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BLACKHEADED FIREWORM, RHOPOBOTA NAEVANA (HUBNER) (LEPIDOPTERA: TORTRICIDAE): A NEW PEST OF APPLE CROP IN KASHMIR HIMALAYA

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ABSTRACT

During survey of apple orchards of Kashmir valley in 2013, the terminals of current season twigs were found severely skeletonised by larvae of a lepidopteran moth. These larvae were collected from the field, brought to laboratory and reared at an ambient temperature (25 ± 5°C) and relative humidity (70 ± 5%) and adult after emergence has been taxonomically identified as Blackheaded fireworm; Rhopobota naevana (Hubner) belonging to tribe Eucosimini of family Tortricidae . Study of biology revealed that the mean pre-oviposition, oviposition and post-oviposition period was 2.26±0.23, 3.37±0.15 and 1.58±0.42 days, respectively, while as mean male/female sex ratio was 1.30±0.12. The fecundity/female ranged from 66.12-92.50 eggs and percentage hatchability ranged between 64.16-82.96 per cent in different generations. The study further clarified that larval period completed through five distinct instars with mean duration of 1st, 2nd, 3rd, 4th and 5th instar larvae as 2.29±0.07, 3.47±0.17, 4.27±0.38, 4.78±0.41 and 6.18±0.79 days, respectively and total larval development period of 21.01±1.80 days. Results thus indicated that R. naevana (Hubner) completed its life cycle in 38.29-47.80 days in different generations, undergoes hibernation for six months in its egg stage and has complete three generations in temperate region of J&K from May to October.

Key words: Apple, Biology, Damage, Kashmir, Taxonomy, Tortricid moth.

I.INTRODUCTION

Apple crop is host plant of an extensive fauna of tortricid moths (Cross, 1996). Meszaros *et al*. (1984) recorded 88 species of tortricid moths in the apple orchards of Hungary and 25 species have been recorded in apple orchards throughout the United Kingdom (Alford, 1984). However, most of them have been considered to be of minor importance and only three species are considered to be of economic importance by UK apple growers. These are *Cydia pomonella* (Linnaeus), *Adoxophyes orana* (Fischer von Roeslerstamm) and *Archips podana* (Scopoli). In temperate region of Jammu and Kashmir, 73 species of tortricid moths have been reported (Ganai

et. al., 2018), out of which only two are yet known to damage apple crop. These are codling moth, *Cydia pomonella* (Linnaeus), which occurs as severe problem in Ladakh region (Wadhi and Sethi, 1975) and Archips moth, *Archips pomivora* Meyrick which appears sporadically in Kashmir valley (Bhagat *et al*., 1994) while as during orchard visits to different apple belts of Kashmir valley during 2013, another tortricid moth was found attacking apple orchards particularly on young plants. The larvae of this moth damage the terminals of current season twigs by skeletonising the leaves often so severely that areas of the apple orchards turn brown and appear burned top of trees. These larvae wriggle vigorously when disturbed and use silk to construct protected feeding sites by webbing together terminal leaves. For successful management, it is desirable to identify this pest taxonomically and predict the age of individuals and to determine the time taken by insect to develop from one life stage to another. To do this, study was conducted on taxonomy, morphomatrics and life cycle of this insect pest which has not been worked out in detail as the available literature itself shows that there is no comprehensive information on different aspects of its life and living except scattered reports.

II.MATERIAL AND METHODS

2.1 Collection

During the survey of apple orchards in Kashmir valley, the terminals of current season twigs were found skeletonised by larvae of a lepidopteran moth. These larvae were collected from the field brought to laboratory and reared at an ambient temperature (25 ± 5^{o}C) and relative humidity (70 ± 5%). These were then kept in glass jars (20 × 15 cm) covered with muslin cloth and fresh twigs of apple duly washed in water were provided them as food so as to obtain adults for identification and further investigation.

2.2 Processing and preservation

The adults so obtained were killed with benzene or ethyl acetate vapours and stretched properly in the small adjustable wooden stretching boards or thermocol sheets after pinning through the mid of mesothorax. Before stretching, the specimens were relaxed on blotting paper placed over water soaked cotton sterilized with phenol in an airtight petri dish and left for 4-6 hours. The stretched specimens were then oven dried for 72 hours at 60^{o}C and preserved in the insect storage boxes, fumigated with naphthalene balls and photographed by digital camera attached to Stereo zoom Olympus microscope.

2.3 Preparation of permanent slide of wings

For taxonomic studies method proposed by Common (1970) and advocated by Zimmerman (1978) for wing venation was followed. For preparation of permanent slides of wings, fore and hind wings of one side were removed carefully from their base by giving an upward jerk with the help of a forcep and a needle. The detached wings were then dipped in 70% alcohol to make them soft and transferred to sodium hypo chloride solution for 5-10 minutes for de-scaling, and the scales were removed gently with the help of a soft camel brush or pencil shaped paper roller. These wings were then washed 3-4 times in distal water and gently placed in a cavity block containing sufficient quantity of glacial acetic acid for 5-10 minutes for dehydration. For staining these were

kept in a cavity block containing glacial acetic acid and acid fuchsin for overnight. There after transferred to another cavity block with carbo-xylol (1 part carbolic acid + 3 parts xylene) to remove excess stain. Then these wings were mounted on a slide in canda balsam and dried enough to get a permanent mount and photographed by digital camera attached to Stereo zoom Olympus microscope. The nomenclature of wing venation proposed by Comstock and Needham (1898-99), followed by Imms (1957) and modified by Miller (1970) has been followed in this study.

2.4 Male and female genitalia

For the study of male and female genitalia, dissections of adult specimens were performed. For this study, whole abdomen was taken from insect body, as detaching of last few segments often damages the important parts of male and female genitalia (Robinson, 1976). The detached abdomen was then kept in 10 per cent KOH solution for about 12 hours, so as to get the musculature sufficiently relaxed, to soften the chitin, to dissolve other unwanted parts and then washed in water. Dissection of genitalia was done in cavity block containing water with the help of a fine forcep and needle under a binocular microscope. Aedeagus was separated from main genitalia by keeping juxta and transtilla intact. The genitalia thus obtained were transferred to glacial acetic acid to remove the traces of KOH. For staining these were kept in a cavity block containing glacial acetic acid and acid fuchsin for 20 minutes. After 20 minutes, genitalia was again washed with fresh glacial acetic acid to remove the excess stain and then transferred to carbo-xylol for clearing. The dissected genitalia was then spread on a micro slide, covered with cover slip and photographed by digital camera attached to Stereo zoom Olympus microscope. Finally these genitalia were preserved in 70% ethyl alcohol in small (3 ml) glass vials. The methodology and terminology given by Klots (1970) has been followed in the present studies for nomenclature purpose.

2.5 Identification

For the identification of said species, communication channel was also established with the eminent taxonomists (Joseph Razowski, Poland and John W. Brown USDA) currently working on family Tortricidae around the globe. The identification was confirmed by sending adult, wing and genitalia photographs to above mentioned tortricid experts for examination and validation of species. Identified adult moths deposited in the insect collection museum of bio-systematic laboratory in the Division of Entomology, SKUAST-K, Shalimar campus, Srinagar.

2.6 Biology

For the study of biology the male & female pupae obtained from larvae reared in laboratory were identified taxonomically, thereafter isolated in pairs and confined to separate glass jars (20 x 15 cm). After adult emergence these were provided with 10 per cent sugar/honey solution soaked in cotton swabs. The fresh apple plant twigs with their petioles wrapped with water soaked cotton were kept in glass jars for oviposition. Observations on number of eggs laid by a female were recorded and freshly laid eggs were transferred along

with a portion of leaf to a piece of filter paper seated over moist cotton in a petri dish to study incubation period and hatching per cent age. Newly hatched larvae were individually transferred to a piece of apple leaf placed on filter paper seated over moist cotton in a petri dish. Fresh leaves were provided them as food daily until pupation, observations on the larval period with different instars with moultings, prepupal and pupal period and longevity of adult moth were recorded.

III.RESULTS AND DISCUSSION

3.1 Systematic account:

Rhopobota naevana (Hubner, 1817)

naevana Hubner, [1814-1817] (*Tortrix*), *Samml. Eur. Schmett.* 7: pl. 41 fig. 261.

Tortrix naevana (Hubner, 1817):pl.41, fig.261.

Tortrix unipunctana (Haworth, 1811):454.

Lithographia geminana Stephens, 1852:99.

Sciaphila luciferana Walker, 1863:342.

Anchylopera vacciniana Packard, 1869:338.

Epinotia ilicifoliana Kearfott, 1907:58.

Acroclita microrryncha Meyrick, 1931:127

Rhopobota naevana Lederer, 1859:367.

3.1.1 Diagnostic characters: Adult head vertex with brown scales; frons white; antenna brown except white scape; labial palpus with basal two segments brown, third segment small, white and porrect (Fig. 1A); Thorax with dorsum and tegula greyish brown. Forewing with upper side ground colour gray, sparsely strigulated with brown or fuscous and a distinct notch below apex; basal patch and median fascia indistinct; chorda extending from R_1-R_2 to mid R_5-M_1, M-stem to CuA_1 or base of M_3, R_4-R_5 separate or stalked (Fig. 1B). Hindwing light fuscous or grey with a patch of grey scales on upper side and a patch of grey-black scales on underside; cilia grey with a sub-basal line dark coloured; M_2 and CuA_1 fused or stalked (Fig.1C). Fore leg brown; mid leg greyish brown, tarsus with brown scales; hindleg gray, tarsus brown; Male with specialized scales on underside.

3.1.2 Genitalia

3.1.2.1 Male

Male genitalia with uncus well developed, bifid apically with two wide-set projections, triangular at base; gnathos weakly developed; tegumen broad, longer than uncus, inverted u-shaped, apically round with a pair of sub-lateral projections; vinculum shorter than tegumen, u-shaped, weakly sclerotized; socii fuse with the base of tuba analis and consisting of two lateral appendages on it which expand apically, covered with bristles and fuse; sacculus not angulated terminally; valvae well developed provided with long clasper at mid-point of ventral margin; cucullus with its caudal edge simple and spined (Fig.1D); aedeagus small, simple with both types of cornuti, ductus ejaculatorious entering apically (Fig.1E).

3.1.2.2 Female

Female genitalia corpus bursae oval shaped with distal sclerotized portion long and thick and single signum with

elongated basal plate; ductus bursae medium, highly striated, simple and weakly sclerotized towards ostium bursae; sterigma small, funnel shaped, terminally expanding, accompanied with small scobinate patches or posterior lobes; antrum with long sclerites near the inception of ductus seminalis; posterior apophyses longer than anterior apophyses; papilla analis long, slightly sclerotized, sparsely setosed with micro and macro setae (Fig.1F).

3.1.3 Wing span: Male 11 mm, Female 12mm.

3.1.4 Distribution: Palaearctic, Nearctic, Oriental and Australian regions.

3.2 Biology

The results shown in table-1 revealed that after matting female on an average laid 78.94±13.20 whitish disc shaped eggs during different generations. Fitzpatrick and Troubridge (1993) also reported female fecundity of 70-80 eggs during first and second generations. The mean diameter of an egg was observed of 0.84±0.05 mm (Table-2), similar results were also reported by Sylvia and Averil (2005). The mean incubation period was found to be 4.18±0.40 days while as mean fertility was observed to be 74.76±9.62 eggs (Table-1). Cockfield *et al.* (1994) also observed incubation period of 6-15 days. The study observed the mean duration of 1^{st}, 2^{nd}, 3^{rd}, 4^{th} and 5^{th} instar larvae as 2.29±0.07, 3.47±0.17, 4.27±0.38, 4.78±0.41 and 6.18±0.79 days, respectively (Table-1 & Fig. 2). Thus five distinct larval instars were reported and the total mean larval development period was found to be of 21.01±1.80 days, however Sylvia and Averill (2005) reported larval development period of 2.5-5.0 weeks. The mean length and width of 1^{st}, 2^{nd}, 3^{rd}, 4^{th} and 5^{th} instar larvae was found as 2.39±0.31 and 0.97±0.12, 4.42±0.60 and 1.33±0.12, 6.08±0.60 and 1.94±0.24, 7.90±0.62 and 2.25±0.12 and 9.16±0.38 and 2.64±0.12 mm, respectively (Table-2). These observations are similar with those of Sylvia and Averill (2005), which also reported the length of fully grown larvae as 7-9 mm.

A

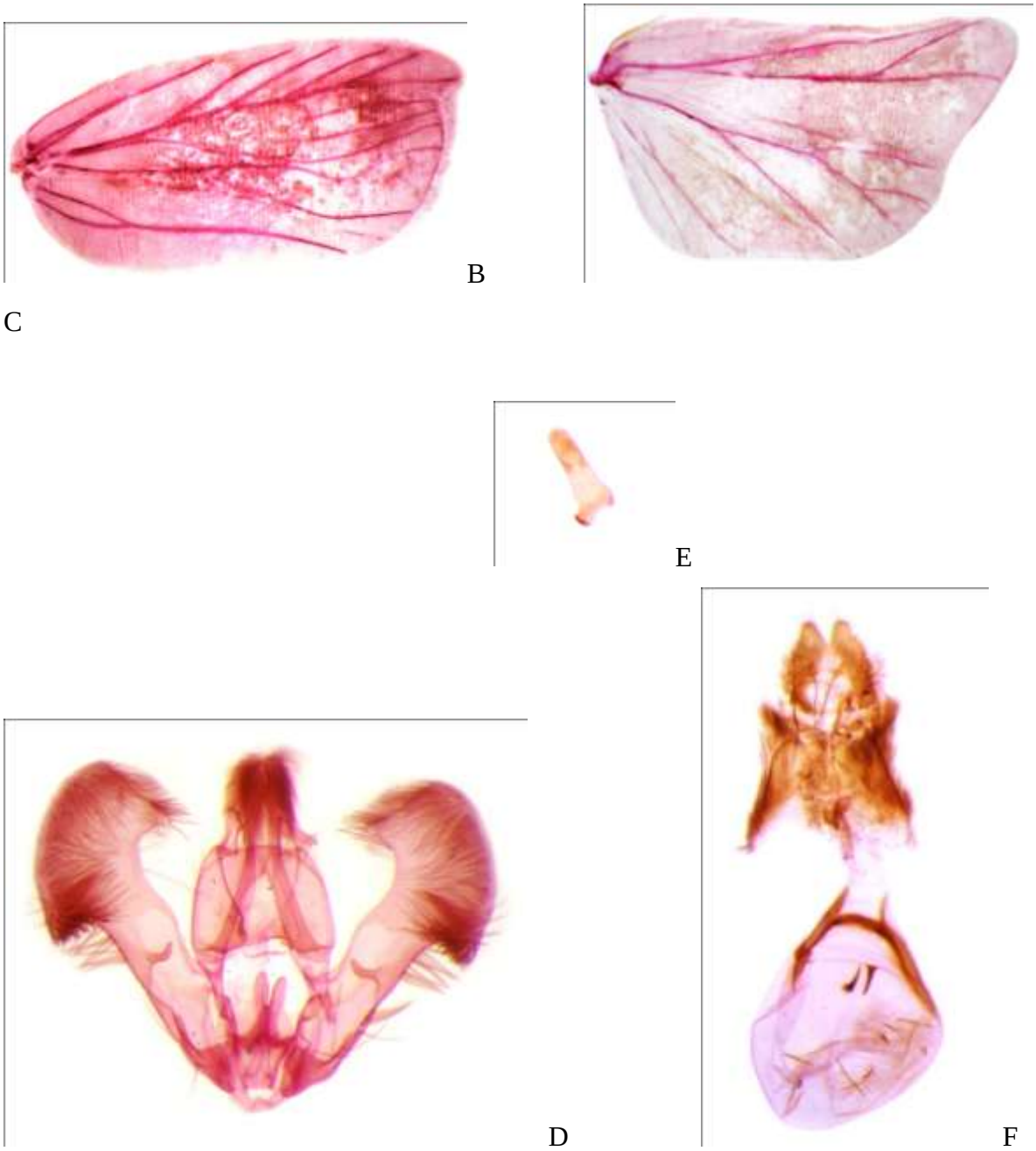

Fig. 1: A. Adult moth, B. Fore wing, C. Hind wing, D. Male genitalia, E. Aedeagus, F. Female genitalia.

The present study also observed that prepupal period lasted for 3.27±0.43 and measured on an average as 7.44±0.63 mm in length and 2.78±0.19 mm in width while as the pupal period on an average lasted for 8.41±1.21 days and the mean length and width of male and female pupae was observed as 6.00±0.60 mm and 3.00±0.12 mm and 6.48±0.48 mm and 3.43±0.30 mm respectively (Table-1 & 2). Sylvia and Averill (2005) also

reported the mean length as 6-7 mm which confirmed our results. Further the male adult measured on an average about 11.52±0.31 mm across the expanded wings and lived for an average of 5.41±0.73 days while as the female on an average was about 12.23±0.32 mm across the expanded wings and lived for an average of 7.22±0.80 days. Thus male was found to complete its life cycle in an average of 42.31±3.82 days while as female in 44.11±3.88 days (Table-1). These findings are in agreement with those of Bradely *et al.* (1979), Alford (1984), and Sylvia and Averill (2005). Finally the study confirmed egg as overwintering stage of *Rhopobota naevana* that hatches around late April to mid May. The first generation larvae generally occur between late May to early June, adults emerge and lay eggs from late June to early July, second generation larvae occur from mid July to early August and adult fly from early to mid August and third generation eggs are laid in mid August, larvae occur from later August to early September, adult fly from mid to late September and lay eggs which overwinter, thus completes three generations per year. The present findings are in disagreement with Sylvia and Averill (2005), which reported only two generations per year.

IV.CONCLUSION

Finally it has been concluded that another tortricid moth that attacks the apple crop in Kashmir has been identified as Blackheaded fireworm; *Rhopobota naevana* (Hubner) which increased the tortricid pest fauna of apple crop in temperate region of Jammu & Kashmir from two to three. Also, the larva of this pest after hatching form dormant egg, damage the terminals of current season twigs by skeletonising the leaves, pass through five larval instars, prepupa and pupal stage and complete its life cycle in 38-47 days. Further, it has three complete generations per year in temperate region of J&K from May to October and undergoes hibernation in egg stage.

V.ACKNOWLEDGEMENT

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Table-1: Biological attributes of Blackheaded fireworm, *Rhopobota naevana* (Hubner).

S. No.	Developmental stage	Duration (Days)	
		Range	Mean ± SD
1.	Pre-oviposition period	2.00 - 2.45	2.26 ± 0.23
2.	Oviposition period	3.25 - 3.55	3.37 ± 0.15

3.	Post-oviposition period	1.12 - 1.97	1.58 ± 0.42
4.	Fecundity	66.12 - 92.50	78.94 ± 13.20
5.	Incubation period	3.78 - 4.59	4.18 ± 0.40
6.	Hatching (%)	64.16 - 82.96	74.76 ± 9.62
7.	1^{st} instar larvae	2.21 - 2.34	2.29 ± 0.07
8.	2^{nd} instar larvae	3.29 - 3.64	3.47 ± 0.17
9.	3^{rd} instar larvae	3.83 - 4.53	4.27 ± 0.38
10.	4^{th} instar larvae	4.35 - 5.18	4.78 ± 0.41
11.	5^{th} instar larvae	5.26 - 6.66	6.18 ± 0.79
12.	Total larval period	18.94 - 22.17	21.01 ± 1.80
13.	Prepupal period	2.80 - 3.66	3.27 ± 0.43
14.	Pupal period	7.21 - 9.63	8.41 ± 1.21
15.	Mean adult emergence:		
	a. Male	5.42 - 5.87	5.65 $\pm$ 0.22
	b. Female	4.12 - 4.57	4.34 $\pm$ 0.22
	c. Sex ratio	1.18 - 1.42	1.30 $\pm$ 0.12
16.	Adult longevity:		
	a. Male	4.62 - 6.07	5.41 ± 0.73
	b. Female	6.37 - 7.97	7.22 ± 0.80
17.	Total life cycle:		
	a. Male	38.29 - 45.90	42.31 ± 3.82
	b. Female	40.06 - 47.80	44.11 ± 3.88

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Table-2: Body sizes of egg, different larval instars, pupa and adult of Blackheaded fireworm, *Rhopobota naevana* (Hubner).

Stage of Development	Number of specimens (n)	Length (mm)		Width (mm)	
		Range	Mean ± SD	Range	Mean ± SD
Egg	20	0.79 - 0.90	0.84 ± 0.05	-	-
Larva:1st Instar	15	2.04 - 2.64	2.39 ± 0.31	0.84 - 1.08	0.97 ± 0.12
2nd Instar	15	3.84 - 5.04	4.42 ± 0.60	1.20 - 1.44	1.33 ± 0.12
3rd Instar	15	5.52 - 6.72	6.08 ± 0.60	1.68 - 2.16	1.94 ± 0.24
4th Instar	12	7.20 - 8.40	7.90 ± 0.62	2.16 - 2.40	2.25 ± 0.12
5th Instar	12	8.88 - 9.60	9.16 ± 0.38	2.52 - 2.76	2.64 ± 0.12
Pupa: Pre pupa	15	6.96 - 8.16	7.44 ± 0.63	2.64 - 3.00	2.78 ± 0.19
Male pupa	12	5.40 - 6.60	6.00 ± 0.60	2.88 - 3.12	3.00 ± 0.12
Female pupa	12	6.00 - 6.96	6.48 ± 0.48	3.12 - 3.72	3.43 ± 0.30
Adult: Male	10	11.28 - 11.88	11.52 ± 0.31 (w.sp.)	3.96 - 4.32	4.12 ± 0.18
Female	10	12.00 - 12.60	12.23 ± 0.32 (w.sp.)	4.44 - 4.80	4.59 ± 0.18

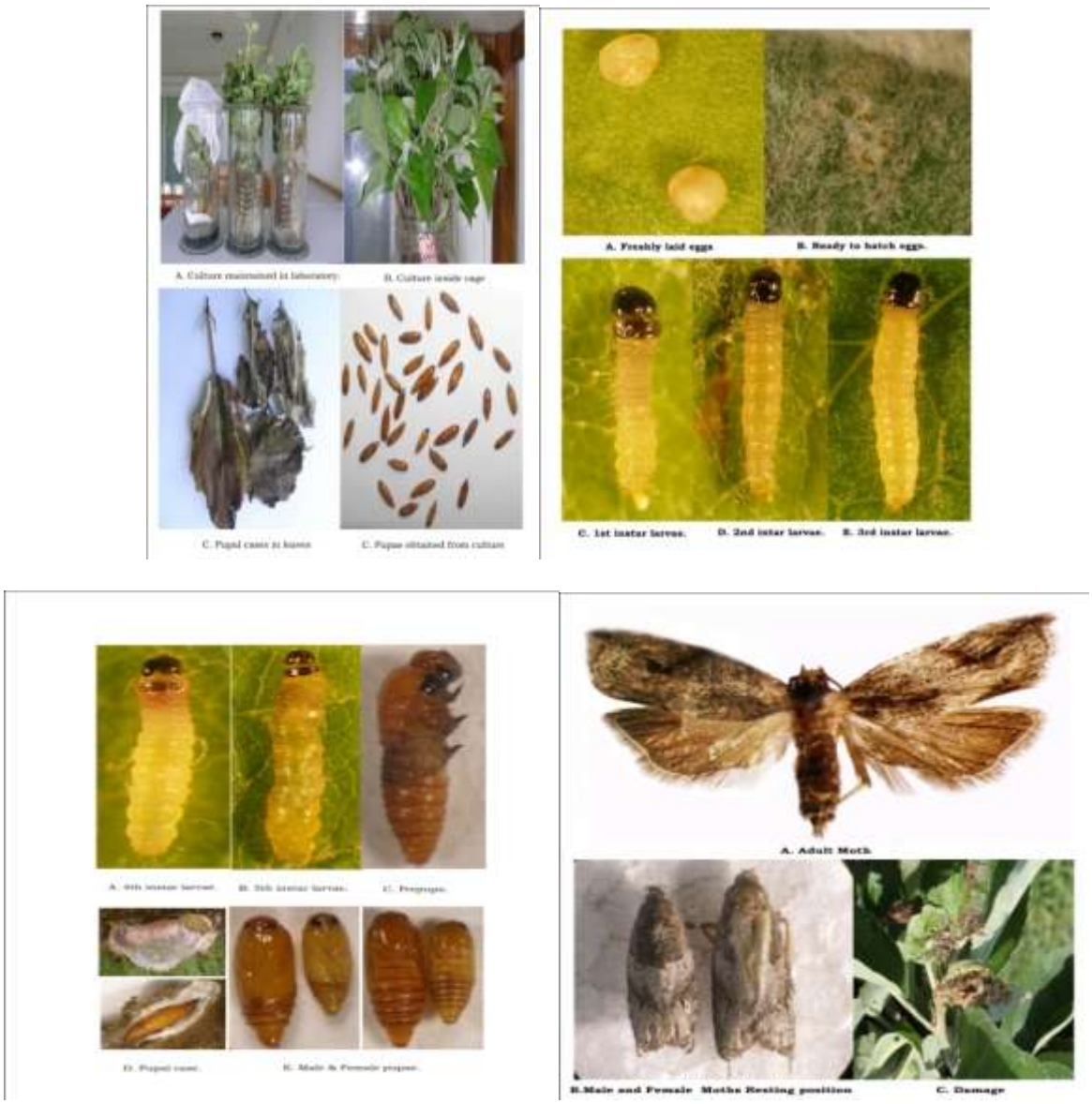

Fig. 2: Different developmental stages of Blackheaded fireworm, *Rhopobota naevana* (Hubner).

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