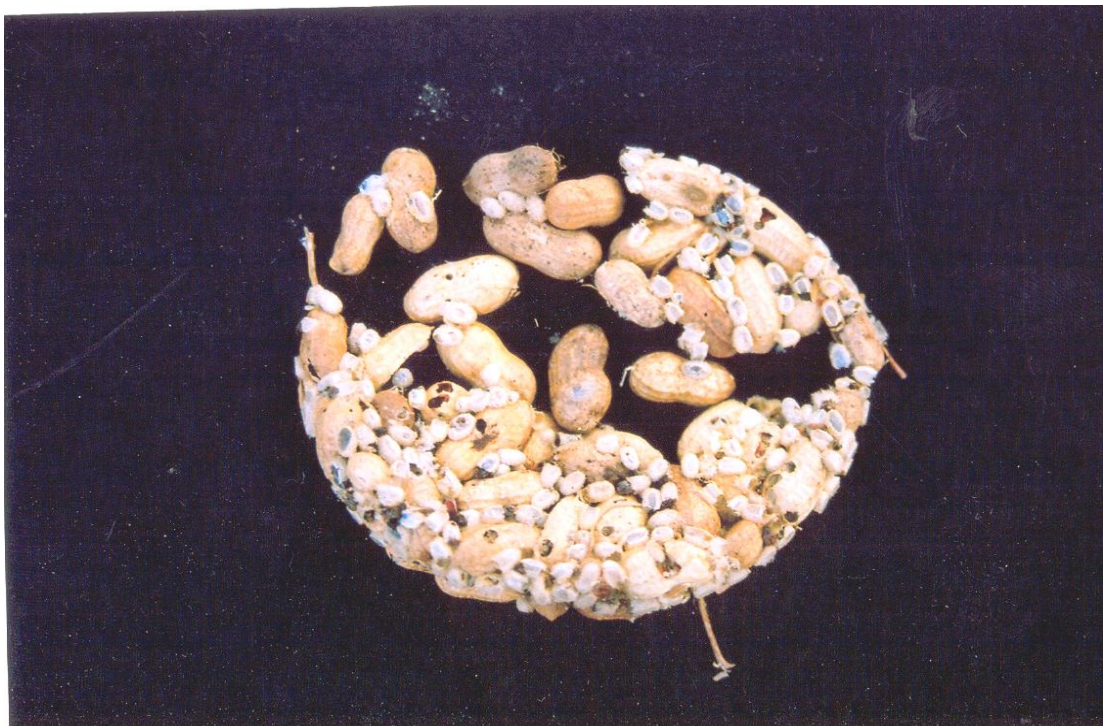


Plate 8. Pupal cases of *C. serratus*



Plate 9. Groundnut pod borer (*C. serratus*) adult.



Plate 1. One Kg. Capacity gunny bag used for groundnut storage.



Plate 2. Cage used for storage of groundnut pods treated with plant products (powders)

## CHAPTER V

### DISCUSSION

Groundnut is an important oilseed crop of India and on an average 6 to 7 m tonnes of groundnut is produced in India. The major portion of groundnut is used for oil extraction and the remaining for seed and consumption purpose. The groundnut stored for the above purpose is prone to the attack of different stored grain pests. *Caryedon serratus* (Olivier) is an important stored product pest of groundnut and appears in large number in warehouses. In view of its importance, studies were made on the biology and control measures of *C. serratus* under laboratory conditions.

#### 5.1 BIOLOGY STUDIES

The pre-oviposition of *C. serratus* on groundnut pods recorded was 1.04 to 2.41 days with an average of 1.69 days, and the oviposition period was 3 to 16 days with an average of 8.44 days.

The pre-oviposition period recorded in the present study is in accordance with Kapadia (1995) (1 to 3 days), Ramadevi (1996) (2 to 24 hours) and Motka and Butani (1999) (1 to 3 days).

However Shabbir (1988) reported pre-oviposition period for *C. serratus* as 2 to 8 days with an average of 4.17 days, while Halle (1999) recorded pre-oviposition period of 4.17 days. The present work differed from the reports of these workers.

The oviposition period (3 to 16 days with an average of 8.44 days) recorded in the present study is in proximity with the reports of Pajni and Mann (1979) (6 to 10 days), Ramadevi (1996) (9 to 10 days), Motka and Butani (1999) (8 to 17 days) and Halle (1999) (8.7 days).

Shabbir (1988) and Kapadia (1995) reported oviposition period of *C. serratus* as 1 to 12 days and 8 to 40 days, respectively. The present work differed from the above reports. The difference in pre-oviposition and oviposition period may be due to variation in the temperature and relative humidity prevailed during experimentation.

The data of the present study revealed that the fecundity of *C. serratus* ranged from 15 to 85 eggs/female with an average of 35.44 eggs. This is in accordance with Babji (1976) (25 to 30 eggs), Pajni and Mann (1979) (42 eggs), Kapadia (1995) (21 to 76 eggs), Haritha (1998) (20 to 80 eggs), and Motka and Butani (1999) (47 to 76 eggs).

The results of the present study indicated that the egg period ranged from 3 to 9 days with an average of 6.25 days and it is in accordance with Babji (1976) (4 to 6 days), Shabbir (1988) (5 to 11 days), Kapadia (1995) (2 to 5 days), Ramadevi (1996) (8 days) and Motka and Butani (1999) (5 to 9 days).

But the present result differed from Sontakke *et al.* (1992) who reported the egg period as 5.42 to 14.57 days.

The results of present study indicated that the larval period of *C. serratus* was in the range of 19 to 38 days with an average of 31.21 days and is in accordance with Babji (1976) (20 to 22 days), Ramadevi (1996) (22.9 days), and Haritha (1998) (23.64 days).

The present findings differed with the reports of other workers, who reported the larval period as 11 to 19 days (Shabbir, 1988) 24.45 to 48.65 days (Sontakke *et al.*, 1992) and 12 to 24 days (Kapadia, 1995). The difference in larval periods reported by these workers may be due to the variety used in the experiment and climatic conditions prevailed.

The pupal period of *C. serratus* in the present findings ranged from 9 to 34 days with an average of 36.55 days and is in proximity with Shabbir (1988), Kapadia (1995), Ramadevi (1996), Haritha (1998), Motka and Butani (1999), and Halle (1999) who reported 25 to 35 days, 10 to 22 days, 15.5 days, 15.5 days, 15.78 days, 12 to 22 days and 20 to 32 days, respectively as the pupal period of *C. serratus*.

The pupal period in the present study differed from report of Sontakke *et al.* (1992), who reported 7.53 to 14.42 days as the pupal period.

The adult longevity of *C. serratus* in the present study ranged from 19 to 30 days with an average of 19.62 days and is in close agreement with the findings of Babji (1976) who reported the adult longevity of *C. serratus* as 18 to 23 days.

The results from the present findings indicate that the total life cycle of *C. serratus* ranged from 43 to 70 days with an average of 57.16 days, which is close to the reports of Shabbir (1988) and Haritha (1998) who reported total life cycle as 43 to 65 days and 42 to 52 days, respectively.

However the total life cycle period during the present study differed from the reports of other workers. Babji (1976) observed that the total life cycle of *C. serratus* lasted for 40 to 43 days, Kapadia (1995) and Ramadevi (1996) reported it as 82 days and 46 days, respectively.

The data on morphometrics of *C. serratus* revealed that the length of egg ranged between 0.95 mm to 1.08 mm with an average of 1.00 mm while the breadth of egg ranged between 0.60 mm to 0.77 mm with an average of 0.71 mm. The length of larva ranged between 6.66 mm to 7.88 mm with an average of 7.28 mm and the breadth ranged between 2.24 mm to 2.82 mm with an average of 2.61 mm.

The length of the pupae ranged between 6.55 mm to 7.38 mm with an average of 6.93 mm while the breadth ranged between 2.49 mm to 2.90 mm with an average of 2.80 mm. The length of adult beetle ranged between 6.05 mm and 6.55 mm with an average of 6.22 mm, while the breadth ranged between 2.65 mm and 3.07 mm with an average of 2.81 mm. There are no reports available for comparison with the morphometrics of *C. serratus* recorded during the present study.

## 5.2 RELATIVE EFFICACY OF PLANT PRODUCTS (POWDERS) AGAINST *C. serratus*.

As the literature on relative efficacy of certain plant products (powders) on oviposition and pod damage by *C. serratus* is scanty, literature pertaining to efficacy of plant products against mortality of different stored grain pests which shows indirect effect on oviposition and pod damage has been compared with the experimental results and discussed below.

The data on effect of plant powders against oviposition of *C. serratus* on groundnut pods revealed that the per cent oviposition increased with increase in the duration of storage period.

The *A. calamus* rhizome powder used @ 1% was found to be the most effective grain protectant in preventing oviposition and pod damage by *C. serratus* as compared to other plant powders tested. Though statistically it was on par with *L. camara* and *O. canum*, initially it recorded zero per cent pods with eggs upto 120 days and zero per cent pod damage upto 150 days. At 150 days after treatment 3.76 per cent pods with eggs was recorded on groundnut pods and 19.79 per cent at 180 days after treatment. As sweet flag rhizome powder has antifeedant, insecticidal and antigonadal properties, it prevented oviposition and pod damage (Anand *et al.*, 1981).

Some investigations had earlier established the usefulness of sweet flag rhizome powder as grain protectant. Gosh *et al.* (1981) reported sweet

flag as most effective treatment, which caused 100 per cent mortality of *Callosobruchus chinensis* in gram. Ramarao and Sarangi (1998) reported that sweet flag rhizome powder (@ 5%) was highly effective against *S. oryzae* among all the treatments with 97.50 per cent mortality at 90 days after treatment. Sweet flag rhizome powder (@ 5%) against *Sitophilus oryzae* gave control upto 180 days after treatment causing 90 per cent mortality (Hanumanthrao, 2003). The present study is in agreement with the above scientific reports.

*L. camara* leaf powder at 1% concentration was found the next best to sweet flag rhizome powder in its efficacy. Upto 90 days only 1.89 per cent pods with eggs was recorded in *L. camara* leaf powder and later it increased to 12.71 per cent at 120 days, 14.45 per cent at 150 days and 17.03 per cent at 180 days after treatment. In case of pod damage it could prevent pod damage upto 120 days and later increased to 6.03 per cent was recorded at 150 days and 12.43 per cent pod damage at 180 days after treatment.

*L. camara* leaf powder @ 2% gave 86.41 per cent protection of green gram seeds against *C. chinensis* (Chiranjeevi, 1991). Leaf powder of *L. camara* had a good oviposition deterrent activity against *C. serratus* upto one month of storage (Kumari *et al.*, 1998). The results in the present study are in congruence with the findings of the above authors.

The *O. canum* leaf powder treatment at 1% concentration was also found to be an effective grain protectant. It prevented oviposition and pod damage by *C. serratus* on groundnut pods upto 120 days. At 150 days after treatment it recorded 18.57 per cent pods with eggs and 11.72 per cent pod damage. The pods with eggs and pod damage increased to 25.94 per cent and 26.30 per cent, respectively at 180 days.

Rajapakse (1996) reported 46 per cent of mortality of *C. maculatus* on mungbean treated with *O. canum* leaf powder @ 0.1 gm/50 seeds of mungbean. Murugesan *et al.* (1998) reported that *O. canum* leaf powder @ 1, 2, 5 and 10 gm per 25 gm on *Acacia nilotica* and tamarind seeds caused growth inhibition, malformation and mortality of *C. serratus*. The results of the present study are in agreement with those of Rajapakse (1996) and Murugesan *et al.* (1998).

During the present study the Karanja (@ 1%) seed powder was also found to be effective by providing zero per cent pods with eggs upto 30 days and zero per cent pod damage upto 90 days after treatment. The pods with eggs were 16.72, 48.54, 48.64 and 53.01 per cent at 90, 120, 150 and 180 days, respectively. The pod damage was recorded as 7.33, 30.12 and 51.82 per cent at 120, 150 and 180 days after treatment, respectively.

Hanumantharao (2003) reported that Karanja seed powder (@ 5%) remained effective upto 180 days after treatment with 70 per cent mortality of *S. oryzae* on maize. Karanja extract @ 0.4% vol/vol gave

complete protection from *S. oryzae* (Rajasekharan *et al.*, 1985). The findings of the present study were in agreement with the reports of mentioned above.

The data revealed that in neem kernel powder treatment, the pods with eggs was 4.07 and 9.52 per cent at 30 days and 60 days after treatment. Later the pods with eggs increased to 32.69, 35.75, 45.75 and 76.23 per cent at 90, 120, 150 and 180 days after treatment, respectively. Initially no pod damage was recorded upto 60 days after treatment and later 2.98, 19.14, 38.41, 63.48 per cent pod damage was recorded at 90, 120, 150 and 180 days after treatment, respectively. The neem kernel powder provided protection only upto 60 days after treatment.

Earlier Hanumanthara`o (2003) reported that neem kernel powder (5%) was effective upto 150 days after treatment against *S. oryzae*. Neem kernel powder (@ 1%) completely prevented the damage of *Trogoderma granarium* on sorghum (Jood *et al.*, 1996). Chiranjeevi (1991) reported 100 per cent protection of green gram seeds treated with neem kernel powder (@ 1%) against *C. chinensis*. The results obtained in the present experiment are in confirmity with the above reports who have reported the effectiveness of neem kernel powder for the control of stored grain pests.

The eucalyptus leaf powder used @ 1% concentration could prevent oviposition of *C. serratus* on groundnut pods upto 30 days only. At 60 days after treatment 14.54 per cent pods with eggs were recorded, later the pods with eggs increased to 25.77, 65.58, 66.95, 78.07 per cent at

90, 120, 150 and 180 days after treatment, respectively. In case of pod damage this treatment could prevent pod damage upto 90 days. At 120 days 9.88 per cent pod damage was recorded. There was 61.08 and 76.64 per cent pod damage at 150 and 180 days after treatment, respectively.

Anand (1981) reported the ovicidal action of *Eucalypta alba* against eggs of *Sitotroga cerealella*. Leaves of *Eucalyptus* reduced tuber damage by 8 per cent against *Phthorimaea operculella* (Lal, 1988). The results in the present studies are in congruence with the findings of above authors.

### **5.3 RELATIVE EFFICACY OF EDIBLE AND NON EDIBLE OILS AGAINST *C. serratus***

As the literature on relative efficacy of certain plant oils on oviposition and pod damage by *C. serratus* is scanty, literature pertaining to efficacy of plant oils against mortality of different stored grain pests which shows indirect effect on oviposition and pod damage has been compared with the present experimental results and discussed below.

The results of the oviposition and pod damage by *C. serratus* on groundnut pods stored in gunny bags treated with oils exhibited a steady increase in the oviposition and pod damage with the increase in duration of storage period.

Neem oil was found to be the most effective among the different oils tested indicating zero per cent pods with eggs and pod damage upto 180 days after treatment. Neem oil was on par with castor oil and the proven check, deltamethrin upto 180 days after treatment.

Neem oil (@ 1%) effectively controlled *C. chinensis* even after 9 months and 150 days as reported by Singh and Sharma (2003) and Singh and Yadav (2003), respectively. Raghavani and Kapadia (2003) also reported that neem oil (@ 1%) protected pigeonpea seeds upto six months against *C. chinensis*. The results in the present studies are in congruence with the findings of the above authors.

Treatment of gunny bags with castor oil was also found to be very effective as it prevented oviposition and pod damage upto 180 days.

Kachare (1994) reported significant repellent action of castor oil (1%) on egg laying by *C. chinensis*. Castor oil at 1 and 3 ml/kg seed was found to be best to check egg laying of pulse beetle on green gram (Singh *et al.*, 1994), castor oil @ 10 ml/kg of seed gave 96.6 per cent protection against *C. maculatus* upto 6 months in pigeonpea. (Raghavani and Kapadia, 2003). The present study also revealed the efficacy of castor oil against *C. serratus*, which is in confirmity with the findings of the above authors.

Citronella oil treatment to gunny bags was also found to be very effective treatment next to the neem oil and castor oil treatments. It prevented oviposition by *C. serratus* upto 120 days and pod damage upto 150 days after treatment. Pods with eggs was found to be 1.78 per cent at 150 days and later increased to 46.58 per cent at 180 days after treatment. A pod damage of 10.69 per cent was recorded at 180 days after treatment. This treatment was found on par with neem oil, castor oil and proven check deltamethrin upto 150 days after treatment.

Saraswathi and Rao (1987) reported repellent effect of citronella oil on *Tribolium castaneum*, *C. chinensis* and *Periplanata americana*. Kumari *et al.* (1998) reported that citronella oil (@ 15 ml/kg pods) inhibited oviposition upto 6 months against *C. serratus*. The results of the present experiment are in conformity with the above reports.

Gunny bag treatment with mustard oil was also found effective. This treatment prevented oviposition upto 30 days. The initial number of pods with eggs in this treatment was 4.61 per cent at 60 days after treatment, later it increased to 7.74, 21.82, 29.98 and 34.98 per cent at 90, 120, 150 and 180 days after treatment, respectively. The pod damage was nil upto 90 days and later increased to 1.61, 19.22, and 26.59 per cent at 120, 150 and 180 days after treatment, respectively.

Mustard oil @ 5 ml/kg of pods caused zero per cent damage to chickpea against *C. chinensis* upto 9 months (Singhal, 1992). Pigeonpea seeds treated with mustard oil recorded zero per cent adult emergence of *C. chinensis* at a concentration of 8 ml/kg of seeds. (Singh, 2003). The results of the above authors are in congruence with the findings of the present experiment.

In karanja oil treatment the pods with eggs were recorded as 0.83, 7.91, 16.34, 33.73, 46.28 and 63.84 per cent at 30, 60, 90, 120, 150 and 180 days after treatment, respectively. But it prevented pod damage upto 90 days and later it increased to 6.06, 33.47, and 43.82 per cent at 90, 120, 150 and 180 days after treatment, respectively.

Karanja oil (@ 1%) showed repellent action for egg laying upto 100 days after treatment against *C. chinensis* (Kachare *et al.*, 1994). Raghavani and Kapadia (2003) reported Karanja oil @ 10 ml/kg seed of pigeonpea provided control of *C. maculatus* upto 4 months of storage. The present findings are in agreement with the reports of above authors.

The gunny bag treatment with sesamum oil has proved to be effective only for a short duration, more than 50 per cent pods with eggs was recorded at 120 days after treatment.

The data revealed that 0.00, 18.76, 33.43, 73.61, 80.15, and 82.85 per cent pods with eggs were recorded at 30, 60, 90, 120, 150 and 180 days after treatment, respectively. Eventhough it prevented pod damage upto 90 days, 28.61 per cent pod damage was recorded at 120 days after treatment. Later it increased to 67.68 and 79.55 per cent at 150 and 180 days after treatment, respectively.

Kachare *et al.*, (1994) reported repellent action of sesamum oil (1%) for egg laying by *C. chinensis* in pigeonpea upto 100 days.

Rajapakse and Emden (1997) reported that adult longevity of *C. chinensis* and *C. maculatus* was reduced by sesamum oil treatment @ 10 ml/kg of seed. Sesamum oil @ 1% concentration gave good protection upto 6 months against *C. maculatus* in pigeonpea (Raghvani and Kapadia, 2003). The present study is in agreement with the work presented by the above scientists.

#### **5.4 INFLUENCE OF GRAIN PROTECTANTS ON GERMINATION OF GROUNDNUT KERNELS**

The perusal of the data obtained during the present investigation on effect of grain protectants on germination of groundnut seeds revealed no variation among treatments for a period of six months. Both the plant powders as well as plant oils did not affect the germination of groundnut kernels.

#### **5.5 INFLUENCE OF GRAIN PROTECTANTS ON MOISTURE CONTENT OF GROUNDNUT IN STORAGE**

The present study on the influence of grain protectants on moisture content of groundnut seeds revealed that the plant products (both plant powders and plant oils) did not affect the moisture content of the grains.

#### **5.6 CONCLUSION**

It can be inferred from the present studies that plant powders like *Acorus calamus* rhizome powder, *Lantana camara* leaf powder and *Ocimum canum* leaf powder and oils of neem, castor and citronella were found to be superior over the rest of the plant products (powders and oils) tested. The above plant powders and oils are easily available locally, although *Acorus calamus* rhizome powder is little bit costlier, at low concentration also it was highly effective against *C. serratus*. The farmers can easily adopt the use of these materials. The plant powders and plant oils did not show any adverse effect on germination of seeds.

As the research on biology and management of *C. serratus* with plant products is scanty further research is needed. Before coming to definite conclusion and recommendation on the use of specific grain protectants their dose and method of application etc., on groundnut needs further research efforts.

## CHAPTER VI

### SUMMARY

Studies on biology and evaluation of few plant derivatives as grain protectants against the test insect, *Caryedon serratus* (Olivier) were conducted in Entomology laboratory of the Post Harvest Technology Centre, Agricultural College Campus, Bapatla during 2004-2005. The aspects of investigations were as follows.

1. Study of biology of *C. serratus* in laboratory conditions.
2. Management of groundnut pod borer with
  - i. Plant powders
  - ii. Edible and non edible oils.

Studies on the biology of *C. serratus* at a temperature range of 19.33°C to 30.26°C and with an average relative humidity of 79.61% revealed that the pre-oviposition and oviposition period ranged from 1.04 to 2.41 days and 3 to 16 days with an average of 1.69 and 8.44 days, respectively. The egg, larval and pupal periods ranged from 3 to 9 days, 19 to 38 days and 9 to 34 days with an average of 6.25, 31.21 and 26.55 days, respectively.

The fecundity of female ranged from 15 to 85 eggs with an average of 35.44 eggs/female. The adult longevity and total life cycle ranged from 19 to 30 days and 43 to 70 days with an average of 19.62 and 57.16 days, respectively.

The average length of egg, larva, pupa and adult was 1.00 mm, 7.28 mm, 6.93 mm and 6.22, respectively whereas the corresponding average breadth of the life stages was 0.71 mm, 2.61 mm, 2.80 mm, and 2.81 mm, respectively.

For management of groundnut pod borer, groundnut pods were admixed with different plant powders *viz.*, neem kernel powder, *Acorus calamus* rhizome powder, Karanja seed powder, *Lantana camara* leaf powder, *Ocimum canum* leaf powder and eucalyptus leaf powder and in case of oils, gunny bags were treated with neem oil, karanja oil, mustard oil, castor oil, sesamum oil and citronella oil. Both the plant powders and oils were tested separately at one per cent concentration.

Freshly emerged beetles were released into the cage in which gunny bags containing groundnut pods were kept. The treatments were replicated three times and observations on oviposition and pod damage were recorded at 30, 60, 90, 120, 150 and 180 days after treatment.

The results revealed that when *C. serratus* released into the cages where gunny bags containing groundnut (treated with plant powders) were kept, *A. calamus* (@ 1%) proved very effective upto 120 days in preventing oviposition compared to the rest of the treatments. At 180 days, after treatment 19.79 per cent pods with eggs and 10.95 per cent pod damage were recorded. It was followed by *L. camara* leaf powder (@ 1%) and *O. canum* leaf powder (@ 1%). At 180 days after treatment the per cent pods with eggs and per cent damage were 17.03 and 12.43 per cent in *L. camara* leaf powder treatment, 25.94 and 26.30 per cent in *O. canum* leaf powder treatment, respectively.

Karanja seed powder controlled oviposition upto 30 days and pod damage upto 90 days after treatment. Neem kernel powder failed to prevent oviposition and recorded pod damage of 63.48 per cent. it was followed by eucalyptus leaf powder (@ 1%) which recorded 78.04 and 76.64 per cent pods with eggs and pod damage, respectively.

With respect to oils, neem (@ 1%) and castor (@ 1%) oils were found superior to others which recorded zero per cent pods with eggs as well as pod damage ensuring the effectiveness upto 180 days after treatment. They were followed by citronella oil (@ 1%), which recorded zero per cent pods with eggs upto 120 days after treatment and zero per cent pod damage upto 150 days after treatment. It also recorded 46.58 and 10.69 per cent pods with eggs and pod damage, respectively at 180 days after treatment. It was followed by mustard oil (@ 1%), which prevented oviposition upto 30 days after treatment and pod damage upto 90 days after treatment. It recorded 34.98 per cent pods with eggs and 26.59 per cent of pod damage at 180 days after treatment. This was followed by karanja oil (63.84 per cent pods with eggs and 43.82 per cent pod damage). Sesamum oil was found to be the least effective with 82.85 and 79.55 per cent pods with eggs and pod damage, respectively at 180 days after treatment.

Deltamethrin, the proven check recorded zero per cent pods with eggs and pod damage upto 180 days after treatment. Both the plant powders as well as plant oils did not affect the germination of groundnut kernels.

## LITERATURE CITED

- Agarwal A, Sone Lal and Gupta K C 1988 Natural products as protectants of pulses against pulse beetles. *Bulletin of Grain Technology* 26(2): 154-164.
- Ahamad M and Kumar S 1990 Ovipositional response of *Caryedon serratus* Olivier (Coleoptera: Bruchidae). *Indian Journal of Forestry* 13(3): 192-198.
- Ali S I, Singh O P and Misra U S 1983 Effectiveness of plant oils against pulse beetle *Callosobruchus chinensis* L. *Indian Journal of Entomology* 45(1): 6-9.
- \*Amaro J P, Ferhino H and Cancela Da Fonseca J P 1958 Contribution to the study of population dynamics of *Caryedon gonagra*. *Garcia de Orta* 6: 637-647.
- Anand P, Pasalu I C and Mathur K C 1981 Plant products for management of stored grains insect pests. *Bulletin of Grain Technology* 19 (3): 213-219.
- Arthur F H 1994 Efficacy of unsynergised deltamethrin and deltamethrin + chloropyriphos-methyl combinations as protectants of stored wheat and stored corn (maize). *Journal of Stored Product Research* 30 (1) : 87-94.
- Azam K M, Shaika A L Harthy, Razvi S A and Al-Racesi A 1994 A relative toxicity of certain insecticides against *Tribolium castaneum* (H), *Sitophilus oryzae* (L.) and *Callosobruchus maculatus* (F.). *Pestology* 18(2): 10-13.

Babji 1976 Studies on biology and control of the groundnut seed beetle *Caryedon serratus* (Olivier). M.Sc.(Ag.) Thesis, Andhra Pradesh Agricultural University, Hyderabad.

Bhujbal A R, Bhole S R and Karmarkar M S 2001 Effect of Residual toxicity of some insecticides and neem oil as pigeonpea seed protection on loss in seed weight and germination of seed against *Callosobruchus maculatus* Fab. *Pestology* 25(2): 44-47.

\*Calderon M 1994 A new host on groundnut seed beetle *Caryedon serratus* (Olivier) in Israel. Proceedings of the 6<sup>th</sup> International Working Conference on Stored Product Protection 1: 498-499.

\*Calderon M, Dohaye F and Navarro 1967 The life cycle of the bruchid beetle *Carryedon serratus* in Israel. *Israel Journal of Agricultural Research* 17: 145-148.

Center for Monitoring Indian Economy (CMIE). Annual reports of the year 2004.

Chandan B S, Chauhan R R S and Kumar A 2001 Phagodetterant and efficacy of rhizome extract of sweet flag, *Acorus calamus* against *Tribolium castaneum* Herbst. *Indian Journal of Entomology* 63(1): 8-10.

Chander H and Ahamed S M 1983 Potential of some new plant products as grain protectants against insect infestation. *Bulletin of Grain Technology* 21(3): 179-188.

Chander H and Ahamed S M 1986 Effect of some plant materials on the development of rice moth *Corcyra cephalonica* Stainton. *Entomon* 11(4): 273-276.

- Chiranjeevi C H 1991 Efficacy of some indigenous plant materials and ashes on the percentage of damaged grains, percentage of protection and viability of green gram seed infested by pulse beetle *Callosobruchus chinensis* (L). Bulletin of Grain Technology 29(2): 84-88.
- Choudhury B S 1992 Residual effect of eight vegetable oils on chickpea against pulse beetle, *Callosobruchus chinensis* (Linnaeus). Bulletin of Grain Technology 30(2): 173-176.
- \*Conway J A 1983 Notes on biology and ecology of the groundnut seed beetle *Caryedon serratus* (Coleoptera: Bruchidae) under field conditions in Senegambia. Tropical Stored Product Information 45: 11-13.
- \*Corby H O R 1941 Report on study of a pest (*Pachymerus longus* Pic.) causing damage to groundnuts in the Wurkum district of the Muri division of Adamawa. Report of Agricultural Department Samaru Zaria No. 9302/167: 15.
- Daglish G J, Erbacher J M and Eelkema M 1993 Efficacy of protectants against *Callosobruchus phaseoli* (Gyu) and *C. maculatus* (F) (Coleoptera: Bruchidae) in mungbeans. Journal of Stored Product Research 29(4): 345-349.
- Davey P M 1958 The groundnut bruchid, *Caryedon gonagra*. Bulletin of Entomological Research 49: 385-404.
- Delobel A 1995 The shift of *Caryedon serratus* from wild *Caesalpinaceae* to groundnuts took place in west Africa (Coleoptera: Bruchidae). Journal of Stored Products Research 31 (1): 101-102.

- Delobel A and Malonga P 1987 Insecticidal properties of six plant materials against *Caryedon serratus* (Olivier) (Coleoptera: Bruchidae). *Journal of Stored Product Research* 23(3): 173-176.
- Devi D R and Rao N V 2000 A note on reaction of groundnut varieties to the bruchid *Caryedon serratus* (Olivier) *Journal of Research ANGRAU* 28: 41-43.
- Dick K M 1987a Pest management in stored groundnuts. International Crop Research Institute for the Semi-Arid Tropics. *Information bulletin*. 22: 1-25.
- Dick K M 1987b Losses caused by insects to groundnuts stored in a warehouse in India. *Tropical Science* 25: 65-75.
- Doharey R B, Katiyar R N and Singh K M 1985 Eco-toxicological studies on pulse beetles infesting green gram. *Bulletin of Grain Technology* 23(2): 118-122.
- Doharey R B, Katiyar R N and Singh K M 1988 Effect of edible oils in protection of greengram (*Vigna radiata*) seed from pulse beetles (*Callosobruchus chinensis* and *C. maculatus*). *Indian Journal of Agricultural Sciences* 58(2): 151-154.
- Dwivedi S L and Nigam S N 2003 Variation in seed and pod characteristics in relation to cooking time among valencia groundnut *Arachis hypogea* L. germplasm. *Journal of Oilseeds Research* 20(1): 16-22.
- Gosh S K, Verma G D and Lall B S 1981 Pesticidal efficacy of some indigenous plant products against pulse beetle *C. chinensis* L. *Bulletin of Grain Technology* 19(2): 96-98.

- Halle D 1999 Biology and management of *Caryedon serratus* (Olivier) in groundnut. M.Sc.(Ag.) Thesis, University of Agricultural Sciences, Dharwad.
- Halliday W R, Arthur F H, and Zettler J L 1988 Resistance status of Red flour beetle (Coleoptera: Tenebrionidae) infesting stored peanuts in the South Eastern United States. Journal of Economic Entomology 81(1): 74-77.
- Hanumantha Rao P 2003 Studies on biology and management of *Sitophilus zeamais* (Motschulsky) infesting maize in storage. M.Sc.(Ag.) Thesis. Andhra Pradesh Agricultural University, Hyderabad.
- Haritha V 1998 Biology and relative preference of *Caryedon serratus* (Olivier) and *Corcyra cephalonica* staintion to selected groundnut genotypes. M.Sc.(Ag.) Thesis, Andhra Pradesh Agricultural University, Hyderabad.
- Hideux P 1984 Possibilities of reproduction and development of bruchid *Caryedon pallidus* (Coleoptera: Bruchidae) on *Cassia torra* (Caesalpinaceae). Acta-Oecologica-Oecologia-Generalis 5:4, 327-332.
- \*Islam N, Bhuiyah I M, Begum A, and Karim M A 1989 Comparative efficacy of different material against *Sitophilus oryzae* L. infesting maize seeds in storage. Bangladesh Journal of Zoology 17(2): 175-178.
- Jacob S 1994 Effectiveness of some plant products for the control of pulse beetle *Callosobruchus chinensis* on stored cowpea. Indian Journal of Plant protection 22(2): 213-214.

- Jadhav and Jadhav L D 1984 Use of some vegetable oils, plant extracts and synthetic products as protectants from pulse beetle, *Callosobruchus maculatus* Fabr. in stored gram. Journal of Food Science and Technology 21: 110-113.
- Johnson C D 1986 *Caryedon serratus* (Oliver) (Bruchidae) established in Northern South America with additional host and locality records from Mexico. Coleopterists-Bulletin 40(3): 264.
- Jood S, Kapoor A C and Ram Singh 1996 Evaluation of some plant products against *Trogoderma granarium* Everts in sorghum and their effects on nutritional composition and organoleptic characteristics. Journal of Stored Product Research. 32(4): 345-352.
- Kachare B V, Khaire K M and Mote U N 1994 Efficacy of different vegetable oils as seed treatment in increasing storage ability of pigeonpea seed against *Callosobruchus chinensis* L. Indian Journal of Entomology 56(10): 58-62.
- Kahare S N, Kahare N P, Harin Khare J P, Kandalkar V and Jhaur S K 1993 Exploitation of herbal products as grains protectants against *Callosobruchus chinensis* L. Journal of soils and Crops 3(1): 33-36.
- Kapadia M N 1995 Biology and varietal preference of groundnut seed beetle *Caryedon serratus* (Olivier). Gujarat Agricultural University Research Journal 20(2): 170-172.
- Khaire V M, Kachare B V, Patil C S 1987 Effect of vegetable oils on pulse beetle, *Callosobruchus chinensis* L. in Pigeonpea. Current Research Reporter 3(2): 53-58

- Khair V M, Kachare B V, Mote U N 1992 Efficacy of different vegetable oils as grain protectants against pulse beetle, *Callosobruchus chinensis* L. in increasing storability of pigeonpea. Journal of stored Product Research 28(3): 153-156.
- \*Kingslover F M 1992 *Caryedon serratus* (Olivier) new to continental United States (Coleoptera: Bruchidae). Insect Mundi 6: 22.
- Kumar D and Parikh S 1996 Efficacy of Deltamethrin on inactive developmental stages of *Tribolium castaneum*. Indian Journal of Entomology 58(3): 260-263.
- Kumari D A, Kumar S T and Reddy V S 1998 Management of the groundnut bruchid *Caryedon serratus* (Olivier) with some plant products. Pest management and Economic Zoology 6(2): 127-131.
- Kumari D A, Vijay Singh, Sudhir Reddy V and Tejkumar S 2002 Quantitative and Qualitative losses caused by pod bruchid *Caryedon serratus* (Olivier) (Bruchidae: Coleoptera) in stored groundnut. Indian Journal of Plant Protection 30(2): 213-214.
- Lal L 1988 Potato tuber moth, *Pthorimaea operculella* (Zeller), in North Eastern hills region and simple methods for its control. Indian Journal of Agricultural Science 58(2): 130-132.
- Lepesme P 1945 Les coleopteres des denrees alimentaires et des produits industriels enterposes Encyclopedia Entomology 22: 335.
- Matakot L, Mapangon D S and Delobel A 1987 Development of populations of *Caryedon serratus* (Coleoptera: Bruchidae) in stored groundnuts in the Congo. Agronomie Tropicale 42: 69-74.

- Mathur Y K, Kripa Shankar and Salik Ram 1985 Evaluation of some grain protectants against *Callosobruchus Chinensis* L. on blackgram. Bulletin of Grain Technology 23(3): 253-259.
- Mishra B K, Mishra P R and Mohapatra H K 1992 Studies on some plant product mixtures against *Sitophilus oryzae* (L) infesting wheat seeds. Indian Journal of Plant Protection 20: 178-182.
- Misra H P 1999 Effectiveness of indigenous plant products against the pulse beetle *Callosobruchus chinensis* on stored blackgram. Indian Journal of Entomology 62(2): 218-220.
- Mittal and Khanna S S 1967 A note on tamarind bruchid (*Caryedon gonagra* Fabricius) (Bruchidae: Coleoptera) a serious pest on stored tamarind (*Tamarindus indicus* L.) and other leguminous seeds of economic importance. Agra University Journal of Research 16: 99-102.
- Mittal V P 1969 Studies on relative resistance and susceptibility of some important groundnut varieties to groundnut bruchid *Caryedon gonagra* (Bruchidae: Coleoptera). Bulletin of Grain Technology 7: 75-79.
- Motka M N and Butani P G 1999 Biology population dynamics, varietal screening and management of groundnut bruchid, *Caryedon serratus* (Olivier). Gujarat Agricultural Research Journal 14 (2): 116.
- \*Mucunguzi P 1995 Bruchids and survival of *Acacia* seeds. African Journal of Ecology 33: 175-183.

- Murugesan S, Pankajam S, Balu A, Durairaj S and Sunitha P 1998 Evaluation and utilization of biopesticidal properties of *Ocimum*, *Sesbania* and *Parthenium* on *Caryedon serratus*, a seed pest of *Acacia nilotica* and *Tamarindus indica*. *Pestology* 22(7): 45-50.
- Naik R L and Dumbre R B 1985 Effect of some vegetable oils used as surface protectants against *Callosobruchus maculatus* on storability and qualities of cowpea. *Bulletin of Grain Technology* 23(1): 33-39.
- Nawale R N, Patil R K and Mote U N 1992 Ovicidal action of synthetic pyrethroids on *Callosobruchus maculatus* F. infesting pigeonpea seed. *Bulletin of Grain Technology* 30(2): 170-172.
- Negi R S, Meera Srivastava and Saxena M M 1997 Egg laying and adult emergence of *Callosobruchus chinensis* on green gram (*Vigna radiata*) treated with pongam oil. *Indian Journal of Entomology* 59(2): 170-172.
- \*Nilson J A and Johnson C D 1992 New host, *Bauhinia variegata* and new locality records for *Caryedon serratus* (Olivier) in the new world (Coleoptera: Bruchidae: Pachymerinae). *Pan Pacific Entomologist* 68: 62-63.
- Pacheco A I, M Ferananda P P M De Castro, Dalmo C. De Paula, Andro L Lourencao, Scheilla Bolonhezi and Margarida K Barbieri 1995 Efficacy of soybean and castor oils in the control of *Callosobruchus maculatus* (F.) and *Callosobruchus phaseoli* *Journal of Stored Product Research* 31(3): 221-228.
- Pajni H R and Mann B K 1979 Some aspects of biology of *Caryedon serratus* (Coleoptera : Bruchidae). *Bulletin of Grain Technology* 7(1): 43-46.

Pandey N D, Shiv Raj Singh and Tewari G C 1976 Use of some plant powders, oils and extracts as protectants against pulse beetle *Callosobruchus chinensis* Linn. Indian Journal of Entomology 38(2): 110-113.

\*Panneru R B, Patourel G N J, Kennedy S H and Lapatourel G N J 1997 Toxicity of *Acorus calamus* L. rhizome powder to *Sitophilus granarium* L. (Coleoptera: Bruchidae). Insect Science Application 11: 47-53.

Patel K P, Valand V M and Patel S N 1993 Powder of neem seed kernel for control of lesser grain borer (*Rhizopertha dominica* F.) in wheat (*Triticum aestivum* L.). Indian Journal of Agricultural Sciences. 63(11): 754-755.

Prakash A and Rao J 1986 Evaluation of plant products as antifeedants against rice storage pests. Proceedings of National Symposium on Pesticide Residues and Environment Pollution, Muzaffarnagar, India 2/4 October pp 201-205.

Pratap Singh 1987 Insect pests of *Acacia tortilis* in India. Indian Forester 113(11): 734-743.

\*Prevett P F 1953 Studies on the fecundity and longevity of the groundnut bruchid, *Caryedon fuscus* Geze and the external morphology of the immature stages. B.Sc. Thesis University of London.

\*Prevett P F 1954 Some aspects of the biology and control of the groundnut bruchid *Caryedon fuscus* Geze. Thesis University of London.

Prevett P F 1966 Observations on biology in the genus *Caryedon* *schonnerr* (Coleoptera: Bruchidae) in Northern Nigeria with a list of associated parasitic Hymenoptera. Proceedings of Royal Entomological Society, London 41: 9-16.

- Prevett P F 1967 The field occurrence of *Caryedon serratus* (Ol.), the groundnut seed beetle (Coleoptera: Bruchidae) in Uganda. Journal of Stored Product Research 3: 267-268.
- Raghavani B R and Kapadia M N 2003 Efficacy of different vegetable oils as seed protectants of pigeonpea against *Callosobruchus maculatus* (Fab.). Indian Journal of Plant Protection 31(1): 115-118.
- Rajapakse H S R 1996 The effect of four botanicals on the oviposition and adult emergence of *Callosobruchus maculatus* (Bruchidae: Coleoptera) Entomon 21 (3 & 4): 211-215.
- Rajapakse R and Emden V H F 1997 Potential four vegetable oils and ten botanical powders for reducing infestation of cowpeas by *Callosobruchus maculatus*, *C. chinensis* and *C. rhodensianus*. Journal of Stored Product Research 33(1): 59-68.
- Rajasekharan B, Kumarswamy T, Regupathy A and Jayaraj S 1985 control of storage insects with seed protectants of plant origin. Proceeding of National Seminar on Behavioural and Physiological Approaches in Pest Management 7: 15-17.
- Ramadevi D 1996 Bio-ecology and management of groundnut bruchid, *Caryedon serratus* (Olivier). M.Sc.(Ag.). Thesis, Andhra Pradesh Agricultural University, Hyderabad.
- Ramarao C V and Sarangi P K 1998 Control of *Sitophilus oryzae* through certain plant products. Indian Journal of Entomology 26(2): 183-185.
- Ranga Rao A V S and Mohan S 2000 Survey of infestation of bruchid *Caryedon serratus* (Olivier) in tamarind and identification of possible infestation to groundnut. Pestology 12: 187-193.

- Rani S, Vijayalakshmi K, Arjuna Rao P 2000 Vegetable oils as surface protectants against bruchid *Callosobruchus chinensis* (L.) infestation on chickpea. Indian Journal of Plant Protection 28(2): 184-186.
- Romero J and Johnson C D 2002 *Cassia moschata* H.B.K., a new host for *Caryedon serratus* (Olivier) in the new world (Coleoptera: Bruchidae: Pachymerinae). Coleopterists Bulletin 56(1): 95-96.
- Sangappa H K 1977 Effectiveness of oils as surface protectants against the bruchid, *Callosobruchus chinensis* L. infestation on redgram. Mysore Journal of Agricultural Science 11: 391-397.
- Saraswathi L and Rao A P 1987 Repellent effect of citronella oil on certain insects. Pesticides 21(70): 23-24.
- \*Sardesai J B 1961 Effects of the density of the adult population on the oviposition of *Caryedon gonagra* F. Garcia de Orta 9: 223-227.
- Satpathi C R, Chatak S S, Verma P K and Barnan D 1992 Efficacy of extracts *Thevetia nerifolia* (Pers) and *Pongamia glabra* (Vent) against rice weevil *Sitophilus oryzae* L. Environmental Ecology 10(2): 376-379.
- Satya V and Jindal S K 1996 Field infestation of *Caryedon serratus* (Olivier) (Coleoptera: Bruchidae) on the pods and seeds of *Acacia nilotica* in the Thar desert of India. Journal of Tropical Forest Science 9: 189-193.
- Saxena R C, Dixit O P and Harshan V 1992 Insecticidal action of *Lantana camera* against *Callosobruchus chinensis* (Coleoptera: Bruchidae). Journal of Stored Product Research 28(4): 279-281.

- Senguttuvan T, Abdul Kareem A, and Rajendran R 1995 Effect of some plant products and edible oils against rice moth *Corcyra cephalonica* Stainton in Stored groundnuts. Journal of Stored Product Research 33(3): 207-210.
- Shabbir S 1988 Bio-Ecology and control of groundnut seed beetle, *Caryedon serratus* (Olivier). M.Sc(Ag.). Thesis, University of Agricultural Sciences, Dharwad.
- Sharma R K 1999 Efficacy of neem products against storage pests in maize. Annals of Agricultural Research 20(2): 198-201.
- Shivalingaswamy 1987 Bioecology and management of *Caryedon serratus* (Olivier). M.Sc.(Ag.) Thesis, University of Agricultural Sciences Bangalore.
- Singal S K and Toky 1988 New host plants of *Caryedon serratus* (bruchidae: coleoptera) from India. Research and Development Reporter 5(1&2): 91-92.
- Singal S K and Toky O P 1989 *Pongamia pinnata* a new host of *Caryedon serratus* (Bruchidae: Coleoptera) from India. Research and Development Reporter 6: 91-92.
- Singal S K and Toky O P 1990 Carryover of bruchid *Caryedon serratus* (Olivier) (Coleoptera) from field to stores through seeds of *Acacia nilotica* (L) in India. Tropical Pest Management 36 (1): 66-67.
- Singh K N and Srivastava P K 1980 Neem seed powder as a protectant against stored grain insect pest. Bulletin of Grain Technology 8(2): 127-129.

- Singh P K 2003 Effect some oils against pulse beetle *Callosobruchus chinensis* in infesting Pigeonpea. Indian Journal of Entomology 65(1): 55-58.
- Singh S and Sharma G 2003 Efficacy of different oils as grain protectants against *Callosobruchus chinensis*, in green gram and their effect on seed germination. Indian Journal of Entomology 65(4): 500-505.
- Singh V and Ansari S V 1991 Farmers level survey on insects and mites on stored groundnut in Andhra Pradesh. Bulletin of Grain Technology 29(1): 14-21.
- Singh V and Yadav D S 2003 Efficacy of different oils against pulse beetle, *Callosobruchus chinensis* in greengram *Vigna radiata* and their effect on germination. Indian Journal of Entomology 65(2): 281-286.
- Singh V N, Pandey N D, and Singh Y P 1994 Effectiveness of vegetable oils in the development of *Callosobruchus chinensis* Linn. infesting stored gram. Indian Journal of Entomology 56(3): 216-219.
- Singhal K S 1992 Treatment of stored chickpea *Cicer arietinum* L. with plant edible oils for protection against pulse beetle *Callosobruchus chinensis* (L.). Bulletin of Grain Technology 30(1): 85-87.
- Singhamony S, Anees I, Chandrakala T and Osmani Z 1986 Efficacy of some indigenous plant products as grain protectants against *Sitophilus oryzae* (L.) and *Rhizopertha dominica* (F.). Journal of Stored Product Research 2(1): 21-23.
- Sontakke B K, Mishra P R and Rout G D 1992 Observation on biology and habits of *Caryedon serratus* (Olivier) (Coleoptera: Bruchidae) infesting stored groundnut pods. Bulletin of Grain Technology 30(3): 228-231.

- Sujatha A and Punnaiah K C 1985 Effect of coating stored seed of green gram with vegetable oils on the development of pulse beetle. *Indian Journal of Agricultural Sciences* 55(7): 415-477.
- Venugopareddy V 1990 Estimation of losses and management of *Caryedon serratus* (Olivier) on groundnut. M.Sc.(Ag.) Thesis Andhra Pradesh Agricultural University, Hyderabad.
- Wightman J A, Amin P W, Rao G V R and Dick K M 1987 Research on groundnut pests of ICRISAT. Proceedings of the Second Regional Groundnut Workshop for Southern Africa pp:103-114.
- Zettler J L 1982 Insecticide resistance in selected stored product insects infesting peanuts in the South Eastern United States. *Journal of Economic Entomology* 75: 359-362
- Zettler J L, Halliday W and Arthur F H 1989 Phosphine resistance in insects infesting stored peanuts in the Southern United States. *Journal of Economic Entomology* 82(6): 1508-1511

**\* Original not seen**

## APPENDIX

**Temperature and relative humidity of the laboratory during the experiment.**

Standard week	Date and month	Mean temperature (%)		RH (%)
		Minimum		
44	29-4 Oct-Nov	22.04	29.9	88.28
45	5-11 Nov	21.78	28.9	83.07
46	12-18 Nov	21.10	31.2	72.89
47	19-25 Nov	18.15	30.77	68.60
48	26-2 Nov-Dec	20.28	30.38	68.57
49	3-9 Dec	18.14	30.35	70.85
50	10-16 Dec	17.45	30.37	75.57
51	17-23 Dec	18.97	30.01	78.00
52	24-31 Dec	20.00	30.5	79.12
1	1-7 Jan	18.12	30.02	80.57
2	8-14 Jan	18.02	30.35	85.00
3	15-21 Jan	17.35	30.22	87.35
4	22-28 Jan	19.91	30.44	90.71
5	29-4 Jan-Feb	20.00	29.70	90.64
6	5-11 Feb	17.82	31.02	89.28
7	12-18 Feb	19.42	33.24	91.57
8	19-25 Feb	20.08	31.51	90.00
9	26-4 Feb-Mar	19.31	33.12	89.64
10	5-11 Mar	21.32	32.47	84.85
11	12-18 Mar	22.9	33.01	87.35
12	19-25 Mar	23.91	32.88	85.14
13	26-1 Mar-Apr	26.34	33.41	83.00
14	2-8 Apr	24.18	33.97	80.64
15	9-15 Apr	27.04	34.85	77.00
16	16-22 Apr	26.08	34.80	75.64
17	23-29 Apr	27.47	35.98	76.42
18	30-6 Apr-May	26.58	34.52	69.57