Andhra Pradesh J Agril. Sci. 5(1): 187-196, 2019

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

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Date of Receipt: 27.6.2019 Date of Acceptance: 24.8.2019

ABSTRACT

Effect of castor genotypes with different blooms on growth and development of castor semilooper, *Parallelia algira* was studied using neonate larvae. Biological parameters such as egg duration, larval duration, pupal duration, adult longevity were recorded along with morphometrics. Among the genotypes evaluated GCH-4, which was a triple bloom genotype was ranked as least preferred one recoded with shortest larval duration, longest adult longevity, shortest incubation period, lower larval weights and lower larval measures. Whereas DPC-9, which was a zero bloom genotype was considered as highly preferred host recorded with shortest larval duration, higher larval weights and higher larval measures.

KEYWORDS:*Parallelia algira*, castor genotypes, wax bloom

INTRODUCTION:

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 (Indiastat, 2018). Andhra Pradesh and Telangana stands third in the country in castor area (33.18 thousand ha) and production (477 kg ha^{-1}) (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

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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).

MATERIALS AND METHODS

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. 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.

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.

Statistical Analysis:

Data regarding biology of *P. algira* was subjected to statistical analysis by using Statistical Package for the Social Sciences (SPSS 20, 2019).

RESULTS AND DISCUSSION:

P. algira life cycle involved egg, larva, pupa and adult stages (Figure 1). Larval stage passed through five instars. 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.

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 and flat on the ventral surface. Dorsal surface of the egg was well sculptured with longitudinal constrictions. 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 1).

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 (2.48 mg/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).

Larva: *P. algira* larva passed through five instars (Figure 2).

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 3). 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 3). Statistically no significant differences were observed in duration of first instar of *P. algira* when reared on castor genotypes with different blooms (Table 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 3). 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 3). Statistically no significant differences were observed in duration of second instar of *P. algira* when reared on castor genotypes with different blooms (Table 2).

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 (1.94 mm) and GCH-4 (1.49 mm) (Table 3). Statistically no significant differences were observed in length of third instar of *P. algira* when reared on castor genotypes with different blooms (Table 3). Statistically no significant differences were observed in duration of third instar of *P. algira* when reared on castor genotypes with different blooms (Table 2). 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).

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 3). There was significant difference between the genotypes in length of the instar, 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 3). Statistically no significant differences were observed in duration of fourth instar of *P. algira* when reared on castor genotypes with different blooms (Table 2). 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).

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 3). 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 3). 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 2). 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 268.6mg in larvae reared on GCH-4 and DPC-9 respectively which were considered as the lowest and the highest values (Table 4).

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 1).

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. Higher amount of phenols in the resistant cultivars of tomato reduced the incidence of *S. litura* on tomato as reported by earlier workers.

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 . However in the biology study the total larval duration of *P. algira* was shortest (15.43 days) 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 . 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 and very few larvae were found on leaf discs of DPC-9 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.

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.

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 3). 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 3). 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 3). 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 3). 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 1). 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 1).

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^{-1}) (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).

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.

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).

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

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 (6.83days) and GCH-4 (5 days).

Statistically no significant differences were observed in fecundity of *P. algira* when larva was reared on castor genotypes with different blooms.

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^{-1}) (Naik, 2017 and 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*.

Total Life cycle

Statistically no significant differences were observed in duration of total life cycle of *P. algira* when

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).

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Table 1. Duration of various life stages of *P. algira* on castor genotypes with different blooms.

Genotype	Egg	Larva	Pre-pupa	Pupa		Adult	
				Male	Female	Male	Female
DPC-9	7.00[a]	15.43[b]	2.30[a]	11.29[b]	16.20[a]	10.71[a]	15.50[a]
48-1	5.80[b]	19.12[a]	2.20[a]	15.75[a]	15.50[a]	8.60[b]	10.80[b]
GCH-4	5.00[c]	18.49[a]	2.62[a]	11.43[b]	14.50[a]	8.57[b]	10.25[b]
LSD at 0.01	0.36	2.85	0.59 (NS)	2.52	6.55 (NS)	0.60	0.99

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

Table 2. Instar wise duration of *P. algira* larva on castor genotypes with different blooms.

Genotype	First instar	Second instar	Third instar	Fourth instar	Fifth instar
DPC-9	2.40[a]	2.54[a]	2.77[a]	2.75[a]	4.96[c]
48-1	2.79[a]	2.40[a]	2.41[a]	3.44[a]	8.08[a]
GCH-4	2.55[a]	2.57[a]	2.59[a]	4.62[a]	6.15[b]
LSD at 0.01	0.43 (NS)	0.62 (NS)	0.50 (NS)	2.12 (NS)	1.41

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

Table 3. Morphometrics of larval instars of *P. algira.*

Genotype	First instar		Second instar		Third instar		Fourth instar		Fifth instar		Pupa			
	Length (mm)	Head capsule width (mm)	Length (mm)	Head capsule width (mm)	Length (mm)	Head capsule width (mm)	Length (mm)	Head capsule width (mm)	Length (mm)	Head capsule width (mm)	Width		Length	
											Male (mm)	Female (mm)	Male (mm)	Female (mm)
DPC-9	8.70^{a}	0.604^{a}	14.26^{b}	1.14^{a}	21.60^{a}	1.94^{b}	33.30^{a}	3.37^{b}	36.90^{a}	3.810^{b}	5.27^{a}	4.54^{b}	18.16^{a}	17.48^{a}
48-1	8.69^{a}	0.692^{a}	14.44^{a}	1.14^{a}	24.15^{a}	1.96^{a}	36.07^{a}	3.39^{a}	36.90^{a}	3.900^{a}	3.19^{b}	2.86^{c}	11.79^{ab}	11.52^{a}
GCH-4	7.57^{b}	0.693^{a}	12.86^{c}	0.93^{b}	21.90^{a}	1.49^{c}	35.83^{a}	2.54^{c}	35.74^{b}	3.630^{c}	5.22^{a}	5.39^{a}	19.06^{a}	18.52^{a}
LSD at 0.01	0.03	0.120 (NS)	0.99	0.03	2.25 (NS)	0.0057	5.74	0.01	0.62	0.005	0.85	0.18	2.52	2.46 (NS)

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

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Table 4. Larval instars weights of *P. algira*.

Genotype	First instar (mg)	Second instar (mg)	Third instar (mg)
DPC-9	82.89[a]	121.56[a]	268.60[a]
48-1	64.91[b]	114.60[ab]	243.80[b]
GCH-4	57.38[c]	110.60[b]	221.50[c]
LSD at 0.01	6.11	7.47	19.74

Values followed by same letter are not significantly different at 0.0 level.

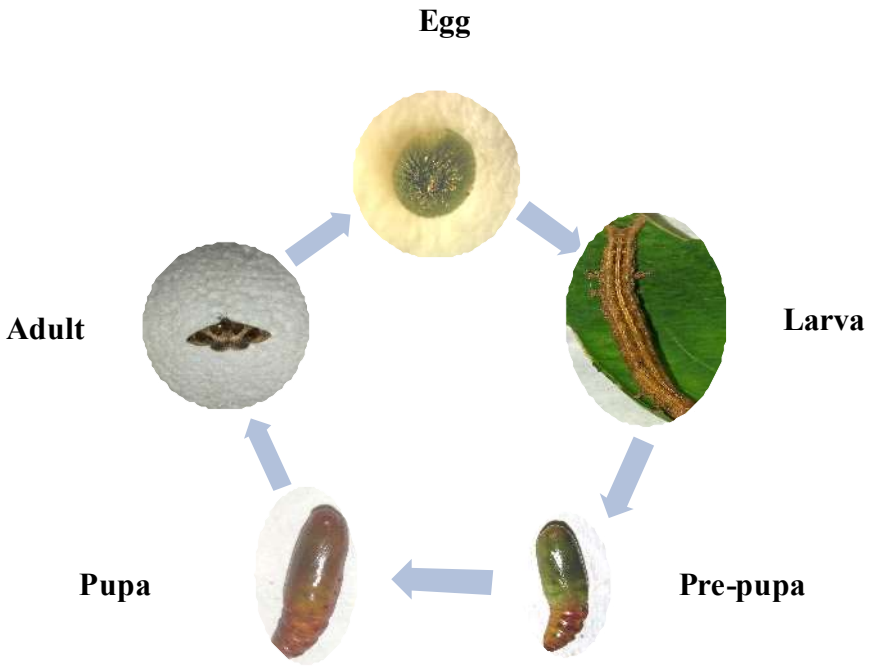

Figure 1. Biology of castor semilooper, *Parallelia algira*

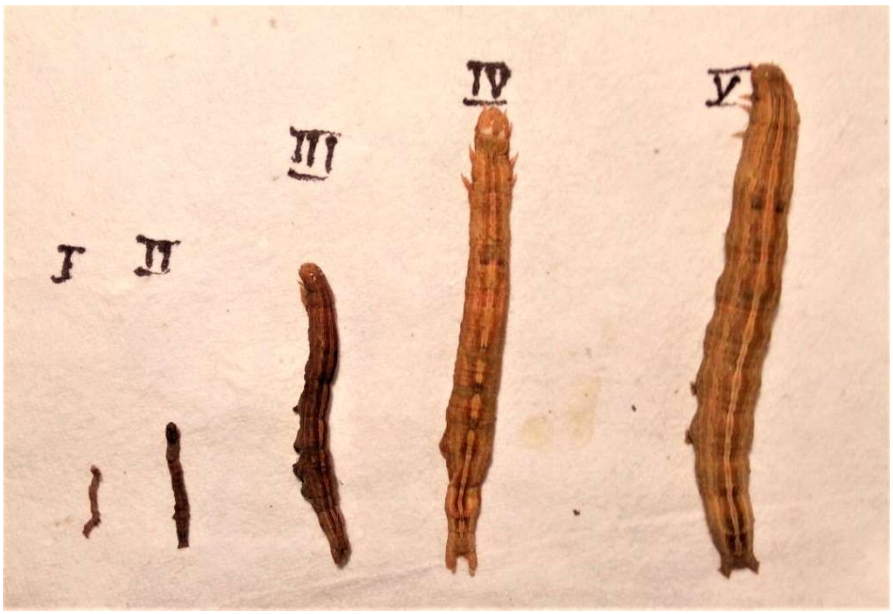

Figure 2. Larval instars of *Parallelia algira*