Chapter I: Introduction

a) General Introduction: India is the second largest producer of vegetables after China. 70% of the peoples of Assam are involved in agriculture. Cucurbitaceous crops play a unique status among vegetables. But the infestation of red pumpkin beetle, *Raphidopalpa (Aulacophora) foveicollis* (Lucas) causes severe losses among all the cucurbitaceous crops.

b) Study Sites: The study was carried out in Cachar District of Barak Valley situated southern part of Assam. The geographical area of this valley at longitude between 92° 15' and 93° 15' East and latitude between 24° 8' and 25° 8' with an altitude of 36 m above msl. Four study sites viz., Alenpur, Dargakona, Katigorah and Narsinghpur were selected for the present investigation. Each locality is separated by interdistance between 20-30 Kms. The zone has an undulating topography characterized by hills, hillocks, wide plains and low lying water logged areas locally called bills.

Chapter II: Review of literature

Review of literature was analyzed and stated in this chapter.

Chapter III: Ecology of *R. foveicollis*

a) Population dynamics: Population dynamics was studied during three crop seasons viz., summer, autumn and winter during January, 2004 to December, 2005 among four study sites. The population fluctuation of *R. foveicollis* was studied on four major cucurbit crops viz., *Lagenaria vulgaris* Ser., *Cucumis sativus* L., *Cucurbita maxima* (Naudin.) Filov. and *Benincasa*
hispida (Thunb.) Cogn. The highest population was recorded on *C. maxima* (10.00) during winter of second year in Narsinghpur. The order of population dynamics in decreasing trend in different sites were Narsinghpur > Katigorah > Dargakona > Alenpur. Multiple correlation ('F'-test) was employed to correlate the population fluctuation with three abiotic factors viz., temperature, rainfall and relative humidity above all the four major crops on various seasons. In Alenpur and Narsinghpur multiple correlation ('F'-test) of all the abiotic factors together were found to be non-significant correlation with population fluctuation (p>0.05). In Dargakona it showed significant only on *L. vulgaris* (F= 3.20, p< 0.05) whereas in case of other three crops viz., *C. maxima, C. sativus* and *B. hispida* the relationship was found to be non-significant, In case of Katigorah 'F'-test proved significant correlation on *C. sativus* (F= 6.18, p< 0.01) and *L. vulgaris* (F=7.15, p< 0.01) whereas non-significant on *C. maxima* and *B. hispida*.

b) Host preference

i) Nature of damage: Nature of damage was studied on four different hosts viz., *L. vulgaris, C. maxima, C. sativus* and *B. hispida* by adult beetles. Out of four hosts leaves and corolla of flowers were damaged by making regular and irregular holes on surfaces and line through edges of the leaves. The upper leaf surface of *C. sativus* was damaged only by making regular holes; androecium and gynoecium of flowers were chosen as whole parts. In case of stem only tender part was infected through bark on *L. vulgaris* and *C. maxima*; tendril was observed to be totally infested. Only fruits of *L. vulgaris*
fruits were infested by the pest on the surface area of both mature and immature stage.

ii) Feeding preference: The investigation of feeding preference indicated that out of four major crops the most preferred one was *L. vulgaris* (1.64) followed by *B. hispida* (1.55) whereas same preference showed on *C. maxima* and *C. sativus* (0.76). The study of feeding preference among different hosts revealed that the pest prefers maximum intensity on leaves followed by flowers. In case of stem no indication proves on tender portions of *C. sativus* and *B. hispida* and tendril of *C. maxima*. Adult did not prefer both the mature and immature fruits of *C. maxima* including the mature fruits of *B. hispida*.

iii) Host preference by *R. foveicollis* on different major cucurbit hosts:
Host preference on eight major cucurbit hosts *viz.*, *L. vulgaris*, *B. hispida* *C*, *maxima C. sativus*, *C. melo var momordica*, *L. acutangula*, *T. dioica*, *M. cochinchinensis* were studied which revealed that striped gourd *Trichosanthes dioica* Roxb. was the most preferred host where the maximum damage (62.15%) was observed whereas *Luffa acutangula* (L.)Roxb. was found to be least preferred host (2.35%). ANOVA was employed between percent damage among different hosts which proved significant (p<0.01) performance among them.

iv) Host preference by *R. foveicollis* on different alternative hosts: Nine alternative hosts belong to six families *viz.*, Leguminoseae, Malvaceae, Tiliaceae, Solanaceae, Chenopodiaceae, Convolvualceae were screened
against *R. foveicollis*. Out of these nine crops five hosts viz., *Dolicos lablab* (Roxb) & L. (Leguminoseae), *Vicia feba* L. (Leguminoseae), *Abelmoschus esculentus* L. (Malvaceae), *Corchorus capsularis* L. (Tiliaceae), and *Solanum tuberosum* L. (Solanaceae) were chosen as alternative hosts by the pest whereas no preference was recorded on other four crops which includes *Spinacia oleracea* L. (Chenopodiaceae), *Ipomoea batatus* Lam. (Convolvulaceae), *Vigna sesquipedalis* L. (Leguminoseae), *Solanum melongena* L. (Solanaceae). The highest preference was recorded on *V. feba* (7.31%) whereas the least preference was observed on *A. esculentus* (0.40%). ANOVA was found to be no significant difference (p>0.05) of percent damage among different crops.

**v) Comparative study of extent of damage by adults and larvae:** The comparative study of extent of damage by adults and larvae indicated that maximum damage was caused by adult beetles on *C. maxima* (20.75%). The degree of extent of damage by adults on different hosts in descending order was as follows: *C. maxima* (20.75%) > *B. hispida* (17.52%) > *C. sativus* (14.73%) > *L. vulgaris* (8.05%). Regarding the larval damage, infliction on *C. sativus* was recorded to be the highest by first instar (10.40%) while by second instar on *C. maxima* (2.84%) and *L. vulgaris* (3.21%). The damage on *B. hispida* was found to be the highest by third instar larvae (5.94%). No damage was recorded by fourth instar of larvae among different hosts.

c) **Diurnal activity:** Diurnal activity of *R. foveicollis* was studied during three crop seasons viz., summer, autumn and winter in Dargakona crop field. The
period of the study confined to 6.00 AM to 6:00 PM during summer and
autumn while from 6.00 AM to 5:00 PM in winter at an interval of 1 hour.
Insect activity was recorded to be higher in morning and evening during
summer whereas the least at noon. In case of autumn, maximum activities
were recorded during morning whereas the least activities were recorded to
be at noon and evening. In winter the maximum activities were recorded at
afternoon whereas very less at morning. 't'-test was employed between peak
hours of activities proved non-significant differences in all the seasons.

Chapter IV: Morphometry and biology of *R. foveicollis*

a) Morphometry of grubs and pupae: For the study of morphometry
of grubs, the different instars were collected from the respective petridish in
rearing box where the larvae were nourished properly in laboratory condition.
The pupae were collected from the petridish beneath the moistened soil.
Larvae and pupae were weighed in an electronic balance. The length and
width of head capsule were measured by ocular micrometer. Body length
was measured by a callipar (Deshmukh *et al.*, 1977). 10 replications were
taken for each larval instars and pupal stage.

i) Grub stages: Full grown grubs measured as 11.45±0.15mm in length and
1.14±0.01mm in width. The body length and width were recorded to be
maximum in IV-instar where as the lowest in case of I-instar. The length and
width of body among different stages in descending order were recorded as
follows: IV-instar>III-instar>II-instar>I-instar. The body weight was recorded
to be the highest in IV-instar whereas the lowest was recorded in I-instar. In
descending order the body weight were as follows: IV-instar (10.94±0.99mg)>III-instar (4.75±0.77mg)>II-instar (3.31± 0.66mg)>I-instar (0.25±0.05mg).

ii) Pupal stage: The body lengths of pupae were measured 5.97± 0.09 mm in length and 3.01± 0.03 mm in width. The head capsule was measured as 1.00±0.02 mm in length and 0.96± 0.01 mm in breadth. The weight measured as 9.39±0.23mg. ANOVA did not show any significant variation of length and weight among grubs and pupae.

b) Morphometry of adult beetles: The study of the morphometry among adult indicated that the body size of females were larger than males with showing little variation among different parameters. The adult male measured 6.93±0.43mm in length and 3.20±0.21 mm in width whereas females measured as 8.14±0.35mm in length and 3.66±0.18mm in breadth.

c) Biology of *R. foveicollis*:
The biology of *R. foveicollis* has been studied in the lab on petridish as well as the twigs of *C. maxima* properly kept in conical flask filled with water in wooden cage covered by net (2mm mesh size). The adult male and female were collected from the field and released in rearing box. After releasing the adult male and female, observations were continued for copulation and development of other stages. For determining the sex ratio 100 adults in each season were collected randomly from the field. The growth index (G.I.) was calculated by employing the formula: G. I. = n/t, where ‘n’ is the per cent
immature attained adult stages and 't' is the time taken to complete the life cycle.

Study revealed that copulation, pre-oviposition, post-oviposition and incubation period varied during three crop seasons viz., summer, autumn and winter. During summer it took minimum time duration whereas maximum time duration in winter. The average life span was found to be shorter during summer and longer in winter. The size of female was comparatively larger than male. Sex ratio indicates that females were outnumbered than males. Growth index showed maximum during summer and least in winter. There were four to five generations observed in a year.

Chapter V: Pest management

a) Management by Chemical Pesticides: For the study of bio-efficacy by chemical pesticides Randomized Block Design (RBD) method was followed. Seven insecticides including three pyrethroid viz., Deltamethrin, Fenvalerate and Cypermethrin; two systemic viz., Phosphamidon and Dimethoate; and two contact viz., Malathion and Endosulfan of two concentrations each were evaluated against *R. foveicollis* in the field condition. Three replications were followed for each treatment. Data revealed that higher concentration of all the treatments showed more efficacy than lower treatments except Deltamethrin and Malathion where the lower concentrations showed more efficacy. Phosphamidon (0.03%) and Endosulfan (0.05%) showed cent per cent population reduction after 1\textsuperscript{st} day of post treatment. The 5\textsuperscript{th} day post application showed cent per cent reduction by Phosphamidon (0.02% and
0.03%), Endosulfan (0.05%), Deltamethrin (0.001% ) and Cypermethrin (0.001% and 0.002%) After 10th day of post treatment cent per cent reduction was afforded by Phosphamidon (0.03%), Endosulfan (0.05%). Cypermethrin (0.001% and 0.002%), Fenvalerate (0.001% and0.002% ), Dimethoate (0.03% ) and Malathion (0.03%). The data of 15th day of post application afforded cent per cent population reduction by Fenvalerate (0.002%) and Cypermethrin (0.001% and 0.002%) The 20th day of post- treatment showed cent percent reduction by Fenvalerate (0.002%) and Cypermethrin (0.002%). All of the concentrations were found to be superior in action. ANOVA revealed that the percent reduction of different treatments was not significantly different from each other from 1st day to 20th days of post treatments between different concentrations.

b) Management by Bio-Pesticides: Five different bio-pesticides viz., Azacel, Cal- MB, Cal- 10, Cal paste and Larvocel with two concentrations each were evaluated against R. foveicollis. The study of bio-pesticides carried in terms of mortality of the pest and a Randomized Block Design (RBD) was followed. After 1st day of treatment, cent per cent population reduction afforded by Cal-paste (0.4%) followed by Larvocel (1.0%) where 83.33% reduction was observed. The 3rd day post application showed cent per cent reduction by Larvocel (0.5%). The 5th day post application gave cent per cent efficacy by both the Cal-paste (0.2%) and Larvocel (0.5%). After 7th day of treatment the highest per cent reduction (75.00%) was recorded by Cal-paste (0.2%) followed by Larvocel (0.5%) where the per cent
reduction was recorded to be 72.22%. All of the concentrations were found to be superior in nature up to a week while no efficacy was obtained by cal-10 (0.4%) after 7th day application, where cent per cent population was increased after a week. ANOVA was recorded to be non-significant difference among all the treatments.

c) Management by Plant Indigenous Materials: For the study of bio-efficacy of plant indigenous materials six plants viz., a) Bankalmi -Ipomoea quamoclit L. syn- Quamoclit pinnata (Desr.) Boj., b) Verenda- Ricinus communis L., c) Chilly- Capsicum frutescens L., d) Pisach- Eupatorium odoratum L., e) Karabi- Nerium indicum Mill., and f) Nayan tara- Vinca rosea L. were used. The fruits of C. frutescens and leaves of other plants were selected for extractions which were air dried thereafter grinded. Extraction of plan materials were done by Soxhlet method using Ethanol (b.p. 78.3°C), Methanol (b.p. 64.7°C), Acetone (b.p. 56.5°C), and Hexane (b.p. 68.7°C), as solvents for 48 hours. In ethanol solvent, four plants materials (viz., I. quamoclit, E. odoratum, R. communis and C. frutescens); in methanol, four plants materials (viz., I. quamoclit, R. communis, N. indicum and V. rosea); one in each of hexane (C. frutescens) and acetone (N. indicum) were used to make the plant extract. Crude extract was prepared after distillation thereafter the desired concentrations (0.5%, 1.0%, 1.5%, 2.0%) were prepared from the crude extract by using 0.5 ml emulsifier (Triton x 100) for treatment. Three replications were considered as RBD. The bio-efficacy of six plant extract in different solvent gave good performance whereas the best
efficacy showed by all the concentrations of *Eupatorium odoratum* (in ethanol) and *Neirium indicum* (in methanol and hexane) where almost cent per cent population reduction afforded up to a week.

**Management by traditional methods:** Six traditional methods viz., Wood ash (100% powder), Fly ash (100% powder), Lime water (1:6), Cow dung: water mixture (1:5), Chilly water mixture (1:10), and Tobacco + turmeric mixture in water (1:2.5:15) were evaluated against *R. foveicollis*. The items were prepared according to the farmers’ opinion. Three replications were considered as RBD. All the treatments gave good performance, up to 5th day post application they showed 60 to 100% efficacy. Thereafter it was decreased but continued up to a week where they gave 40 to 65 per cent performance. The efficacy in descending order was as follows: Fly ash, cow dung> lime water> wood ash> chilly water mixture> tobacco and turmeric mixture.

**Chapter VI: Farmers’ Traditional Belief in Management of *R. foveicollis***:

One hundred sixty farmers’ were interviewed among four villages of Cachar district viz., Alenpur, Dargakona, Katigorah and Narsinghpur during 2006-2007. They were interviewed by supplying questionnaire (Schedule-I). The farmers’ of all the sites were involved in cultivation of cucurbitaceous crops along with other crops whereas maximum respondents (80.00%) from Katigorah and Narsinghpur. Total response from the district revealed that 75.00% farmers were involved in cultivating the cucurbits along with other crops whereas 76.25% of farmers believed infestation caused by *R.*
foveicollis on cucurbits. The farmers' response in insect pest management by using various traditional methods revealed that the maximum respondents (75.00%) were using cow dung and fly ash followed by red chilly powder (50.00%) and the least (25.00%) by black soil powder. Cent per cent respondents from three villages viz., Alenpur, Katigorah and Narsinghpur were practicing traditional methods as well as chemical pesticides. Total response from this district revealed that 80.00% of farmers were using chemical pesticides where 77.50% were using traditional methods along with chemical pesticides. The maximum agricultural land (0.19ha/ family) was occupied by the farmers of Alenpur and the area of cucurbit land occupied by the farmers showed the same and the highest among three villages viz., Alenpur, Katigorah and Narsinghpur where 0.06 ha /family was occupied for cucurbit whereas the lowest in Dargakona i.e. 0.05 ha / family. The annual income was highest in Alenpur (@ Rs. 89,275.00/family). In Katigorah the percentage income was highest from vegetable (50.75%) as well as from cucurbits (24.75%).

As traditional practices farmers used major four types of treatments (viz., cow dung, black soil powder, red chilly powder and fly ash to control the red pumpkin beetles. Black soil and Chilly were mixed with water to prepare a suspended solution and sprayed on beetle infested field which repelled the pests. Few rare methods also practiced by the farmers along with the above mentioned methods which were very less practices but have good performance. The rare practiced methods include lime water, tobacco
and turmeric mixture in water, tobacco and lime water mixture. All of those treatments mainly acted as repellent and antifeedant to control the pests.

Chapter VI: Conclusion and recommendation: The study of population fluctuation with the abiotic factors clearly indicated that moderate temperature, high humidity and no rainfall may favourable for the pest resurgence. The adult beetles infested on various parts of crops viz., leaves, flowers, stems and fruits of major cucurbitaceous crops. Among the chemical insecticides, cypermethrin (0.002%) and fenvalerate (0.002%) were recommended to control the pest whereas Cal-paste and Larvocel were found to be most effective among the applied biopesticides and those may be recommended. *Eupatorium odoratum* in ethanol, *Neirium indicum* in methanol and hexane solvents were recommended in case of plant extract along with the other indigenous methods. As regards farmers' traditional belief to manage *R. foveicollis*, cow dung, fly ash, wood ash, tobacco, turmeric, *kala maati* (black soil) powder and lime water may be recommended to document as well as encouraged for practicing such Indigenous Traditional Knowledge (ITK) based methods.