EFFECT OF CASTOR GENOTYPES WITH DIFFERENT BLOOMS ON GROWTH AND DEVELOPMENT OF CASTOR SEMILOOPER, *Parallelia algira* (Linnaeus)

BY

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B.Sc. (Ag.)

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DECLARATION

I, **M. MUNESWARI**, hereby declare that the thesis entitled "**EFFECT OF CASTOR GENOTYPES WITH DIFFERENT BLOOMS ON GROWTH AND DEVELOPMENT OF CASTOR SEMILOOPER, *Parallelia algira* (Linnaeus)**" submitted to the Acharya N.G. Ranga Agricultural University for the degree of **MASTER OF SCIENCE IN AGRICULTURE** is the result of original research work done by me. I also declare that no material contained in the thesis has been published earlier in any manner.

Place: **(M. MUNESWARI)**

I. D. No. TAM/2017-21

Date:

CERTIFICATE

Ms. M. MUNESWARI has satisfactorily prosecuted the course of research and that thesis entitled **"EFFECT OF CASTOR GENOTYPES WITH DIFFERENT BLOOMS ON GROWTH AND DEVELOPMENT OF CASTOR SEMILOOPER, *Parallelia algira* (Linnaeus)"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that neither the thesis nor its part thereof has been previously submitted by her for a degree of any University.

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This is to certify that the thesis entitled "**EFFECT OF CASTOR GENOTYPES WITH DIFFERENT BLOOMS ON GROWTH AND DEVELOPMENT OF CASTOR SEMILOOPER, *Parallelia algira* (Linnaeus)**" submitted in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURE**' of the Acharya N.G. Ranga Agricultural University, Guntur is a record of the bonafide original research work carried out by **Ms. M. MUNESWARI** under our guidance and supervision.

No part of the thesis has been submitted by the student for any other degree or diploma. The published part and all assistance received during the course of the investigations have been duly acknowledged by the author of the thesis.

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M. Muneswari… ✍

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LIST OF SYMBOLS AND ABBREVIATIONS

%	:	Per cent
±	:	Plus or Minus
µl	:	Microlitre
cm	:	Centimetre
mm	:	Millimeter
AD	:	Approximate Digestibility
ECD	:	Efficiency of Conversion of Digested food to body substance
ECI	:	Efficiency of Conversion of Ingested food to body substance
CI	:	Consumption Index
GR	:	Growth Rate
RGR	:	Relative Growth Rate
RCR	:	Relative Consumption Rate
CR	:	Consumption rate
ECD	:	Efficiency of Conversion of Digested food
FP	:	Dry weight of Faecal Material Produced
et al	:	And others
µg	:	Microgram
mg	:	Milligram
g	:	Gram
kg	:	Kilogram
LSD	:	Least Significant Difference
m	:	Metre
ml	:	Millilitre
No.	:	Number
^{o}C	:	Degree Celsius
RH	:	Relative Humidity
SPSS	:	Statistical Packages for Social Sciences
viz.,	:	Namely
Max	:	Maximum
Min	:	Minimum

m^2	:	Square meter
cm^2	:	Square centimeter
i.e.,	:	That is
g/g	:	Gram/gram
mg/g	:	Milligram/gram
$\mu g. cm^{-2}$	:	Microgram/square centimeter
Mha	:	Million hectares
Kg/ha	:	Kilogram/hectare
MT/Ha	:	Million tones/Hectare
Ha	:	Hectare
DOR	:	Directorate of Oilseed Research
NS	:	Non Significant
HPR	:	Host Plant Resistance

ABSTRACT

Name:	**M. MUNESWARI**
Title of the Thesis:	**EFFECT OF CASTOR GENOTYPES WITH DIFFERENT BLOOMS ON GROWTH AND DEVELOPMENT OF CASTOR SEMILOOPER, *Parallelia algira* (Linnaeus).**
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University:	Acharya N.G. Ranga Agricultural University
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Investigations were carried out on “Effect of castor genotypes with different blooms on growth and development of castor semilooper, *Parallelia algira* (Linnaeus)” during 2018-19 at Insectary, Department of Entomology, S.V. Agricultural college, Tirupati.

Feeding preference of first, second and third instar larvae of *P. algira* (free choice condition) on castor genotypes with different blooms *viz.,* DPC-9 (zero bloom), 48-1 (double bloom) and GCH-4 (triple bloom) was studied. In the present investigation DPC-9 (zero bloom) having no wax on the leaf surface, attracted very few first, second and third instar larvae of *P. algira* compared with 48-1 (double bloom) and GCH-4 (triple bloom), this probably is due to the fact that, DPC-9 which is a zero bloom genotype does not have any wax on leaf surface and phagostimulants therein and hence could not elicit any preference behavior in larvae of *P. algira*.

Ovipositional preference studies of *P. algira* on castor genotypes with different blooms revealed that less number of eggs were laid on DPC-9 (4.08) (zero bloom) followed by GCH-4 (4.23) (triple bloom) and 48-1 (7.65) (double bloom).

Feeding indices such as AD, ECI, ECD and CI of *P. algira* has been calculated on castor genotypes with different wax blooms using third instar larvae of uniform weight and size. In the present investigation low ECI (33.26%) and ECD (53.70 %) and high AD (60.90 %) and CI (1.07) values were observed when larvae were fed on leaf disc of GCH-4 (triple bloom)

which was regarded as least preferred host for growth and development of larvae of *P. algira*. Larvae of *P. algira* fed on leaf discs of DPC-9 (zero bloom) had high ECI (39.83 %) and ECD (62.43 %) values and low AD (53.01 %) and CI (0.93) indicating that genotype as more preferred host for growth and development of larvae of *P. algira*.

Biology of *P. algira* was studied on castor genotypes with different wax blooms *viz*., DPC-9 (zero bloom), 48-1 (double bloom) and GCH4 (triple bloom) at 25 ± 2 ˚C temperature and 75 ± 5 (%) R H. Observations on duration of each stage in the life cycle of *P. algira* including their morphometrics were recorded.

P. algira larva passed through five instars. Shortest larval duration was observed when larvae were fed on DPC-9 (zero bloom) which was ranked as highly preferred host for growth and development of *P. algira* compared to 48-1 (double bloom) and GCH-4 (triple bloom). Lowest values of adult longevity and oviposition period of *P. algira* were observed when larva was fed on GCH-4 (triple bloom) compared to DPC-9 (zero bloom) and 48-1 (double bloom) indicating GCH-4 as least preferred host for growth and development of *P. algira*.

Chapter –I

Introduction

Chapter I

INTRODUCTION

India is one of the largest producers of oilseeds in the world and oilseed sector occupies an important position in the agricultural economy of the country. India is the fourth leading oilseeds producing country in the world, next only to the USA, China and Brazil harvesting about 29 million tonnes of oilseeds per annum, grown in an area of nearly 27 M ha with an annual average yield of 1058 kg/ha (Reddy and Immanuelraj, 2017). Oilseed sector has an annual turnover of about rupees 80000 crores which subjugate a vital position in the agrarian economy of the country. India is the fifth largest vegetable oil economy in the world, next only to USA, China, Brazil and Argentina (Jha *et al*., 2012). With its rich agro-ecological diversity, India is ideally suited for growing all the major annual oilseed crops. Among the nine oilseed crops grown in the country, seven are of edible oils (soybean, groundnut, rapeseed-mustard, sunflower, sesame, safflower and niger) and two are of non-edible oils (castor and linseed). India ranks first in the production of most of the minor oilseeds (castor, niger, safflower and sesame). In case of major oilseeds, India ranks first in the production of groundnut, second in rapeseed-mustard, and fifth in soybean in the world (Rai *et al*., 2016).

Oilseed crops are the second most important determinant of agricultural economy, next only to cereals within the segment of field crops. The self-sufficiency in oilseeds attained through "Yellow Revolution" during early 1990's, could not be sustained beyond a short period. Despite being the one of the largest oilseed producing country, India is also one of the largest importers of vegetable oils today.

The demand-supply gap in the edible oils has necessitated huge imports accounting for 60 per cent of the country's requirement (Import 14.01 million tones; cost Rs. 73,048 crores, 2016-17) (National Mission on Oilpalm, 2018).

Despite commendable performance of domestic oilseed, production of the nine annual crops, could not match with the increase of per capita demand (6%) due to enhanced per capita consumption (18 kg oil per annum) (National Mission on Oilpalm, 2018) driven by increase in population and enhanced per capita income.

Castor is one of an industrially important non-edible oilseed crop grown in India and has gained an importance in the world for its numerous industrial applications. Castor is a perennial crop but is also grown as an annual crop for economic purpose and is cultivated mainly in Africa, South America and India. Oil content of the seed varies from 35-58 per cent. Castor oil has global importance specially in chemical industry as it is the only commercial source of a hydroxylated fatty acid. In India, castor seed and its derivatives are mainly consumed in paint industry (45-50%), soap industry (25-30%) and lubricants (15-20%). In general, the current rate of castor oil production is not considered sufficient to meet the anticipated increase in demand (Patel *et al*., 2016).

At present India is the world's largest producer of castor seed and oil contributing about 85 per cent of seed production. Total area under castor in the country is about 1061 thousand hectare (Indiastat, 2016), producing about 1497 MT/ha (Indiastat, 2018). Andhra Pradesh and Telangana stands third in the country in castor area (33.18 thousand ha) and productivity (477 Kg/ha) (Executive summary castor crop survey, 2018).

Though castor productivity in India is more than the world average, there are several production constraints in the traditional rainfed castor growing areas of India, among them insect pests and diseases dominate the scenario. Insect pests such as defoliators *viz*., semilooper (*Achaea janata* L.), red hairy caterpillar (*Amsacta moorei* Butler), tobacco caterpillar (*Spodoptera litura* F.) and shoot and capsule borer (*Conogethes punctiferalis* Guenee) were reported as major pests and recently, serpentine leaf miner (*Liriomyza trifoli* Burgess) has also became a serious pest (Lakshminarayana, 2010).

Castor semilooper acts as a major defoliator and under severe infestation completely devours the green foliage, leaving only the veins and enforce the farmers to re-sow the crop. It causes yield reduction to the extent of 20 to 23 per cent (Gaikwad and Bilapate, 1992). There are two different species of castor semilooper, *viz*., *Achaea janata* (Linnaeus) and *Parallelia algira* (Linnaeus) both of which belongs to family Noctuidae of Lepidoptera.

Castor semilooper, *A. janata* and *P. algira* (Lepidoptera: Noctuidae) are polyphagous pests and feeds on many different species of plants. Alternate hosts include banana, cabbage, Chinese cabbage, crown of thorns, ficus, macadamia, mustard, poinsettia, rose, sugarcane and tomato as well as some legumes, teas, and other brassica species. Castor is the major host, and under severe infestations, the caterpillar devour the green foliage completely, leaving only the veins and enforce the farmers to re-sow the crop (Gaikwad and Bilapate, 1992) the damage is continued from vegetative stage to early reproductive phase of the crop (Lakshminarayana and Raoof, 2005).

Host plant resistance in castor is mainly based on wax bloom on different plant parts. Presence of surface wax acts as feeding barrier for lepidopteran caterpillars resulting in reduced infestation (Sarma *et al*., 2006).

Though lot of work has been done on ecobiology, plant resistance and management of castor semilooper, the work focused mainly on one semilooper *i. e*., *Achaea janata*. Work on *P. algira* is either scanty or nil. By keeping above points in consideration the present work was formulated with the following objectives.

1. To study the feeding and ovipositional preference of *P. algira* on castor genotypes with different blooms.

2. To calculate the feeding indices of *P. algira* on castor genotypes with different blooms.

3. To study the growth and development of *P. algira* on castor genotypes with different blooms.

Chapter – II

Review of Literature

Chapter II

REVIEW OF LITERATURE

The literature pertaining to the feeding preference, ovipositional preference, calculation of feeding indices of *Parallelia algira* and growth and development of *P. algira* has been reviewed and presented under following headings.

2.1. FEEDING AND OVIPOSITION PREFERENCE OF LEPIDOPTERAN PESTS ON HOST PLANTS WITH WAX BLOOMS

Majority of work on castor semilooper has been focused on one species *i. e*., *Achaea janata* though both *A. janata* and *P. algira* acts as major defoliator. The literature pertaining to studies on *P. algira* is scanty and hence the work on *A. janata* and other major insect pests of castor and other crops has been reviewed and discussed here under.

Uematsu and Sakanoshia (1988) found differences in oviposition of *Plutella xylostella* on cabbage leaves (with and without wax bloom) placed in a glass tube. In first case when *P. xylostella* has been allowed to oviposit on cabbage leaves (with surface wax) placed in glass tube, the authors observed 10-20 per cent of eggs deposited on cabbage leaves whereas remaining eggs has been reported to be laid on the glass tube walls. In the second case the authors placed a piece of surface wax washed cabbage leaf, and observed that 75 per cent of oviposition on leaves and remaining eggs were reported to be laid on glass tube wall. These results suggest that presence of wax made the cabbage leaves unattractive to the adults of *P. xylostella* to oviposit.

Eigenbrode and Shelton (1990) conducted a study on dispersal and survival of neonate diamondback moth larvae, *P. xylostella* on cabbage genotypes with normal bloom (susceptible) (Round-up and 2535) and resistant genotype from glossy cabbage (PI 234599, 3891, 8329 and 2518). Among the genotypes evaluated the survival of neonates up to fourth instar stage was reported to be the highest on susceptible varieties with normal bloom *viz.*, round-up (31.14%) followed by 2535 (18.55%). Whereas no survival of neonates reported to occur on 2518 glossy type (0%). The author found a negative correlation between the survival of larva and movement rate of larva *i. e*., higher the survival of larva on a genotype lesser the movement of larva on a genotype. Hence the movement of larva was reported to be the highest on 2518 (glossy variety), whereas least movement on Round-up (normal bloom variety). In other case the authors removed wax on 8329 cultivar using dichlormethane and compared the larva movement of *P. xylostella* on Round-Up and dichlormethane treated 8329 cultivar in which they observed no difference in movement of larva. From this the authors concluded that wax morphology plays major role in larval movement of *P. xylostella* on various cabbage cultivars with different blooms.

Charleston and Kfir (2000) examined the effect of wax on surface of plants *viz.*, cabbage, cauliflower, broccoli, Chinese cabbage and Indian mustard, on the oviposition preference and larval survival of *P. xylostella*. Among the plants examined the highest oviposition and lowest larval survival has been reported on Indian mustard, which the authors opined that the reduced wax load of Indian mustard might be the reason.

Justus *et al.* (2000) studied the effect of wax on ovipositional preference of *P. xylostella*. In the study they compared the oviposition of *P. xylostella* in two approaches. In first approach the authors compared oviposition of *P. xylostella* between canola plant that had epicuticular wax reduced by application of a carbamate herbicide (S-ethyl dipropylthiocarbamate) and an untreated control canola plants. The authors observed more number of eggs on herbicide treated plants than on untreated plants from which they opined that application of herbicide removed wax on plants which attracted *P. xylostella* to oviposit. In second approach the authors compared the ovipositional preference between sibling strains of *Brassica* *napus* with different wax blooms (glossy and waxy), in which the authors observed more number of eggs on glossy than on waxy variety of *B. napus*.

Cervantes *et al*. (2002) studied the oviposition responses of hessian fly, *Mayetiola destructor*, to wheat cultivars varying in surface waxes *viz*., Avalon, Brigand, Virtue, Non-glaucous Avalon, Non-glaucous Brigand and Non-glaucous Virtue. The authors found no difference in oviposition preference of hessian fly in dual choice conditions when evaluated at seedling stage of the cultivars. However the authors observed a negative correlation between glaucous leaf surface and oviposition when evaluated at flag leaf stage, where 25-100 per cent more eggs has been reported to be laid on nonglaucous (without wax) genotypes compared to normal wax genotype.

Ulmer *et al.* (2002) studied the feeding and ovipositional preference of *P. xylostella* on glossy and waxy *Brassica rapa* (L.) lines. The authors found significant difference in feeding preference of first instar larva on waxy and glossy plants where waxy plants has been proved to be highly preferred compared to glossy plants. Though no significant difference has been reported to be observed in ovipositional preference of *P. xylostella*, but the highest and the lowest oviposition has been reported on glossy plants than on waxy plants.

Lakshminarayana (2005) had conducted a study on antixenosis mechanism of resistance in castor, *Ricinus communis* L. against major insect pests such as *Spodoptera litura*, castor capsule borer, *Conogethes punctiferalis* and castor leafhopper, *Empoasca flavescens*, castor thrips (*Scirtothrips dorsalis*) and whiteflies (*Trialeurodes ricini*). *S. litura* damage has been reported to be low on castor genotypes with leaves of papaya type (RG-1766), flat (RG-2291), shallow cup (RG-2327) and small size leaves (RG-2679) than those with purple (RG-1930) and large size leaves (RG-11). Capsule borer damage has been reported to be low on the genotypes with loose (RG-1934) and very loose (RG-2543) spikes and with small size (RG-2635) and non-spiny capsules (RG-258). The castor genotypes with double and triple bloom *viz*., RG-2551 and 2646 and zero and single bloom were reported to be more and less preferred by castor leafhopper respectively. The author opined that morphological characters of the castor genotypes such as size of leaves, shape of leaves, epicuticular wax, spiny capsules provided resistance to the plants.

Sarma and Singh (2005) evaluated eight varieties of castor *viz*., against *A. janata* and *S. litura* in Manipur between 2001-03 and found that 48-1 (double bloom) emerged to be the most resistant variety with least population (4.20, 5.55 larvae/plant, respectively) followed by local red powdery variety (4.62, 5.70 larvae/plant, respectively). Local green (non-powdery) variety has been found to be the least resistant with the highest mean infestation (5.15, 6.75 larvae/plant, respectively).

Sarma *et al*. (2006) evaluated four castor genotypes such as local red (gloomy), local red (non-gloomy), local green (gloomy) and local green (non gloomy) for two years for their resistance to two major defoliators *viz*., *A. janata* and *S. litura*. Among the genotypes tested the local red gloomy type has been reported to show high resistance with least mean population of both the defoliators and lowest defoliation to a tune of 39.2 per cent. Whereas the local green non-gloomy proved to be least resistant with the highest population of semilooper (5.15/ plant); tobacco caterpillar (6.75/ plant) and also with severe defoliation of 42.5 per cent. The author concluded that varieties with wax bloom on the plant surface as less damaged compared to non-gloomy type varieties.

Hegde *et al*. (2009) had screened castor cultivars against castor semilooper, *A. janata* and reported that cultivars such as 48-1, Aruna, SHB-392, SHB-150, MCV-10, RHC-25, SHB-556, SHB-370 and RHC-8 has been reported to be resistant against semilooper infestation, genotypes TCV-15, SHB-392, 48-1, Hiriyur Local, SKI-102, SHB-150, SHB-370 and RHC-25 as leaf miner resistant and 48-1, SHB-556, Hiriyur Local, JI-130, SKI-129, SKI-126 as resistant to shoot and capsule borer.

Ploomi *et al*. (2009) studied the ovipositional preference of cabbage moth, *Mamestra brassicae* on different *Brassica oleracea* cultivars *viz*., Parel, Golden Acre, Krautman, Lennox, Turquoise and Krautkaizer. Among the cultivars examined the authors observed the highest oviposition on Krautkaizer (52%) followed by Turquoise (40%), Krautman (5%) and Lennox (2.5%). Parel and Golden Acre have been reported to be resistant with least oviposition by cabbage moth, *M. brassicae*. The authors found variation in thickness of wax coating on leaf surface of various cultivars which has been reported to thinnest on Krautkaizer.

Patel *et al*. (2012) evaluated the castor genotypes against castor semilooper, *A. janata*. Among the genotypes evaluated, eleven genotypes *viz*., SKI-137, SKI-139, 48-1, XVI-9, SKI-130, SKI-133, SKI-134, SKI-147, SKI-25, SKI-109 and SKI-122 has been reported to be resistant with least mean larval population of 2.8 per cent while remaining four genotypes *viz*., SKI-48, SKP-1, VP-1 and VP-1 X SKI-152 (F1) as susceptible. Among the susceptible genotypes, they reported SKI-48 and VP-1 X SKI-152 (F1) as less susceptible, SKP-1 as moderately susceptible and VP-1 as highly susceptible.

Laxman (2014) has conducted an experiment on evaluation of genotypes against major defoliators and sucking pests of castor and evaluated 21 genotypes of castor such as DPC-9 (zero bloom), DCS-9 (double bloom), 48-1 (double bloom), Haritha (double bloom), PCH-288 (double bloom), PCH-111 (double bloom), Kiran (double bloom), PCH-106 (double bloom), PCH222 (double bloom), PCH-262 (double bloom), Kranthi (double bloom), M-574 (triple bloom), RG- 1180 (triple bloom), PCH-254 (triple bloom), GCH-4 (triple bloom), PCH-282 (triple bloom), PCH-248 (triple bloom), PCH-294 (triple bloom), RG-2835, RG-2928 and RG-776. Among the genotypes, 48-1 recorded maximum mean population of *A. janata i. e.,* 2.73 larvae per plant and was considered to be highly susceptible. Similarly, GCH-4, PCH-106 and RG-2928 had been reported to be moderately susceptible showing an average of 1.3 to 1.6 larvae per plant. Whereas the genotypes, Haritha, RG-2835, PCH-222 and RG-1180 were reported as resistant to *A. janata* with larval population ranging from 0.20 to 1.13. The author reported that double and triple bloom genotypes with red stem and spiny parts as highly resistant to *A. janata* except 48-1 which was reported to be susceptible.

Patel *et al*. (2016) screened castor cultivars against *Dichocrocis punctiferalis* during *kharif* season of 2011-12. Based on capsule damage the cultivars GCH-2 (6.03%), GAUC 1 (7.08%), GCH-7 (9.16%), GCH-3 (10.25%) and GCH-5 (11.00%) have been proved to be resistant at reproductive phase whereas GCH-6 (14.63%), GCH-2 (15.85%) and ANDCI-8 (16.57%) have been reported to be moderately susceptible group at reproductive group. While, at harvest stage cultivars such as GCH-2 (8.55%), GAUCH-1 (8.88%), GCH-7 (13.22%), GCH-3 (16.65%), GCH-5 (17.32%) and GCH-6 (18.59%) has been categorized into resistant whereas cultivars GCH-2 (21.22%) and ANDCI-8 (22.55%) as less susceptible.

Shilpakala and Krishna (2016) screened 21 castor genotypes against leafhoppers (*E. flavescens*), and castor shoot and capsule borer, (*C. punctiferalis*). The genotypes, M-574 (2.97), 48-1 (2.89) and PCH-294 (2.80) recorded lower incidence of leafhopper whereas high incidence was recorded in DPC-9 (7.41) followed by DCH-111 (6.43). The highest percentage of capsule damage by shoot and capsule borer was recorded in DPC-9 (47.29), PCS-262 (32.78) and PCS-171 (30.79). The least incidence was found in GCH-4 (13.17), PCH-288 (14.47), 48-1 (16.78), PCH-111 (17.37) and PCH-254 (17.39). The entries with triple bloom, loose spike, and non-spiny capsules were reported to be resistant to leafhopper and capsule borer when compared to the entries with zero and single bloom, compact spike and bold, spiny capsules.

Mounica *et al*. (2017) have screened 28 castor genotypes such as Jwala, DCH-177, DCH-519, DCS-107, DCS-78, Jyothi, DPC-9, GCH-4, GCH-7, JC-12, JP-96, M-574, PCH-111, PCH-254, PCH-282, Haritha, Kiran, Pragathi, Kranthi, SKI-215, SKI-333, SKI-335, SKI-336,SKI-341, SKI-84, TMV-5, VP-1 bloom) and YRCH-1 for resistance against green leafhopper, *E. flavescens* Fabricius. Among the genotypes evaluated the highest leafhopper population of about 54.28 has been reported on DPC-9 whereas lowest population of about 20.48 and 20.63 were reported on GCH-7 and VP-1 respectively. Castor genotypes with triple bloom has been reported to be resistant to leafhopper, whereas zero and single bloom has been reported to be susceptible.

Silva *et al*. (2017) experimented on effect of wax on feeding and ovipositional preference *P. xylostella* on collard cultivars *viz.,* Santo Antonio and Hybrid Kope F1 100MX. Feeding preference test has been examined in two cases, in first case comparison has been made between Hybrid Kope F1 100MX cultivar with wax and without wax in no choice conditions. In no choice condition of feeding preference with Hybrid Kope F1 100MX they observed the highest larval feeding on Hybrid Kope F1100MX cultivar without wax (65.3 mg) than on same cultivar with wax (23.5 mg). In ovipositional preference study they observed higher oviposition on Santo Antonio and Hybrid Kope F1 100MX cultivars without wax compared to same cultivars with wax. 6.4 times higher oviposition has been reported on Hybrid Kope F1 100MX without wax than on same cultivar with wax. The authors observed that presence of wax provided resistance to the cultivar which when removed makes the cultivar more susceptible to *P. xylostella*.

Manjunath *et al*. (2018) screened fifteen castor genotypes *viz*., RG-3336, HCGP-1, RG-3294, RG-3405, RG-3315, M-574, DPC-9, HCGP-3, RG-3388, DCH-519, DCS-9, JC-12, 48-1, GCH-4 and DCS-107. Among the genotypes evaluated, RG-3336, RG-3294, DPC-9, HCGP-2, RG-3388, DCH-519, HCGP-1, DCS-9, M-574, 48-1 and DCS-107 has been reported to be tolerant (<10 % damage) and entries HCGP-3, RG-3405, GCH-4, DCS-107, RG-3336, RG-3315, DPC-9, RG-3388, DCH-519, JC-12, RG-3294, DCS-9 and GCH-4 (triple bloom) were reported to be moderately tolerant (with 20-30 % damage) against leaf miner, *Liriomyza trifolii*, capsule borer, *C. punctiferalis*, semilooper, *A. janata* and tobacco caterpillar, *S. litura* infestation.

2.2. ESTIMATION OF FEEDING INDICES OF LEPIDOPTERAN PESTS OF CASTOR

As the literature pertaining to feeding indices of *P. algira* is scanty, literature pertaining to feeding indices of other lepidopteran insects on castor and other crops are reviewed here under.

Suganthy and Nagapasupathi (2005) conducted an experiment on consumption and utilization of food by castor semilooper, *A. janata* (Lepidoptera). The author calculated the Consumption Index (CI), Approximate Digestibility (AD), Efficiency Conversion Index (ECI) and Efficiency Digestibility Index (EDI) values and found an increasing trend in consumption and excretion of *A. janata* with the age of the larva. Based on the results obtained they reported on existence of an inverse relationship between CI; AD and ECI; EDI where the values of CI and AD reported to be maximum of about 2.07 and 80.5 where as both ECI and EDI values as minimum and equals to 1.8 and 1.9 per cent respectively at eighth day after emergence.

Naseri *et al*. (2009) studied nutritional indices of *Helicoverpa armigera* on different cultivars of soybean and reported that EDI (0.299 %) value of fourth instar was the highest on Zane cultivar while EDI value was lowest on 356 cultivar (0.133 %). ECI of fifth instar has been reported to be the highest and the lowest on Zane and M4 cultivar respectively. ECI and ECD values of all instars has been reported to be the highest on M7 cultivar (0.524 and 0.820 respectively) whereas the lowest values on Sahar cultivar (0.279 and 0.353 respectively). From the study author concluded M7 cultivar as susceptible and Sahar as resistant cultivar to *H. armigera*.

Atluri *et al*. (2010) conducted a study on ecobiology of the common castor butterfly *Ariadne merione* (Cramer) (Lepidoptera: Rhopalocera:

Nymphalidae). The author calculated the feeding indices *viz*., Approximate Digestibility (AD), Efficiency Conversion Index (ECI), Consumption Index (CI), Growth Ratio (GR) and Efficiency Digestibility Index (EDI) of *A. merione* (Cramer) on its host plant castor. The amount of food consumed was reported to increase from instar to instar with the highest consumption during fifth instar. Consumptions index and EDI has been reported to decrease with the instar progression whereas ECI decreased with instar progression. On the other hand Growth Ratio (GR) value has been reported to decrease from instar second to third and then increase to fifth instar.

Mehrkhou *et al*. (2013) studied the feeding indices *viz.*, Efficiency conversion Index (ECI), Efficiency Digestibility Index (EDI), Relative Growth Rate (RGR) and FP (dry weight of faecal matter produced) of third to fifth larval instars of cabbage butterfly on white cabbage (*Brassica oleracea* var. *Capitata f. Alba*), cauliflower (*B. oleracea* var. *botrytis*), red cabbage (*B. oleracea* var. *viridis* f. Rubra) and broccoli (*B. oleracea* var. *italica*). Among the hosts evaluated *B. oleracea* var. *capitata* was reported to be nutritionally rich food among the cabbage crops with maximum value of ECI (14.76 ± 0.5%) and ECD (14.71 ± 0.60%). Whereas *B. O. var. Botrytis* variety were reported as partially resistant with least values of Relative Growth Rate (RGR) (77.04 g/g/day), ECI (0.11%), ECD (Efficiency of conversion of Digested food) (0.11%) and FP (0.01g).

Kianpour *et al*. (2014) calculated the nutritional indices of *P. xylostella* on cultivars of cabbage. Feeding indices values *viz.*, RCR and RGR has been reported to be the highest on RGS_{003} (95.68 mg/mg/day) and SLM_{046} (0.382 mg/mg/day) respectively. The authors found the highest values of ECI and ECD on SLM_{046} *i. e.*, 2.298 and 2.471 per cent respectively. From the study the author concluded SLM_{046} as susceptible cultivar and RGS_{003} as resistant cultivar to *P. xylostella*.

Kouhi *et al*. (2014) studied the nutritional indices of fourth, fifth and sixth instars of tomato fruit borer, *H. armigera*, on different tomato cultivars *viz*., Sum 6108 fl, Cal JN3, Korral, Super crystal, CH falat, Hedriogrande, Super strain B and Riogrande UG. Among the cultivars evaluated, CI and AD were reported to be the highest on CH falat whereas ECI and ECD values on Cal.JN3. In fifth instar larva CI and AD values were reported to be the highest on Super crystal (8.80) and Rio grande UG (96.305%) respectively, whereas ECI and ECD values on Super strain B *i. e*., 18.13 and 19.68 per cent respectively. In sixth instar CI and AD were reported to be the highest on Super strain B (5.33) and CH falat (92.94%) respectively whereas ECI and ECD values on Hedriogrande. For all the instars the highest and lowest values of ECI and ECD were reported to be on Hed rio grande and Rio grande UG. From the experiment the authors concluded that Rio grande UG as unsuitable host for *H. armigera*.

Naik (2017) has calculated the feeding indices *viz*., AD, ECI, ECD and CI of *A. janata* on castor genotypes with different blooms *viz*., DPC-9 (zero bloom), DCH-177 (single bloom), PCH-111, 48-1 (double bloom), DCH-519 (triple bloom) and GCH-4 (triple bloom). During third instar AD and ECI values of about 0.953 mg and 0.479 mg has been reported to be the highest on GCH-4 (triple bloom) whereas ECD and CI values as the highest on 48-1 (double bloom) (0.087 mg) and DPC-9 (zero bloom) (0.0091 mg) respectively. During fourth instar AD and ECI values were reported to be the highest on GCH-4 (Triple bloom) (0.913 mg) and DPC-9 (zero bloom) (0.84 mg) respectively. Whereas ECD and CI has been reported to be the highest on 48-1 (double bloom) (0.283 and 0.074 respectively). At fifth instar stage AD and ECI values has been reported as the highest on GCH-4 (triple bloom) (0.737 mg) and DCH-519 (triple bloom) (0.854 mg) respectively whereas ECD and CI values as the highest on DPC-9 (zero bloom) (0.675 and 0.914) respectively. Among the genotypes evaluated by the author, GCH-4 was reported as most resistant genotype compared to other genotypes.

2.3. STUDIES ON GROWTH AND DEVELOPMENT OF CASTOR SEMILOOPER, *P. algira* ON CASTOR GENOTYPES WITH DIFFERENT BLOOMS

2.3.1. Bionomics of lepidopteran insect pests on castor and other major crops

Khan (1946) studied the biology of *A. janata* on castor. The author reported on biological parameters such as egg duration; larval period (first, second, third and forth instar duration); pupal period; pre-oviposition period and oviposition period as 3-4; 12-13 (2, 2, 2 and 5-7 days); 11-27; 28 and 6-21 days respectively.

Srivastava and Pande (1946) conducted a study on bionomics of castor semilooper, *A. janata* on castor. They have recorded observations such as egg, larval, pre-pupal, pupal and adult durations, including instar wise duration of larva. Duration of egg, larva, pre-pupa, pupa and adult were reported to be about 2-4, 10-16, 1-2, 10-15, 38 ± 2 days.

Garad *et al*. (1985) studied the larval and post-larval development of *S. litura* on host plants *viz*., castor, okra, sunflower and groundnut in which they mentioned about larval duration and mean larval weight on the 11th day of age on castor as 11.5 days and 941.26 mg from which author concluded castor as most suitable host for rearing *S. litura*.

Holihosur (1985) made a study on biology of *A. janata* on castor and reported on egg; larval and pupal duration as 3-4; 12-13 and11-27 days respectively.

Islam (1988) has conducted an experiment to study the biology, seasonal incidence, host range and damage potential of the castor hairy caterpillar, *Euproctis lunata* (Lymentridae: Lepidoptera) on castor. Castor hairy caterpillar has been reported to undergo six larval instars, with first, second, third, fourth, fifth and sixth larval duration of about 3.3 ± 0.07, 3.5 ± 0.08, 3.7 ± 0.11, 4.7 ± 0.12 and 5.0 ± 0.15 days respectively. Male and female longevity was reported to be about 4.00 ± 0.16 and 4.45 ± 0.13 days respectively. The author reported that consumption of leaves was more in case of fifth and sixth instars compared to first four instars.

Ganesha *et al*. (2013) studied on the biology of shoot and capsule borer of castor (Pyralidae: Lepidoptera) on castor. Their results revealed that, biology of castor shoot and capsule borer lasted for about 26. 29 ± 0.56 days with mean ovipositional, incubation, larval, pupal, adult male longevity and female adult longevity of about 1.41 ± 0.14, 2.66 ± 0.17, 11.33 ± 1.92, 10.51 ± 0.85, 8 to 9.45 and 9 to 10.65 days. Castor shoot and capsule borer has been proved to have fecundity of 95.7 ± 10.23 days with egg viability of 72.8 to 88.55 per cent.

Manjunatha *et al.* (2014) studied the biology of *A. janata* on castor. Observations such as duration and morphometrics of egg, larva, pupa and adult has been reported. The duration of incubation, larval, pre-pupal, pupal, total developmental, pre-mating, pre-oviposition and oviposition periods were reported to last for about 2-4, 15-21, 1-2, 15-20, 34-37, 1-3, 1-3, 2-3 days respectively. Female *A. janata* reported to last for 12-14 days possessing fecundity of 438-483 eggs and viability of 6.68-86.81 per cent. Male adult has been reported to last for 8-10 days.

Sontakke and Chowdhury (2014) studied the biology of castor spiny butterfly on castor. Biology was reported to be about 34.62 days including egg, larval, pupal periods and male; female adult longevity lasting for about 5.2, 14.4, 7.02 and 7.3; 8.1 days respectively. Number of larval instars were reported to be about five instars with first, second, third, fourth and fifth instars living for about 2.71, 2.81, 2.21, 3.4 and 3.3 days respectively.

Yashdev *et al.* (2014) studied on bionomics of *A. janata* on castor. They reported on biological parameters such as duration of life stages such as egg, larva, pupa and adult as 2.32 ± 0.2, 11.9 ± 0.54, 8.95 ± 0.43 days respectively. The pre-oviposition, oviposition and post oviposition period ranges from 1-3, 4-7 and 3-6 days respectively. The average moth emergence was reported to be 1:0.85 (male: female). Female moth having fecundity of 351.2 ± 26.84 eggs during life span reported to live for 11.2 days, whereas male adult reported to live on an average of 9.3 days.

Kamboj *et al*. (2015) studied the biology of castor hairy caterpillar. *E. lunata*. They reported on biological parameters such as incubation period; larval duration (first, second, third, fourth, fifth and sixth instar); pupal, male adult and female adult duration as 5-10; 62 (5, 8, 10, 11, 13 and 15 days); 12-19; 31.02 and 36.06 days respectively.

Ansari *et al*. (2016) studied the biology of *Trabala vishnou* (Lefebvre) on castor. The authors reported that *T. vishnou* takes nearly 54.46 days to complete the entire life cycle with mean egg; larval and pupal period lasting for about 8.8 and 7.2; 54.46 and 52.63; 16 and 18 days in first and second generations respectively. Larval stage was reported to pass through six instar with mean duration of 7.18 and 6.58; 7.25 and 7.45; 8.12 and 8.85; 7.75 and 7; 7.25 and 7; 7.75 and 8.55 days in first and second generations respectively. Adult longevity of male and female in first and second generations has been reported to be about 9.25 and 8.65; 11.75 and 10.84 respectively.

Kumar *et al*. (2017) studied the biology of castor shoot and capsule borer, *C. punctiferalis* Guenee on castor (*R. communis* L.). The authors experiment revealed that life cycle of *C. punctiferalis* lasted for about 30.65 days including egg, larval, pre pupal and pupal lasted for about 2.51, 13.25, 2.75 and 9.5 days. Male and female adult longevity was reported to be about 8 and 9.5 days respectively. Larva was reported to undergo five instars with first, second, third, fourth and fifth instar duration lasting for about 2.85, 2.5, 2.25, 2.7 and 2.95 days respectively.

Ramaiah and Maheshwari (2018) studied the biology of *S. litura* on castor under laboratory conditions. Egg, larval, pupal durations were reported to be about 3, 23.9 and 17.8 days respectively. Larva has been reported to undergo five instars with first, second, third, fourth and fifth instar duration lasting for about 2.5, 2.5 3.5, 2.5 and 2.5 respectively. Duration of first, second, third, fourth and fifth instars has been reported to about 2.5, 2.5, 3.5, 2.5 and 3 days respectively. Length of larval instars were reported to be about 1.49, 4.44, 11.92, 23.15, 37.72 mm of first, second, third, fourth and fifth instars respectively. Male and female adult longevity was reported to be about 6.4 and 8 days respectively. Female possess fecundity of 890.5 ± 16.26 eggs with pre-oviposition and oviposition period of about 3.11 and 4.00 days respectively. Width of the first, second, third, fourth and fifth instar was reported to about 0.23, 0.51, 1.49, 3.44 and 5.94 mm respectively. Head capsule width of first, second, third, fourth and fifth instar was reported to be about 0.25, 0.36, 0.50, 0.70 and 1.11 mm respectively.

2.3.2. Effect of plant resistance on biology of insect pests

Fugi *et al*. (2005) studied the biology of *Anticarsia gemmatalis* on four soybean genotypes *viz*., PI 229358, IAC 17, IAC 24 and IAC PL-1. Among the genotypes experimented, IAC PL-1 was reported as highly susceptible host with shorter larval (11.9 days) and higher pupal duration (8.4 days). Whereas PI 229358 genotype was reported to be resistant to *A. gemmatalis* with the highest larval (13.6 days) and lowest pupal duration (8.2 days).

Halder and Srinivasan (2007) who have studied the six biochemical parameters, *i.e*., total sugar, reducing sugar, non-reducing sugar, amino acids, proteins and phenols in urd bean pods in relation to the expression of varietal reaction towards the spotted pod borer, *Maruca vitrata* in ten mung bean cultivars (LGG-450, LGG460, LGG-492, LGG-485, LGG-483, LGG-489, LGG-407, LGG-523, MGG348 and LGG-497), conducted in Andhra Pradesh, India, during the 2003/04 rabi season, phenols were the highest in the resistant cultivar LGG-497 (21.03 mg/g) than the susceptible cultivar LGG-450 (20.00 mg/g).

Ebrahimi *et al*. (2008) studied the biology of *Plutella xylostella* on five rapeseed varieties *viz*., Licord, Modena, Okapi, RGsoo3 and REGX kobra. Among the varieties examined, the author observed lowest larval duration has been reported on Licord whereas the highest larval duration was reported on

Okapi. Fecundity of females developed from larvae fed on REGX kobra (173.75) and Okapi (92.27) has been reported to be the highest and lowest respectively. Shortest and longest adult longevity were reported on Modena (5.00) and RGsoo3 (10.02 days). From this experiment, Lincord variety has been considered to be most susceptible and Okapi as highly resistant to *Plutella xyllostella*.

Hariprasad and Emden (2010) observed the highest fecundity of diamondback moth when larvae were reared on Chinese cabbage cultivar of *Brassica rapa* compared to Red drumhead, Offenham compacta and Minicole cultivars of *Brassica oleracea*. Chinese cabbage cultivar was reported to have least surface wax on leaves compared to the other cultivars thus making it highly susceptible for growth and development of diamondback moth larva. Whereas Minicole cultivar was reported to be highly resistant due to presence of surface wax which acted as barrier for feeding, growth and development of diamondback moth.

Farahana *et al*. (2011) compared the biology of *Spodoptera exigua* on soybean cultivars *viz*., Sahar, JK, BP, Williams and L17. The authors reported preimaginal development period of males and females as the highest and lowest on L17 (30.17 days) and BP and Sahar. Adult longevity of male and female as longest on Williams (13.86 days and 20.20 days respectively) and Sahar (9.36 and 12.75 days respectively) respectively; Life span as longest and shortest on L17 (44.86 days) and Sahar (39 days); the highest percentage of egg and larval mortality L17 (73.48% and 39.35% respectively) whereas lowest on Williams (57.96% and 10.81% respectively); the highest pupal mortality on Sahar (12.5%); the highest female pupal weight on Sahar (88.10 mg) and lowest on BP (73.00 mg); number of eggs laid per female per day as the highest on Williams (569.50 eggs) and lowest on Sahar (448.90 eggs). Among the cultivars evaluated L17 has been reported to be resistant to *S. exigua* compared to other cultivars.

Sadozai and Khan (2014) studied the developmental response of *Pieris brassicae* (Lepidoptera: Pieridae) on ten cauliflower cultivars *viz*., White corona, Snow mystique, Snow grace, Local, Clima, Semenis RS 5340, Sydney, Snow crown, White magic and AX-2034. The authors report focused on biological parameters *viz*., larval developmental period, larval length, per cent larval mortality and pupal weight. Among the genotypes evaluated. Larval mortality has been reported to be the highest on AX-2034 (86.66%) followed by Semeins RS 5340 (46.66%), Snow mystique (40%), Snow crown (40%), Sydney (33.3%), White corona (20.66%) and Snow grace (20.00 %) while lowest value of 6.60 per cent on Clima. Larval length has been reported to be significantly higher on White magic (35.13 mm) and lower on AX-2034 (24.55 mm). From the experiment authors concluded AX-2034 as resistant or poor host for *P. brassicae*.

Amin (2015) investigated the morphological and biochemical characteristics of the CB1, CB3, CB5, CB8 and CB12 cotton varieties and their resistance to *Spodoptera litura*. Among the varieties, lowest larval weights of first (9.00 mg), second (21.10 mg), third (166.20 mg), fourth (173.30 mg) and fifth instar (1012.60 mg) were reported on CB5 variety which has been ranked as susceptible variety. Whereas lowest values of larval weights of first (8.60 mg), second (16.90 mg), third (140.70 mg), fourth (153.00 mg) and fifth instar (907.8 mg) was recorded on CB12.

Dhillon and Chaudhary (2017) evaluated the six sorghum genotypes *viz*., IS 2123, IS 2205, ICSV 700, ICSV 708, ICSV 25066 and Swarna. Among the genotypes evaluated, Swarna has been considered as highly susceptible genotype with lowest larval duration (35.20 days) and the highest larval weight (135.30 mg), whereas IS 2123 genotype has been considered by the author as highly resistant genotype with lowest larval weight (28.40 mg) and the highest larval duration (48.70 days).

Naik (2017) had studied on biology of *A. janata* on six castor genotypes such as DPC-9 (zero bloom), DCH-177 (single bloom), PCH-

111(double bloom), GCH-4 (triple bloom), DCH-519 (triple bloom) and 48-1 (double bloom). The author reported that longest larval duration, adult longevity, total life cycle with more larval weights and fecundity of *A. janata* had been observed when it was reared on DPC-9 (14.42 ± 0.87 days; 13.15 ± 0.93; 40.77 ± 1.52 days and 1.253 ± 0.129 g; 316 ± 20.07 eggs; respectively). Whereas shortest larval duration, adult longevity, total life cycle with less larval weight and fecundity of *A. janata* had been reported when reared on GCH-4 (12.42 ± 0.81 days; 12.75 ± 0.73 days; 36.47 ± 3.21 days and 0.925 ± 0.218 g; 234.25 ± 20.27 eggs, respectively), followed by DCH-519 (12.50 ± 0.58 days; 12.65 ± 0.58 days; 37.15 ± 1.25 days and 1.191 ± 0.095 g; 231.0 ± 13.16 eggs, respectively) reported as least preferred hosts for growth and multiplication of *A. janata*. From this experiment he concluded that DPC-9 (zero bloom) was the most preferred and GCH-4 (triple bloom) as least preferred genotype by *A. janata*.

Almeida *et al*. (2019) evaluated the antibiosis resistance in nine soybean cultivars *viz.*, P98Y30RR, NA 7337 RR, SYN 1163 RR, NK 7059 RR, ANTA 82 RR, BRS 8160 RR, BRSGO Jatal, IAC 100 and M 7110 IPRO. against *Heliothis virescens*. Among the cultivars evaluated, IAC 100and M 7110 IPRO have been reported to possess antibiosis resistance. M 7110 IPRO was reported to possess toxins that caused mortality in early instars of *H. virescens*, whereas IAC 100 has been recorded with the highest larval duration (29.70 days) and larval weight (34.90 mg). Lower larval duration higher larval weights were reported on P98Y30 RR (25.50 days and 70.30 mg respectively), BRSG0 Jatai (27.10 days and 76.70 mg respectively) and BRS 8160 RR (26.30 days and 77.80 mg respectively) and these cultivars have been ranked as susceptible.

Chapter – III

Material and Methods

Chapter III

MATERIAL AND METHODS

The present studies on "**Effect of castor genotypes with different blooms on growth and development of castor semilooper, *Parallelia algira* (Linnaeus)**" were carried out at the Insectary, Department of Entomology, S. V. Agricultural College, Tirupati, Andhra Pradesh during 2018-19. The details of materials used and methodologies employed during the course of study are presented in this chapter.

3.1 MAINTENANCE OF CASTOR GENOTYPES (In the net house and field conditions)

3.1.1. Net house

Castor genotypes with different blooms were grown in plastic pots of 23 cm diameter and 20 cm height filled with red soil: vermicompost in 3:1 proportion. Two seeds were sown in each pot and after germination the pots with plants were maintained in the net house conditions (Plate No. 3a), by frequently watering the plants and the plants were kept free from attack of insect pest and disease by frequently observing for any insect pest and disease.

Table3.1 Characters of castor genotypes evaluated in the study (Plate No. 1 and 2)

Genotype	Bloom Type	Plant part with wax
DPC-9	Zero	Absent
48-1	Double	Petiole and leaf lower surface
GCH-4	Triple	Petiole, leaf upper and lower surfaces

Source: DOR, 1977

3.1.2. Field

‘Kranthi’ a popular castor variety was sown in the field with plot size of 6 X 6 m^2 with a spacing of 90 X 60 cm between rows and plants (Plate No. 3b). Leaves from these plants were used for feeding and maintenance of the base population of *Parallelia algira* in the laboratory.

3.2 ESTABLISHMENT OF BASE POPULATION OF CASTOR SEMILOOPER, *P. algira*

The base population of *P. algira* was maintained for five generations in the Insectary, Department of Entomology, S. V. Agricultural College, ANGRAU, Tirupati, Andhra Pradesh at 25 ± 2 ºC, 75 ± 5 per cent RH during 2018-19. Late instar larvae of *P. algira* were collected from castor plants near college farm and Regional Agricultural Research Station (RARS), Tirupati and were reared on leaves of Kranthi variety upto pupation. Male and female pupae were separated based on position of genital opening (Genc *et al*., 2017) and were kept in individual boxes of 8 X 4 cm size till adult emergence. Adults emerged from these pupae were released into 26 X 26 cm^2 size ovipositional cages and were provided with 20 per cent honey solution mixed with proteinex powder (manufactured by Nutrica international private limited, containing protein, carbohydrates, sugar and Vitamins) as food material (Plate No. 4).

The adults were allowed to mate and lay eggs on a fully emerged leaf, kept in erect position with its petiole dipped inside water in a conical flask.

After 24 hours, leaves with eggs were collected and placed inside a plastic trough lined with moist blotting paper to keep the leaves fresh. Neonates or first instars emerging from these eggs were collected carefully with a soft camel brush and were used in the experiments.

New leaves were provided every day for seven to eight days continuously till the egg laying was stopped.

Upper surface

Lower surface

DPC-9 (Zero bloom)

Upper surface

Lower surface

48-1 (Double bloom)

Upper surface

Lower surface

GGCH-4 (Triple bloom)

Plate 1. Leaf characters of castor genotypes evaluated in the study

DPC-9 48-1 GCH-4

Plate 2a. Petioles of three castor genotypes

DPC-9 48-1 GCH-4

Plate 2b. Stems of three castor genotyeps

Plate 2. Stem and petiole characters of three castor genotypes with different blooms

GCH-4	DPC-9	48-1
(Triple bloom)	(Zero bloom)	(Double bloom)

Plate 3a.Pot culture of castor genotypes with different blooms grown under net house conditions

Plate 3b.Castor plants grown at college farm

Plate 3. Maintenance of castor plants

Plate 4. Oviposition cage containing *P. algira* adults and castor leaves in conical flask

3.3. STUDIES ON FEEDING AND OVIPOSITIONAL PREFERENCE OF CASTOR SEMILOOPER, *P. algira* ON CASTOR GENOTYPES WITH DIFFERENT BLOOMS

3.3.1. Feeding preference of *P. algira* (Free choice condition)

Leaves of castor genotypes with different blooms at maximum vegetative stage were taken to study the feeding preference of *P. algira* under free choice condition. Leaves of three castor genotypes were cut into small discs of 3 cm diameter with the help of a cork borer and were placed in Petri plates of 14 cm diameter in such a way that each leaf disc was at equidistance from the other disc and the edges of leaf discs does not touch each other. Blotting paper was placed at the bottom of the Petri plate and was kept moist to prevent drying of leaf discs. A total of seven replications were taken, for the present study. Ten first instar larvae of *P. algira* were released into centre of each Petri plate containing leaf discs (Pate No. 5). Larvae were allowed to choose the leaf disc freely under free choice condition. After 24 hours, number of larvae on each leaf disc of different genotypes were counted and the genotype with highest number of larvae was ranked as preferred host compared to other genotypes.

This experiment was carried out for newly emerged first, second and third instar larvae of *P. algira*.

The data collected on feeding preference of *P. algira* was subjected to statistical analysis by using Statistical Package for the Social Sciences (SPSS 20).

3.3.2 Ovipositional preference of *P. algira* (Free choice condition)

Fully developed fresh castor leaves of different genotypes having different blooms were taken to study the ovipositional preference of *P. algira* under free choice condition. Leaves of three castor genotypes were placed separately in conical flasks filled with water up to the neck with petioles dipped in water. Conical flasks containing leaves were placed at equidistant from each other making sure that the leaves do not touch each other in a cage of 60 X 30 cm size. A pair of male and female adults emerged on the same day were released into the ovipositional cages and were provided with 20 per cent honey solution mixed with proteinex powder as food material (Plate No. 6). The adults were allowed to mate and lay eggs on leaves of different genotypes having different wax bloom. After 24 hours leaves with eggs were collected and total number of eggs laid on each genotype was counted. New leaves were provided everyday for seven to eight days continuously till the egg laying was stopped. Genotype with highest number of eggs laid was ranked as highly preferred one compared to the other genotypes.

Data collected on ovipositional preference of *P. algira* was subjected to statistical analysis by using Statistical Package for the Social Sciences (SPSS 20).

4. STUDIES ON ESTIMATION OF FEEDING INDICES OF CASTOR SEMILOOPER, *P. algira* ON CASTOR GENOTYPES WITH DIFFERENT BLOOMS

P. algira larvae of uniform size and weightof 80 to 90 mg (third instar) were used in the present study to calculate the feeding indices of *P. algira* on leaves of castor genotypes with different blooms. A fully developed castor leaf was cut into leaf discs of 5 cm diameter using a cork borerand was placed in Petri plates of 9 cm diameter. A single larva was released in each Petri plate containing individual castor leaf discs of different blooms. Blotting paper was placed at the bottom of the Petri plate and was kept moist to prevent drying of the leaves (Plate No. 7). All together there were three Petri plates with individual leaves of different genotypes having different blooms. A control was kept with leaf disc alone to calculate the per cent moisture loss of the leaves during the course of study. The leaves were provided adlib to the feeding larvae till pupation. Observations such as weight of leaf disc before and after feeding and weight of larva before and after feeding, weight of

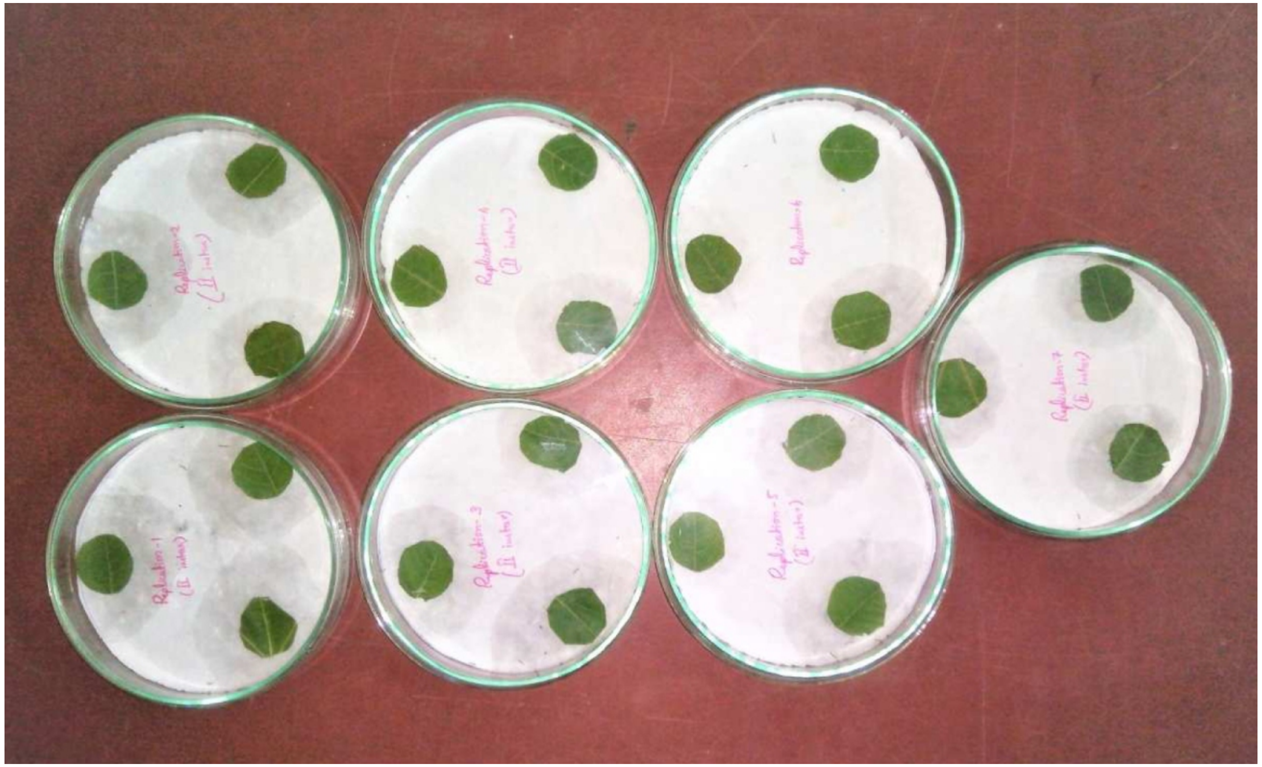


Plate 5. Petri plates containing leaf discs of three castor genotypes and first instar larvae of *P. algira*

Plate 6. Oviposition Cages containing three castor genotypes and adults of *P. algira* released to study ovipositional preference

Plate 7. Petri plates containing third instar *P. algira* larvae on leaf discs of three genotypes

Plate 8. Plastic boxes containing leaf discs of three castor genotypes with different blooms along with *P. algira* larva

faecal matter were taken for every 24 hours. Weights were measured using an electronic balance (Afcoset Max-210 g; Min-100 mg). Feeding indices were calculated using formulae given by Waldbauer, 1968. Totally there were seven replications in the present study.

$$AD = \frac{\text{Weight of food ingested - Weight of faecal matter}}{\text{Weight of food ingested}} \times 100$$

$$ECI = \frac{\text{Weight gained by larvae during feeding period}}{\text{Weight of food ingested}} \times 100$$

$$ECD = \frac{\text{Weight gained by larvae during the feeding period}}{\text{Weight of food ingested- Weight of faecal matter}} \times 100$$

$$CI = \frac{\text{Weight of food ingested}}{\text{Duration of feeding period x Mean larval weight}}$$

AD = Approximate Digestibility; ECI= Efficiency of Conversion of Ingested Food to body substance; ECD = Efficiency of Conversion of Digested food to body substance; CI= Consumption Index

Feeding indices data of *P. algira* was subjected to statistical analysis by using Statistical Package for the Social Sciences (SPSS 20).

3.5 STUDIES ON GROWTH AND DEVELOPMENT OF CASTOR SEMILOOPER, *P. algira* ON CASTOR GENOTYPES WITH DIFFERENT BLOOMS

Newly hatched neonates of *P. algira* were released onto leaves of castor genotypes with different blooms, separately into individual plastic boxes of 8 X 4cm size (Plate No. 8). There were a total of ten replications for each genotype, with ten larvae in each replication. Leaves of different genotypes were provided to the larvae adlib till the end of experiment *i. e.,* upto adult emergence.

Observations were taken on number of instars, total larval duration, instar wise duration (in days), larval weight (in g), head capsule width of larva (in mm), length of larva (in mm or cm). Change of instar was noted based on presence of exuviae. Duration between two moults was taken as duration of a larval instar. Head capsule width of larvae, length of first and second instar larvae were measured using stereo microscope. Length of third, fourth and fifth instar were measured using a 30 cm long scale, larval and pupal weights were measured using electrical balance (Max-210 g; Min-100 mg).

After larvae reached pupal stage, observations were taken on pupal duration, length and width of pupae (mm), weight of the pupae and the pupae were sexed on the basis of position of genital opening (Genc *et al* . 2017).

After adult emergence, adults emerged from pupa of larvae reared on each genotype with different bloom were offered with their respective leaves for oviposition. The adults were provided with 20 per cent honey solution as food material and were allowed to oviposit on the respective genotypes. The pre-oviposition, oviposition duration were recorded. After oviposition, fecundity and egg duration was noted along with longevity of the adults.

Data regarding biology of *P. algira* was subjected to statistical analysis by using Statistical Package for the Social Sciences (SPSS 20).

Chapter – IV

Results & Discussion

Chapter IV

RESULTS AND DISCUSSION

The results of experiments conducted on "Effect of castor genotypes with different blooms on growth and development of castor semilooper, *Parallelia algira* (Linnaeus)" are furnished and discussed here under.

4.1. STUDIES ON FEEDING AND OVIPOSITIONAL PREFERENCE OF CASTOR SEMILOOPER, *P. algira* ON CASTOR GENOTYPES WITH DIFFERENT BLOOMS

4.1.1. FEEDING PREFERENCE OF *P. algira* (Free choice condition)

Data on feeding preference of first, second and third instar larvae of *P. algira* among the three castor genotypes with different blooms *i. e*., DPC-9 (zero bloom), 48-1 (double bloom) and GCH-4 (triple bloom) was recorded after 24 hours of larval release by counting number of larva on each castor genotype (Plate No. 9) and is presented in Table 4.1, 4.2 and 4.3.

4.1.1.1. First instar

Highest mean number of first instar larva was observed on 48-1 (5.57) followed by GCH-4 (3.71) whereas the lowest mean number of larvae was observed on DPC-9 (0.42) which was significantly different from other two genotypes (Table 4.1).

Table 4.1. Feeding preference of first instar larva of *P. algira* among castor genotypes with different blooms

Genotype	Mean no. of larvae (in numbers)
DPC-9 (zero bloom)	0.42^{b}
48-1 (double bloom)	5.57^{a}
GCH-4 (triple bloom)	3.71^{a}
LSD at 0.01	2.54

Values followed by same letter are not significantly different at 0.01 level

4.1.1.2. Second instar

Statistically no significant differences were observed in the feeding preference of second instar larva of *P. algira* on castor genotypes with different blooms (Table 4.2).

Table 4.2. Feeding preference of second instar larva of *P. algira* among castor genotypes with different blooms

Genotype	Mean no. of larvae (in numbers)
DPC-9 (zero bloom)	2.86[a]
48-1 (double bloom)	3.14[a]
GCH-4 (triple bloom)	3.86[a]
LSD at 0.01	3.67 (NS)

Values followed by same letter are not significantly different at 0.01 level

4.1.1.3. Third instar

In third instar, mean number of third instar larvae was highest on GCH-4 (4.86) followed by 48-1(3.00) and DPC-9 (2.14) (Table 4.3).

Table 4.3. Feeding preference of third instar larva of *P. algira* among castor genotypes with different blooms

Genotype	Mean no. of larvae (in numbers)
DPC-9 (zero bloom)	2.14[b]
48-1 (double bloom)	3.00[ab]
GCH-4 (triple bloom)	4.86[a]
LSD at 0.01	1.86

Values followed by same letter are not significantly different at 0.01 level

Plate 9. Petri plate containing *P. algira* larva (after 24 hours of larval release)

Among the genotypes evaluated for larval preference of first, second and third instar of *P. algira*, DPC–9 (zero bloom) had the lowest number of first, second and third instar caterpillar indicating that DPC-9 (zero bloom) was least preferred compared to 48-1 (double bloom) and GCH-4 (triple bloom). Zero bloom varieties of castor was earlier been designated as susceptible to attack by lepidopteran caterpillar reported by several workers and hypothesized that presence of wax bloom on castor confers resistance to insect herbivores including lepidopteran caterpillar.

The present results were in accordance with Sarma *et al*. (2006) who evaluated four castor genotypes *viz*., local red (gloomy), local red (non-gloomy), local green (gloomy) and local green (non gloomy) for their resistance to two major defoliators *viz*., *A. janata* and *S. litura*. Among the genotypes tested the local red gloomy type has been reported to show high resistance with least mean population of both the defoliators. Whereas the local green non-gloomy proved to be least resistant with highest population of semilooper (5.15/ plant); tobacco caterpillar (6.75/ plant) and also with severe defoliation of 42.5 per cent. The authors concluded that varieties with wax bloom on the plant surface was less damaged compared to non-gloomy type varieties.

Laxman (2014) have conducted an experiment on evaluation of genotypes against major defoliators and sucking pests of castor. They have evaluated 21 genotypes of castor such as DPC-9 (zero bloom), DCS-9 (double bloom), 48-1 (double bloom), Haritha (double bloom), PCH-288 (double bloom), PCH-111 (double bloom), Kiran (double bloom), PCH-106 (double bloom), PCH222 (double bloom), PCH-262 (double bloom), Kranthi (double bloom), M-574 (triple bloom), RG- 1180 (triple bloom), PCH-254 (triple bloom), GCH-4 (triple bloom), PCH-282 (triple bloom), PCH-248 (triple bloom), PCH-294 (triple bloom), RG-2835, RG-2928 and RG-776. The author reported that double and triple bloom genotypes with red stem and spiny parts as highly resistant to *A. janata* except 48-1 which was reported to be susceptible.

Though bloom varieties having more wax load confers resistance to insect herbivores in terms of growth, development and multiplication, wax on plant surfaces also have an additional role of acting as phagostimulants to insect herbivores (Eigenbrode and Espelie, 1995). Similar results were also reported by Hamilton *et al*. (1979) observed that hydroxyl β-diketone, the wax component from the shoot surface of oats, acts as an attractant for the frit fly, *Oscinella frit*. Albert and Parisella (1988) reported that chemicals present in epicuticular wax of four host plants of eastern spruce budworm *viz.,* Balsam fir, White spruce, Black spruce and Red spruce stimulated the feeding preference of spruce budworm. Ulmer *et al.* (2002) studied the feeding preference of *Plutella xylostella* on glossy and waxy *Brassica rapa* (L.) lines. The author reported that waxy plants have been proved to be highly preferred compared to glossy plants (without wax).

In the present investigation, DPC-9 having no wax on the leaf surface, attracted very few first, second and third instar caterpillar of *P. algira* compared with 48-1 (double bloom) and GCH-4 (triple bloom). This probably is due to the fact that DPC-9 that does not have any surface wax and phago-stimulants therein, could not be able to elicit any preference behavior in larvae of *P. algira*. Genotypes 48-1 and GCH-4 that are double and triple bloom genotypes, had probably phagostimulant compounds dissolved within the wax bloom, that elicited preference in the larvae of *P. algira* that resulted in more number of larvae on 48-1 (double bloom) and GCH-4 (triple bloom) at the end of larval preference experiment.

4.1.2. OVIPOSITIONAL PREFERENCE OF, *P. algira* (Free choice condition)

Statistically no significant differences were observed in ovipositional preference of *P. algira* adult on castor genotypes with different blooms (Table 4.4).

Table 4.4. Ovipositional preference of *P. algira* among castor genotypes with different blooms.

Genotype	Mean number of eggs laid (in numbers)
DPC-9 (zero bloom)	4.08[a]
48-1 (double bloom)	7.65[a]
GCH-4 (triple bloom)	4.23[a]
LSD at 0.01	7.40 (NS)

Values followed by same letter are not significantly different at 0.01 level

4.2. ESTIMATION OF FEEDING INDICES OF CASTOR SEMILOOPER, *P. algira* LARVA ON CASTOR GENOTYPES WITH DIFFERENT BLOOMS

Data regarding feeding indices was recorded after 24 hours of larval release (Plate No. 10) and presented in Table No 4.5.

4.2.1. Approximate Digestibility (AD)

Though there were no significant difference between three castor genotypes with different blooms with respect to AD higher value of AD was observed in *P. algira* when reared on GCH-4 (60.90 %) followed by 48-1 (55.03 %) and DPC-9 (53.01 %) (Table 4.5).

4.2.2. Efficiency of Conversion of Ingested food to body substance (ECI)

Though there were no significant difference between three castor genotypes with different blooms with respect to ECI, higher value of ECI was observed when larva was fed on DPC-9 (39.83 %) followed by 48-1 (36.19 %) and GCH-4 (33.26 %) (Table 4.5).

4.2.3. Efficiency of Conversion of Digested food to body substance (ECD)

Though there was no significant difference between three castor genotypes with different blooms with respect to ECD, higher value of ECD of *P. algira* larva was observed when larva was fed on DPC-9 (62.43 %), the values were lower when larva was fed on GCH-4 (53.70 %) (Table 4.5).

4.2.4. Consumption Index (CI)

Though there was no significant difference between three castor genotypes with different blooms with respect to CI values higher values were observed when larva was fed on GCH-4 (1.075) whereas the values were lower when larva was fed on DPC-9 (0.93) (Table 4.5).

Table 4.5. Feeding indices of *P. algira* on castor genotypes with different blooms.

Genotype	AD (%)	ECI (%)	ECD (%)	CI
DPC-9 (Single bloom)	53.01^{a}	39.83^{a}	62.43^{a}	0.93^{a}
48-1(double bloom)	55.03^{a}	36.19^{a}	68.44^{a}	0.93^{a}
GCH-4 (triple bloom)	60.90^{a}	33.26^{a}	53.70^{a}	1.07a
LSD at 0.01	14.75 (NS)	18.16 (NS)	26.02 (NS)	0.21 (NS)

Values followed by same letter are not significantly different at 0.01 level

In the present investigation when third instar larvae of *P. algira* were allowed to feed on leaf discs of castor genotypes with different wax load,

Plate 10. Petri plates containing *P. algira* larvae and leaves of three castor genotypes (24 hours after larval release)

lower values of ECI and ECD and higher values of AD and CI (Table 4.5) were observed when the larvae were allowed to feed on leaf disc of genotype GCH-4 which was a triple bloom variety followed by 48-1 (double bloom) and DPC-9 (zero bloom) (Table 4.5).

The feeding indices generally gives an indication of growth and development of insect herbivores which is governed by plant resistance. Consumption Index indicates the amount of food ingested by the insect. Efficiency conversion Index defines the ability of an insect to use the food consumed for growth and development. Approximate Digestibility indicates the ability of insect to digest food. Efficiency of Conversion of Digested food refers to the efficiency of the insect to convert digested food to growth and development.

In the present investigation low ECI and ECD values for *P. algira* fed on leaf discs of GCH-4 indicate that GCH-4 was the least preferred host for growth and development of larvae of *P. algira*. Larvae of *P. algira* feeding on leaf discs of DPC-9 had highest ECI and ECD values indicating that DPC-9 genotype was more preferred for growth and development of larvae of *P. algira* (Table 4.5).

Genotype GCH-4 which was reported earlier as the least preferred variety (Sarma *et al*. 2006., Naik, 2017., Priya, 2018) also exhibited highest value of CI indicating that GCH-4 was least preferred, as this genotype was nutritionally poor due to higher phenol and lower proteins, total sugars (Naik, 2017) and more surface wax (Priya, 2018) hence the larvae were forced to eat more of less nutritious food to get the required amount of nutrients for the proper growth and development of larvae.

Priya (2018) who reported that GCH-4, a triple bloom genotype had significantly more wax load on leaf surface (1.43 µg. cm^{-2}) than on double and zero bloom genotypes.

GCH-4 having more wax load coupled with more secondary metabolites such as phenols, and less total sugars *etc*, have given GCH-4 as the least preferred genotype for growth and development of *P. algira*.

Lower values of CI values were obtained when larvae were fed on leaf discs of 48-1 (double bloom) and DPC-9 (zero bloom) (Table 4.5) and these two genotypes were reported to be preferred for the growth and development of lepidopteran insects by earlier workers (Naik, 2017., Priya, 2018). As these genotypes had low amount of wax, low phenols, high proteins, total sugars (Naik, 2017), the larva was able to get the required nutrients from a nutritional rich or preferred host *i. e*., DPC-9 and 48-1. The present results were in agreement with Naik (2017) who reported that CI values of *A. janata* has been higher when reared on GCH-4 (0.219) (triple bloom) whereas lower values were reported on DPC-9 (0.914) (zero bloom). Consumption Index of a genotype has shown inverse relationship with its ECI and ECD values *i. e.,* higher the value of Consumption Index lower will be the ECI and ECD of particular genotype and vice versa. The present results were in accordance with Hwang *et al*. (2018) who observed higher consumption rate of *Pieris brassicae* larva on nutritionally poor host compare to nutritionally good host.

Hemati *et al*. (2011) also reported that highest ECI and ECD values of *H. armigera* on potato cultivar 'Satina' was high and gave it the status of good host compared to the lowest ECI and ECD values on tomato and giving it the status of poor host.

Similarly Baghery *et al*. (2013), reported that ECI and ECD values of *H. armigera* has been highest on cowpea which the authors ranked as a preferred host.

4.3. STUDIES ON GROWTH AND DEVELOPMENT OF CASTOR SEMILOOPER, *P. algira* ON CASTOR GENOTYPES WITH DIFFERENT BLOOMS

P. algira life cycle involved egg, larva, pupa and adult stages (Plate No. 11). Larval stage passed through five instars (Plate No. 12). Observations on total and instar wise larval duration; pupal duration; length and head width of larvae; length and width of pupa; adult longevity; fecundity; egg duration were recorded.

4.3.1. EGG

Incubation period of *P. algira* eggs laid by the adult developed from the larvae reared on castor genotypes with different blooms was recorded. *P. algira* adult laid eggs singly on the lower surface and upper surface of leaf. Initially green in color which turned brown color at the time of larval emergence. Shape of the egg was convex on the dorsal surface with well sculptured longitudinal constrictions and flat on the ventral surface. The mean egg duration was longest on DPC-9 (7.00 days) followed by 48-1 (5.80 days) and was shortest on GCH-4 (5.00 days) which were significantly different (Table 4.6).

Table 4.6. Egg duration of *P. algira* reared on castor genotypes with different blooms

Genotype	Mean Egg Duration (in days)
DPC-9 (zero bloom)	7.00[a]
48-1 (double bloom)	5.80[b]
GCH-4 (triple bloom)	5.00[c]
LSD at 0.05	0.36

Values followed by same letter are not significantly different at 0.05 level

Incubation period of *P. algira* was observed to be longest when fed on DPC-9 (zero bloom) and the shortest on GCH-4 (triple bloom). The outcome in the present study can be due to secondary metabolites in the genotypes coupled with differences in surface wax. Longest incubation period of *P. algira* when fed on DPC-9 can be due to presence of highest amount of reducing sugars in DPC-9 (15.15 mg/g) compared to 48-1 (7.49 mg/g) and GCH-4 (10.06 mg/g) (Naik, 2017) and wax (Priya, 2018).

The result of present study agree with that of Peeru *et al*. (2018) who reported a positive correlation of reducing sugars in the various groundnut cultivars *viz*., TCGS-894, ASK-2013-1, K-1563, TCGS-1156, K-1628, Narayani and K6 with incubation period of groundnut leaf bud borer, *Anarsia ephippias*. Among the varieties KK-1563 has been reported to have longest incubation period due to presence of lower amount of proteins (194.42 mg/g) and higher amount of reducing sugars (2.48mg/g) whereas the shortest incubation period has been reported on Narayani containing highest amount of proteins (232.63 mg/g) and the lowest amount of reducing sugars (1.18 mg/g).

4.3.2. LARVA

P. algira larva passed through five instars (Plate No. 11).

4.3.2.1. First instar

First instar of *P. algira* was dark green in color. Statistically no significant difference was observed in head capsule width of first instar of *P. algira* when reared on castor genotypes with different blooms.

Table 4.7. Head capsule width of first instar of *P. algira* larva reared on castor genotypes with different blooms

Genotype	Mean head width of first instar (in mm)
DPC-9 (zero bloom)	0.604[a]
48-1 (double bloom)	0.692[a]
GCH-4 (triple bloom)	0.693[a]
LSD at 0.01	0.120 (NS)

Values followed by same letter are not significantly different at 0.01 level

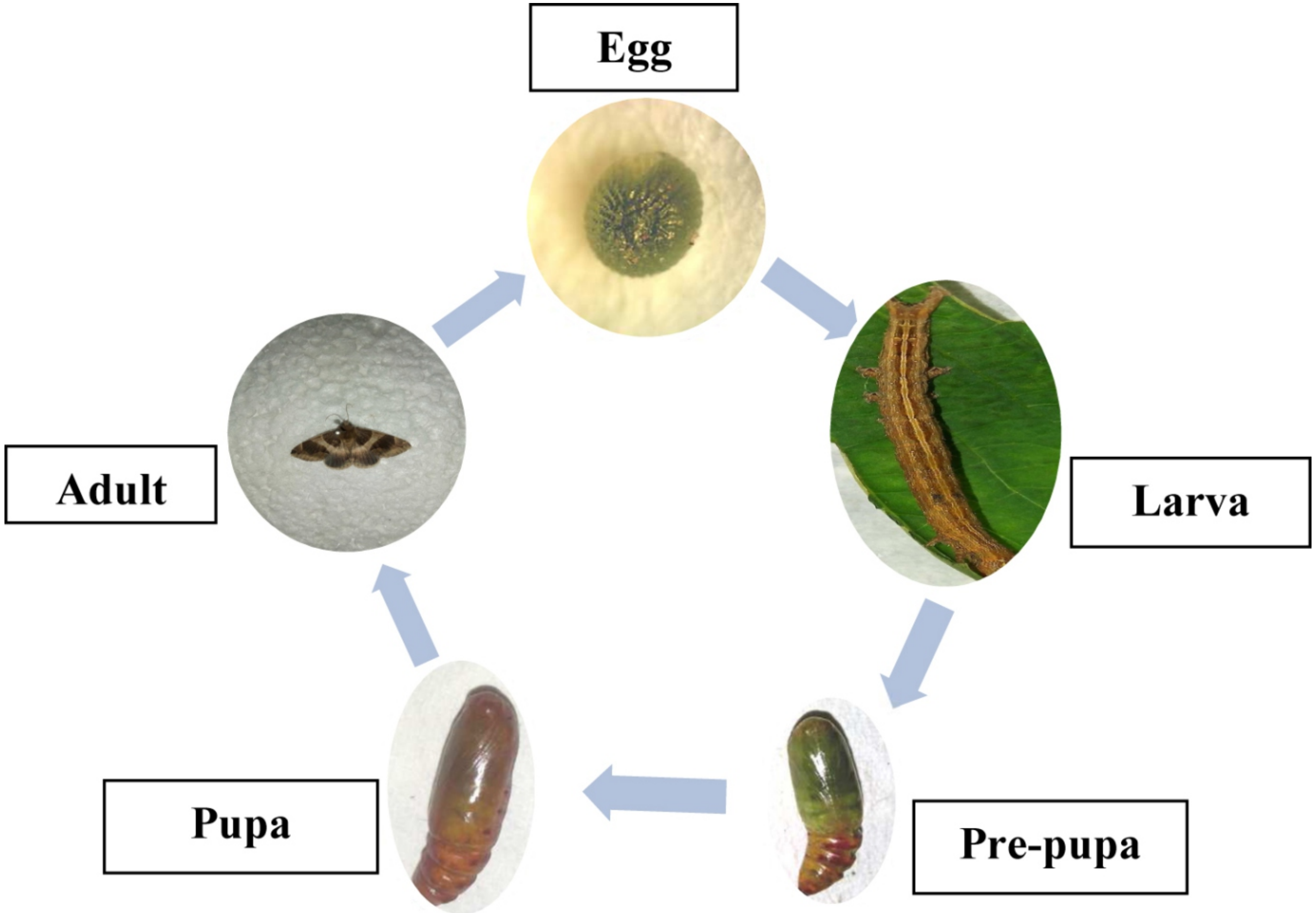
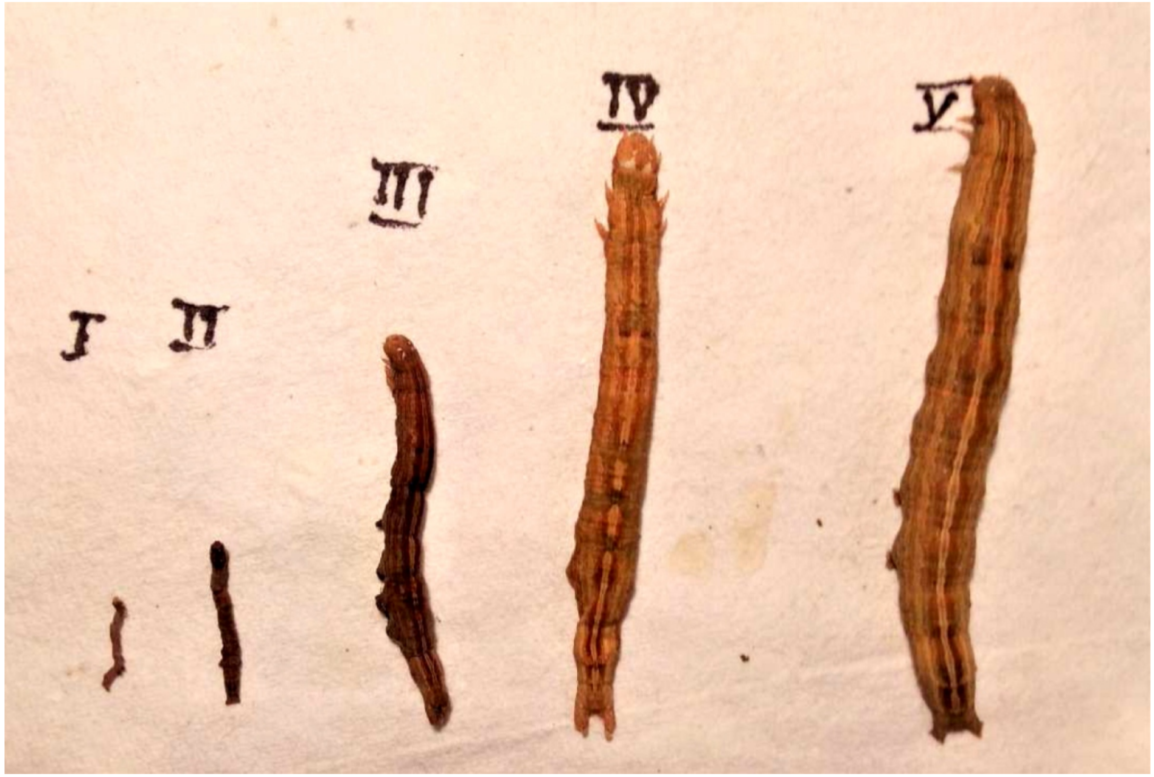


Plate 11. Biology of castor semilooper, *P. algira*



I Instar II Instar III Instar IV Instar V Instar

Plate 12. Larval instars of *Parallelia algira*

Significant differences were observed in length of larvae reared on the three castor genotypes with different blooms. Length of the first instar at emergence was longest when fed on DPC-9 (8.70 mm) followed by 48-1 (8.69mm). Shortest length of the instar was observed when fed on GCH-4 with mean length of 7.57 mm (Table 4.8).

Table 4.8. Length of first instar of *P. algira* larva reared on castor genotypes with different blooms

Genotype	Mean length of first instar (in mm)
DPC-9 (zero bloom)	8.70[a]
48-1 (double bloom)	8.69[a]
GCH-4 (triple bloom)	7.57[b]
LSD at 0.01	0.03

Values followed by same letter are not significantly different at 0.01 level

Statistically no significant differences were observed in duration of first instar of *P. algira* when reared on castor genotypes with different blooms (Table 4.9).

Table 4.9. Duration of first instar of *P. algira* larva reared on castor genotypes with different blooms

Genotype	Mean first instar duration (in days)
DPC-9 (zero bloom)	2.40[a]
48-1 (double bloom)	2.79[a]
GCH-4 (triple bloom)	2.55[a]
LSD at 0.01	0.43 (NS)

Values followed by same letter are not significantly different at 0.01 level

4.3.2.2 Second instar

Second instar was light ash colored. Highest head capsule width of 1.14 mm observed when larva was fed on DPC-9 which was significantly different from GCH-4 (0.93mm) (Table 4.10).

Table 4.10. Head capsule width of second instar of *P. algira* larva reared on castor genotypes with different blooms

Genotype	Mean head width of second instar (in mm)
DPC-9 (zero bloom)	1.14[a]
48-1 (double bloom)	1.14[a]
GCH-4 (triple bloom)	0.93[b]
LSD at 0.01	0.03

Values followed by same letter are not significantly different at 0.01 level

Length of second instar at emergence was longest when fed on 48-1 (14.44 mm) followed by DPC-9 (14.26mm) and was shortest when larva was fed on GCH-4 (12.86 mm) (Table 4.11).

Table 4.11. Length of second instar of *P. algira* larva reared on castor genotypes with different blooms

Genotype	Mean length of second instar (in mm)
DPC-9 (zero bloom)	14.26[b]
48-1 (double bloom)	14.44[a]
GCH-4 (triple bloom)	12.86[c]
LSD at 0.01	0.99

Values followed by same letter are not significantly different at 0.01 level

Statistically no significant differences were observed in duration of second instar of *P. algira* when reared on castor genotypes with different blooms (Table 4.12).

Table 4.12. Duration of second instar of *P. algira* larva reared on castor genotypes with different blooms

Genotype	Mean second instar duration (in days)
DPC-9 (zero bloom)	2.54[a]
48-1 (double bloom)	2.40[a]
GCH-4 (triple bloom)	2.57[a]
LSD at 0.01	0.62 (NS)

Values followed by same letter are not significantly different at 0.01 level

4.3.2.3 Third instar

Third instar larvae of *P. algira* appeared light brown in color with light cream colored parallel lines on the body. Highest head capsule width was observed when fed on 48-1 (1.96 mm) which was significantly different from DPC-9 (1.94mm) and GCH-4 (1.49 mm) (Table 4.13).

Table 4.13. Head capsule width of third instar of *P. algira* larva reared on castor genotypes with different blooms

Genotype	Mean head width of third instar (in mm)
DPC-9 (zero bloom)	1.94[b]
48-1 (double bloom)	1.96[a]
GCH-4 (triple bloom)	1.49[c]
LSD at 0.001	0.0057

Values followed by same letter are not significantly different at 0.01 level

Statistically no significant differences were observed in length of third instar of *P. algira* when reared on castor genotypes with different blooms (Table 4.14).

Table 4.14. Length of third instar of *P.algira* larva reared on castor genotypes with different blooms

Genotype	Mean length of third instar (in mm)
DPC-9 (zero bloom)	21.60[a]
48-1 (double bloom)	24.15[a]
GCH-4 (triple bloom)	21.90[a]
LSD at 0.01	2.25 (NS)

Values followed by same letter are not significantly different at 0.01 level

Statistically no significant differences were observed in duration of third instar of *P. algira* when reared on castor genotypes with different blooms (Table 4.15).

Table 4.15. Duration of third instar of *P. algira* larva reared on castor genotypes with different blooms

Genotype	Mean third instar duration (in days)
DPC-9 (zero bloom)	2.77[a]
48-1 (double bloom)	2.41[a]
GCH-4 (triple bloom)	2.59[a]
LSD at 0.01	0.50 (NS)

Values followed by same letter are not significantly different at 0.01 level

Weight of third instar was 57.38 mg and 82.89 mg when fed on GCH-4 and DPC-9 which were considered to be the lowest and the highest (Table 4.16).

Table 4.16. Weight of third instar of *P. algira* larva reared on castor genotypes with different blooms

Genotype	Mean weight of third instar (in mg)
DPC-9 (zero bloom)	82.89[a]
48-1 (double bloom)	64.91[b]
GCH-4 (triple bloom)	57.38[c]
LSD at 0.01	6.11

Values followed by same letter are not significantly different at 0.01 level

4.3.2.4. Fourth instar

Color of forth instar larva was light brown color with dark brown lines on the body. Significant difference was observed between the genotypes in case of head capsule width of the forth instar at emergence with highest value in larvae reared on 48-1 (3.39mm) followed by DPC-9 (3.37mm) whereas the lowest head capsule width was observed in larvae reared on GCH-4 (2.54 mm) (Table 4.17).

Table 4.17. Head capsule width of fourth instar of *P. algira* larva reared on castor genotypes with different blooms

Genotype	Mean head width of forth instar (in mm)
DPC-9 (zero bloom)	3.37[b]
48-1 (double bloom)	3.39[a]
GCH-4 (triple bloom)	2.54[c]
LSD at 0.01	0.01

Values followed by same letter are not significantly different at 0.01 level

There was no significant difference between the genotypes in length of the instar when reared on castor genotypes with different blooms. However, longest length of fourth instar at emergence was observed when fed on 48-1 (36.07 mm) followed by GCH-4 (35.83mm) whereas the shortest length was recorded when fed on DPC-9 (33.3mm) (Table 4.18).

Table 4.18. Length of fourth instar of *P. algira* larva reared on castor genotypes with different blooms

Genotype	Mean length of forth instar (in mm)
DPC-9 (zero bloom)	33.30[a]
48-1 (double bloom)	36.07[a]
GCH-4 (triple bloom)	35.83[a]
LSD at 0.01	5.74

Values followed by same letter are not significantly different at 0.01 level

Statistically no significant differences were observed in duration of fourth instar of *P. algira* when reared on castor genotypes with different blooms (Table 4.19).

Table 4.19. Duration of fourth instar of *P. algira* reared on castor genotypes with different blooms

Genotype	Mean forth instar duration (in days)
DPC-9 (zero bloom)	2.75[a]
48-1 (double bloom)	3.44[a]
GCH-4 (triple bloom)	4.62[a]
LSD at 0.01	2.12 (NS)

Values followed by same letter are not significantly different at 0.01 level

Highest weight of fourth instar was observed in larvae fed on DPC-9 (121.56 mg) and the lowest was observed in larvae reared on GCH-4 (110.6 mg) (Table 4.20).

Table 4.20. Weight of fourth instar of *P. algira* larva reared on castor genotypes with different blooms

Genotype	Mean weight of forth instar (in mg)
DPC-9 (zero bloom)	121.56[a]
48-1 (double bloom)	114.60[ab]
GCH-4 (triple bloom)	110.60[b]
LSD at 0.01	7.47

Values followed by same letter are not significantly different at 0.01 level

4.3.2.5. Fifth instar

Fifth instar larva was light brown in color with parallel lines extending from head to end of the body. Head capsule width of the instar at emergence was highest when reared on 48-1 (3.9 mm) followed by DPC-9 (3.81 mm) whereas the lowest head capsule width was observed when reared on GCH-4 (3.63mm) (Table 4.21).

Table 4.21. Head capsule width of fifth instar of *P. algira* larva reared on castor genotypes with different blooms

Genotype	Mean Head width of fifth instar (in mm)
DPC-9 (zero bloom)	3.810[b]
48-1 (double bloom)	3.900[a]
GCH-4 (triple bloom)	3.630[c]
LSD at 0.001	0.005

Values followed by same letter are not significantly different at 0.01 level

Length of fifth instar larva was longest when fed on both DPC-9 (36.9 mm) and 48-1 (36.9 mm) whereas the shortest length was observed when reared on GCH-4 (35.74 mm) (Table 4.22).

Table 4.22. Length of fifth instar of *P. algira* larva reared on castor genotypes with different blooms

Genotype	Mean length of fifth instar (in mm)
DPC-9 (zero bloom)	36.90[a]
48-1 double bloom)	36.90[a]
GCH-4 (triple bloom)	35.74[b]
LSD at 0.01	0.62

Values followed by same letter are not significantly different at 0.01 level

Duration of fifth instar ranged from 4.96 to 8.08 with highest value when fed on 48-1 (8.08 days) followed by GCH-4 (6.15 days) (Table 4.23).

Table 4.23. Duration of fifth instar of *P. algira* larva reared on castor genotypes with different blooms

Genotype	Mean fifth instar duration (in days)
DPC-9 (zero bloom)	4.96[c]
48-1 (double bloom)	8.08[a]
GCH-4 (triple bloom)	6.15[b]
LSD at 0.01	1.41

Values followed by same letter are not significantly different at 0.01 level

Significant difference has been observed in weight of fifth larval instar of *P. algira*. Mean weight of the fifth instar were 221.5 mg and 268.6 mg in larvae reared on GCH-4 and DPC-9 respectively which were considered as the lowest and the highest values (Table 4.24).

Table 4.24. Weight of fifth instar *P. algira* larva reared on castor genotypes with different blooms

Genotype	Mean weight of fifth instar (in mg)
DPC-9 (zero bloom)	268.60[a]
48-1 (double bloom)	243.80[b]
GCH-4 (triple bloom)	221.50[c]
LSD at 0.01	19.74

Values followed by the same letter are not significantly different at 0.01 level

4.3.2.6 Total larval duration

The larval duration was longest when reared on 48-1 (19.12 days) followed by GCH-4 (18.49 days) whereas it was the shortest in larvae fed on DPC-9 (15. 43 days) which was significantly different from 48-1 and GCH-4 (Table 4.25).

Table 4.25. Total larval duration of *P. algira* reared on castor genotypes with different blooms

Genotype	Mean larval duration (in days)
DPC-9 (zero bloom)	15.43[b]
48-1 (double bloom)	19.12[a]
GCH-4 (triple bloom)	18.49[a]
LSD at 0.01	2.85

Values followed by same letter are not significantly different at 0.01 level

The longest and shortest larval duration was observed in larvae fed on 48-1 (double bloom) and DPC-9 (zero bloom) respectively. Larval duration was found to be extended in larvae fed on nutritionally poor castor genotypes with wax bloom, 48-1 (double bloom) and GCH-4(triple bloom) compared to the genotypes without wax bloom (zero bloom).

The shortest larval duration in case of DPC-9 (zero bloom) can be due to the lowest amount of wax content (0.98 µg/g) (Priya, 2018), highest amount of proteins (2.53 mg/g), total free amino acids (0.44 mg/g), reduced sugars (15.15 mg/g) and the lowest amount of phenols (11.47 mg/g) in DPC-9 (zero bloom) compared to 48-1 (double bloom) and GCH-4 (triple bloom) (Naik, 2017). The extended duration of *P. algira* larva reared on 48-1 (double bloom) and GCH-4 (triple bloom) compared to DPC-9 (zero bloom) can be described as a compensatory action for a larva to recover when feeding on a low quality host. Hence DPC-9 (zero bloom) could be considered as good host for growth and development of *P. algira* compared to 48-1 (double bloom) and GCH-4 (triple bloom).

The present results were in accordance with Ambenagare *et al*. (2011) who determined the biochemical basis of *Aproaerema modicella* resistance in seven soybean cultivars (MAUS-81, JS-9863, MAUS-71, MAUS-158, JS-335, MACS-1055 and Bragg). High protein per cent (21.15%) has been observed from the susceptible control, Bragg.

The results were also in agreement with Silva *et al*. (2016) who reported that larval duration of *Spodoptera frugiperda* extended when fed on both cotton and soybean and considered them as poor quality hosts compared to Maize, Oat and Wheat which were reported as good quality or susceptible hosts. Similarly Muthukumaran (2016) reported that presence of higher amount of phenols in the resistant cultivars of tomato reduced the incidence of *S. litura* on tomato.

The results were also in confirmity with Naik (2017) who reported on presence of a negative correlation between duration of total life cycle of castor semilooper, *A. janata* and phenol content in castor genotypes with different blooms.

In the present investigation, the result of larval feeding preference indicated that DPC-9 was least preferred compared to 48-1 and GCH-4 (Table 4.1, 4.2 and 4.3). However in the biology study the total larval duration of *P. algira* was shortest (15.43 days; Table 4.25) when fed on leaf discs of DPC-9 which was significantly different from that of GCH-4 (18.49 days) and 48-1 (19.12 days). Also larvae (third, fourth and fifth instars) reared on DPC-9 had significantly more weights compared to 48-1 and GCH-4 (Table 4.16, 4.20 and 4.24). The shortest larval duration and the highest larval weight were observed when reared on DPC-9 indicating that DPC-9 as highly preferred host for growth and development of *P. algira* larva compared to 48-1 and GCH-4.

The differences in preference ranking between larval feeding preference studies and biology studies are due to the fact that preference studies were done in free choice where larvae were given a free choice among three genotypes (3.3 Material and Methods) and very few larvae were found on leaf discs of DPC-9 (Table 4.1, 4.2 and 4.3) ranking it as poor host, whereas the biological studies were done in no choice condition where the larvae were allowed to feed on only one genotype.

Earlier reports also mentioned that DPC-9 which is a zero bloom genotype had very low wax (0.98 µg. cm^{-2}) (Priya, 2018) and higher proteins (2.53 mg/g), reducing sugars (15.15 mg/g), total free amino acids (0.44 mg/g), total carbohydrates (36.16 mg/g) and lower phenols (11.47 mg/g) (Naik, 2017). When larvae were fed on DPC-9 (with no wax, low phenols, high proteins, high carbohydrates, high total free aminoacids and total reducing sugars) which is nutritionally rich, larvae completed its larval duration within shorter period of time as the nutritional requirement of larva was achieved by feeding on nutritional rich genotype with in a shorter period of time and with more larval weights.

Peeru *et al*. (2018) observed a positive correlation between protein and phenols in groundnut varieties *viz*., TCGS-894, ASK-2013-1, K-1563, TCGS-

1156, K-1628, Narayani and K-6 and growth and development of groundnut leaf bud borer, *Anarsia ephippias*. Among the varieties larval duration was reported to be the lowest and the highest on Narayani (13.17 days) and ASK 2013-1 (14.00 days) varieties containing highest and the lowest amount of proteins.

4.3.3. PRE-PUPA

Statistically no significant differences were observed in pre-pupal duration of *P. algira* when larva was fed on castor genotypes with different blooms (Table 4.26).

Table 4.26. Pre-pupal duration of *P. algira* reared on castor genotypes with different blooms

Genotype	Mean pre-pupal duration (in days)
DPC-9 (zero bloom)	2.30[a]
48-1 (double bloom)	2.20[a]
GCH-4 (triple bloom)	2.62[a]
LSD at 0.01	0.59 (NS)

Values followed by same letter are not significantly different at 0.01 level

4.3.4. PUPA

Pupa of *P. algira* was of decticous type. Male pupa possess genital opening on the ninth abdominal segment whereas female pupa possess genital opening or suture in the middle of eighth abdominal segments. Width of male pupa was 5.27 mm in pupa developed from larvae fed on DPC-9 and 3.19 mm in pupa developed from larvae fed on 48-1 and were highest and the lowest values respectively (Table 4.27).

The width of female pupa developed from larvae fed on GCH-4, DPC-9 and 48-1 measured 5.39 mm; 4.54 mm and 2.86 mm respectively (Table 4.27).

Table 4.27. Width of *P. algira* pupa reared on castor genotypes with different blooms (Measured at 0.67 magnification)

Genotype	Mean pupal width (in mm)	
	Male	**Female**
DPC-9 (zero bloom)	5.27[a]	4.54[b]
48-1 (double bloom)	3.19[b]	2.86[c]
GCH-4 (triple bloom)	5.22[a]	5.39[a]
LSD at 0.01	0.85	0.18

Values followed by same letter are not significantly different at 0.01 level

Length of male pupa was highest when developed from larvae fed on GCH-4 (19.06 mm) followed by DPC-9 (18.16 mm) and the lowest when developed from larvae fed on 48-1 (11.79 mm) (Table 4.28).

Statistically no significant differences were observed in length of female pupa of *P. algira* when larva was reared on castor genotypes with different blooms (Table 4.28).

Table 4.28. Length of *P. algira* pupa reared on castor genotypes with different blooms (Measured at 0.67 magnification)

Genotype	Mean pupal length (in mm)	
	Male	**Female**
DPC-9 (zero bloom)	18.16[a]	17.48[a]
48-1 (double bloom)	11.79[ab]	11.52[a]
GCH-4 (triple bloom)	19.06[a]	18.52[a]
LSD at 0.01	2.52	2.46 (NS)

Values followed by same letter are not significantly different at 0.01 level

The longest duration of male pupa was observed when developed from larvae fed on 48-1 (15.75 days) followed by GCH-4 (11.43 days) and the lowest value was observed when developed from larvae reared on DPC-9 (11.29 days) (Table 4.29).

Statistically no significant differences were observed in duration of female pupa of *P. algira* when larva was fed on castor genotypes with different blooms (Table 4.29).

Table 4.29. Duration of *P. algira* pupa reared on castor genotypes with different blooms

Genotype	Mean pupal duration (in days)	
	Male	Female
DPC-9 (zero bloom)	11.29[b]	16.20[a]
48-1 (double bloom)	15.75[a]	15.50[a]
GCH-4 (triple bloom)	11.43[b]	14.50[a]
LSD at 0.01	2.52	6.55 (NS)

Values followed by same letter are not significantly different at 0.01 level

Wax bloom of castor genotypes did not show any effect on female pupal duration of *P. algira*. However significant difference has been observed in male pupal duration with the lowest value observed when developed from larvae fed on GCH-4 (triple bloom) compared to DPC-9 (zero bloom) and 48-1 (double bloom). This can be due to presence of highest amount of wax (1.43 µg. cm^{-2}) (Priya, 2018) phenol content in GCH-4 (22.83 mg/g) (Naik, 2017) which resulted in reduced pupal duration of *P. algira*. The result was in accordance with Naik (2017) who reported on existence of negative correlation between phenol content in the castor genotypes with different blooms and pupal duration of castor semilooper, *A. janata*.

The male pupal weight was highest when developed from larvae fed on 48-1 (300 mg) followed by GCH-4 (271.43 mg) whereas the lowest when developed from larvae fed on DPC-9 (266.67 mg) (Table 4.30).

Statistically no significant differences were observed in weight of female and male pupa of *P. algira* when larva was reared on castor genotypes with different blooms (Table 4.30).

Table 4.30. Weight of *P. algira* pupa reared on castor genotypes with different blooms

Genotype	Mean pupal weight (in mg)	
	Male	**Female**
DPC-9 (zero bloom)	266.67[a]	300.00[a]
48-1 (double bloom)	300.00[a]	266.67[a]
GCH-4 (triple bloom)	271.43[a]	266.67[a]
LSD at 0.01	47.99 (NS)	55.28 (NS)

Values followed by same letter are not significantly different at 0.01 level

4.3.5. ADULT

Adult of *P. algira* was a medium sized moth with brown colored head, thorax and abdomen. Wings were black in color with white colored parallel bands on both fore and hind wings. White bands on both fore and hind wings showed continuous pattern when wings were opened. Male adult lived for 9.37 days with highest longevity observed on DPC-9 (10.71 days) which was significantly different from 48-1 (8.6 days) and GCH-4 (8.57 days) (Table 4.31).

Female longevity was longest when larva was reared on DPC-9 (15.5 days) which was significantly different from 48-1 (10.80 days) and GCH-4 (10.25 days) (Table 4.31).

Table 4.31. Adult longevity of *P. algira* reared on castor genotypes with different blooms

Genotype	Mean adult longevity (in days)	
	Male	Female
DPC-9 (zero bloom)	10.71[a]	15.50[a]
48-1 (double bloom)	8.60[b]	10.80[b]
GCH-4 (triple bloom)	8.57[b]	10.25[b]
LSD at 0.01	0.60	0.99

Values followed by the same letter are not significantly different at 0.01 level

Statistically no significant differences were observed in pre-oviposition period of *P. algira* when larva was reared on castor genotypes with different blooms (Table 4.32).

Table 4.32. Pre-oviposition period of *P. algira* reared on castor genotypes with different blooms

Genotype	Mean pre-oviposition duration (in days)
DPC-9 (zero bloom)	4.00[a]
48-1 (double bloom)	4.8[a]
GCH-4 (triple bloom)	5.00[a]
LSD at 0.01	0.60 (NS)

Values followed by same letter are not significantly different at 0.01 level

Duration of oviposition was longest when adult was developed from larvae fed on DPC-9 (8.00 days) which was significantly different from 48-1 (6.83 days) and GCH-4 (5 days) (Table 4.33).

Table 4.33. Oviposition period of *P. algira* reared on castor genotypes with different blooms

Genotype	Mean oviposition duration (in days)
DPC-9 (zero bloom)	8.00[a]
48-1 (double bloom)	6.83[b]
GCH-4 (triple bloom)	5.00[c]
LSD at 0.01	0.35

Values followed by the same letter are not significantly different at 0.01 level

Statistically there is significant difference in fecundity of *P. algira* when larva was reared on castor genotypes with different blooms (Table 4.34).

Table 4.34. Fecundity of *P. algira* reared on castor genotypes with different blooms

Genotype	Mean Fecundity (in numbers)
DPC-9 (zero bloom)	403.00[a]
48-1 (double bloom)	365.00[b]
GCH-4 (triple bloom)	350.00[b]
LSD at 0.01	30.53

Values followed by same letter are not significantly different at 0.01 level

Adult longevity and fecundity of *P. algira* was found to be highest when developed from larvae fed on DPC-9 (zero bloom) compared to 48-1 (double bloom) and GCH-4 (triple bloom). This can be due to the presence of the lowest amount of phenols in castor genotype without wax bloom DPC-9 (zero bloom) (11.47 mg/g) compared to waxy bloom type *viz.*, 48-1 (double bloom) (17.71 mg/g) and GCH-4 (triple bloom) (22.83 mg/g) (Naik, 2017., Priya, 2018). Among the secondary metabolites, plant phenols constitute one of the most common and widespread group of defensive compounds, which play a major role in Host Plant Resistance (HPR) against herbivores, including insects.

Roy and Barik (2013) observed a negative correlation between phenol content in host plants *viz*., sunflower, castor, sesame and jute and *Diacrisia casignetum*'s fecundity, among which the lowest fecundity has been reported on sesame containing highest phenol content.

Similarly Naik (2017) reported on existence of a negative correlation between phenol content in castor genotype with different wax bloom and fecundity of castor semilooper, *A. janata*.

Peeru *et al*. (2018) observed a negative correlation between phenol and reducing sugars content in groundnut cultivars with adult longevity of groundnut leaf bud borer, *Anarsia ephippias*.

4.3.6. Total Life cycle

Statistically no significant differences were observed in duration of total life cycle of *P. algira* when larva was reared on castor genotypes with different blooms (Table 4.35).

Table 4.35. Duration of total life cycle of *P. algira* reared on castor genotypes with different blooms

Genotype	Mean total duration (in days)
DPC-9 (zero bloom)	41.74[a]
48-1 (double bloom)	39.86[a]
GCH-4 (triple bloom)	40.82[a]
LSD at 0.01	1.96 (NS)

Values followed by same letter are not significantly different at 0.01 level

From the present investigation GCH-4 (triple bloom) was ranked as least preferred genotype with longest larval duration, the shortest pupal duration, shortest adult longevity, the lowest fecundity compared to DPC-9 (zero bloom) and 48-1 (double bloom). Whereas DPC-9 (zero bloom) was considered as highly preferred host with shortest larval duration, longest adult longevity, highest fecundity compared to 48-1 (double bloom) and GCH-4 (triple bloom).

Chapter – V

Summary & Conclusions

Chapter V

SUMMARY AND CONCLUSIONS

The results pertaining to the laboratory studies on "**Effect of castor genotypes with different blooms on growth and development of castor semilooper, *Parallelia algira*, (Linnaeus)"** conducted at Insectary, Department of Entomology, S. V. Agricultural College, Tirupathi, Andhra Pradesh, during 2018-19 are submitted in this chapter.

In the larval preference studies, highest mean number of first instar larvae were observed on 48-1 (5.57) followed by GCH-4 (3.71) whereas lowest mean number of larvae were observed on DPC-9 (0.42) which was significantly different from other two genotypes.

In case of second instar larva though there was no significant difference between the genotypes, highest mean number of larvae were observed on GCH-4 (3.86) followed by 48-1 (3.14) and DPC-9 (2.86).

In case of third instar larva highest mean number of third instar was observed on GCH-4 (4.86) followed by 48-1 (3.00) and DPC-9 (2.14).

In the feeding indices studies, Approximate digestibility (AD) value was higher when larva was fed on GHC-4 (60.90%) followed by 48-1 (55.03 %) whereas lower when fed on DPC-9 (53.01%).

Efficiency of Conversion of Ingested food to body substance (ECI) value was more when larvae were reared on DPC-9 (39.83%) followed by 48-1 (36.19%) whereas the value was low when larva was fed on GCH-4 (33.26%).

Efficiency of Conversion of Digested food to body substance (ECD) was more when larva was fed on 48-1 (68.44%) followed by DPC-9 (62.43 %) whereas the value was 53.70 (%) when larva was fed on GCH-4 which was considered as low.

Consumption Index (CI) was highest when larva was fed on GCH-4 (1.07) followed by DPC-9 (0.93) and on 48-1 (0.93).

Biology of *P. algira* was studied on castor genotypes with different blooms. Observations were recorded for every 24 hours.

P. algira adult laid eggs singly on the lower surface and upper surface of the leaf. Initially egg was green in color which turns brown color at the time of larval emergence. Shape of the egg was convex on the dorsal surface and flat on the ventral surface. Dorsal surface of the egg was well sculptured with longitudinal constrictions. Mean duration of the egg was longer when laid by the adult developed from larvae reared on DPC-9 (7.00 days) followed by 48-1 (5.80 days) and shorter when laid by adult developed from larva reared on GCH-4 (5.00 days).

P. algira larva passed through five larval instars. Length of the first instar larva was longest when fed on DPC-9 (8.70 mm) followed by 48-1 (8.69 mm). Shortest length of the instar was observed in larva reared on GCH-4 with mean length of 7.57 mm. Head capsule width and duration of 1st instar larvae reared on different genotypes were not significantly different.

Highest head capsule width of second instar larva was observed when fed on DPC-9 and 48-1 (1.14 mm) which was significantly different from GCH-4 (0.93 mm) respectively. Length of second instar was more when fed on 48-1 (14.44 mm) followed by DPC-9 (14.26 mm) and GCH-4 (12.86) which were significantly different among themselves. Duration of 2nd instar larvae reared on different genotypes did not show any significant difference.

Highest head capsule width of third instar larva was observed when fed on 48-1 (1.96 mm) which was significantly different from DPC-9 (1.94 mm) and GCH-4 (1.49 mm). Weight of third instar larva was more (82.89 mg) when the larvae were fed on DPC-9 followed by 48-1 (64.91) and lowest weight was observed when larvae were fed on GCH-4 (57.38). No significant differences were observed in terms of length and duration of third instar when they were fed on genotypes with different blooms.

Highest head capsule width of fourth instar larva was observed when fed on 48-1 (3.39 mm) followed by DPC-9 (3.37 mm) whereas lowest head capsule width was observed on larvae reared on GCH-4 (2.54 mm). No significant differences were observed in terms of length of fourth instar larvae and its duration when the larvae were fed on genotypes with different blooms. Mean weight of the fourth instar larva was the highest when fed on DPC-9 (121.56 mg) followed by 48-1 (114.60 mg) and the lowest when fed on GCH-4 (110.60 mg).

Head capsule width of the fifth instar larva was highest when fed on 48-1 (3.9 mm) followed by DPC-9 (3.81 mm) whereas lowest when fed on GCH-4 (3.63 mm). Length of fifth instar larva was longest when fed on both DPC-9 (36.90 mm) and 48-1 (36.90 mm) whereas shortest when fed on GCH-4 (35.74 mm). Longest duration of fifth instar was observed when larva was fed on 48-1 (8.08 days) followed by GCH-4 (6.15 days). Shortest larval duration (4.96) was observed when larvae were fed on DPC-9. The weight of larvae was more when fed on DPC-9 (268.60) followed by 48-1 (243.80) and lowest weight was observed when fed on GCH-4 (221.50).

Total larval duration was longest when fed on 48-1 (19.12 days) followed by GCH-4 (18.49 days). Shortest larval duration was observed when fed on DPC-9 (15.43 days).

No significant differences were observed in pre-pupal duration when fed on different genotypes.

Width of male pupa was 5.27 mm when developed from larva reared on DPC-9 followed by GCH-4 (5.22mm) and 3.19 mm when fed on 48-1. Width of female pupae was 5.39 mm on GCH-4 followed by DPC-9 (4.54 mm) and 48-1 (2.86 mm).

No significant differences were observed in length of both male and female pupae, pupal duration and pupal weights when developed from larvae reared on different genotypes.

Male adult longevity was longest when developed from larvae reared on DPC-9 (10.71 days) followed by 48-1 (8.60 days) and GCH-4 (8.57 days). Mean longevity of female adult was longest when developed from larvae reared on DPC-9 (15.50 days) followed by 48-1 (10.80 days) and GCH-4 (10.25 days).

Significant difference was observed in fecundity whereas no significant differences were observed in pre-oviposition period of adults and total life cycle of *P. algira* when reared on different genotypes.

Duration of oviposition was longest when developed from larvae reared on DPC-9 (8.00 days) which was significantly different from 48-1 (6.83 days) and GCH-4 (5.00 days).

Conclusions

1. Feeding preference of all the instars of *P. algira* was highest on waxy bloom genotype 48-1 (Double bloom) and GCH-4 (Triple bloom) compared to DPC-9 (Zero bloom).

2. Oviposition preference of *P. algira* was high on 48-1 (Double bloom) genotype compared to DPC-9 (Double bloom) and GCH-4 (Triple bloom).

3. Lower values of ECI and ECD and higher values of AD and CI values of *P. algira* larvae was observed on GCH-4 genotype which was a triple bloom variety followed by 48-1 (double bloom) and DPC-9 (zero bloom). From these results GCH-4 could be ranked as least preferred host due to lower ECI and ECD values compared to DPC-9 (zero bloom) and 48-1 (double bloom) having higher ECI and ECD values.

4. Shortest larval duration of *P. algira* was observed on DPC-9 which was ranked as good host for growth and development of *P. algira*.

5. Morphometrical observations such as head capsule width, length and weight of *P. algira* larvae were lowest when fed on GCH-4 (triple bloom) which was ranked as poor host for *P. algira* whereas values were highest when fed on 48-1 which was ranked as suitable host for growth and development of *P. algira*.

6. Pupal duration of *P. algira* was lowest when fed on GCH-4 (triple bloom) which was ranked as resistant host compared to DPC-9 (zero bloom) and 48-1 (double bloom).

7. Adult longevity and fecundity of *P. algira* was found to be highest when fed on DPC-9 (zero bloom) compared to 48-1 (double bloom) and GCH-4 (triple bloom) which was ranked as susceptible host in the present study.

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