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BIOLOGY OF MIDRIB FOLDER, *Banisia myrsusalis elearalis* WALKER (LEPIDOPTERA: THYRIDIDAE) ON SAPOTA

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ABSTRACT

Biological studies on the sapota midrib folder, *Banisia myrsusalis elearalis* Walker, were conducted under laboratory conditions at the Department of Entomology, College of Agriculture, Anand Agricultural University, Vaso, during 2025. The average incubation period was 5.16 ± 0.98 days, with an egg hatchability of 86.00 ± 12.80%. The developmental durations of the first, second, third, and fourth larval instars were 5.53 ± 0.86, 3.63 ± 0.55, 3.20 ± 0.66, and 1.50 ± 0.62 days, respectively, culminating in a total larval period of 13.86 ± 2.71 days. The pre-pupal and pupal stages lasted 1.40 ± 0.49 and 10.13 ± 1.04 days, respectively. Regarding reproduction, the pre-oviposition, oviposition, and post-oviposition periods averaged 2.40 ± 0.51, 1.90 ± 0.73, and 2.40 ± 1.26 days, respectively, with a mean fecundity of 37.40 ± 16.98 eggs per female. Adult longevity averaged 5.50 ± 1.35 days for males and 6.30 ± 1.15 days for females. The total lifespan was 36.05 ± 6.57 days for males and 36.85 ± 6.37 days for females, with a male-to-female sex ratio of 1:0.87.

Keywords **:** Biology, midrib folder, *Banisia myrsusalis elearalis*, sapota.

Introduction

Sapota (*Achras zapota* L., *Syn*. *Manilkara achras* (Mill.) Forsberg) is an important fruit crop that belongs to the family Sapotaceae. In India, this fruit is commonly referred to as sapodilla or chiku. Although it originated in Mexico and Central America, it is now widely grown across tropical regions for its tasty fruits (Bose & Mitra, 1990). Sapota fruits are a good source of sugars, typically ranging from 12 to 14 per cent. On average, 100 g of the edible portion of the fruit contains about 73.7 g moisture, 21.49 g carbohydrates, 0.7 g protein, 1.1 g fat, 28 mg calcium, 27 mg phosphorus, 2 mg iron and 6 mg ascorbic acid (Bose & Mitra, 1990). Approximately three dozen varieties of sapota are cultivated in different regions of the country, including Kalipatti, Cricket Ball, Guthi, Kirtibarthi, CO-1, CO-2, PKM-2, PKM-3, DHS-1 and DHS-2 (Meena *et al*., 2019). India is the leading producer of sapota in the world with Mexico, Guatemala and Venezuela also recognized as important producing countries. Sapota is cultivated on about 70,000 ha in India with an annual production of approximately 8,58,000 MT (Anonymous, 2025a). Major producing states include Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Tamil Nadu, Kerala, Punjab, West Bengal and Haryana. Gujarat accounts for 24,622 ha under cultivation with a production of 2,43,612 MT and an average productivity of 9.89 MT/ha. In Anand district, sapota is cultivated over 390 ha, producing about 3,687 MT with an average productivity of 9.45 MT/ha (Anonymous, 2025b).

About 25 species of insect-pests have been reported to infesting sapota in India (Butani, 1979). Among the various foliage feeding insect-pests of sapota the midrib folder, *Banisia myrsusalis elearalis* belongs to the family Thyrididae under the order Lepidoptera (Martinez *et al*., 2017). In India, its occurrence on sapota was first reported from Punjab (Sandhu & Sran, 1980). The pest was recorded for the first time at Mudigere in the hill zone of Karnataka,

where it has emerged as a serious problem (Ravulapenta *et al.*, 2013). Similarly, the incidence of this pest has also been reported in the South Gujarat region, where it damages the leaves of *Khirnee* [*Manilkara hexandra* (Roxb.) Dubard], which is commonly used as a rootstock in nurseries (Jhala *et al.*, 1988). The pest is generally active during January to April and October to December with peak incidence observed from November to December. The larvae characteristically fold the terminal leaves either singly, forming a "pea-pod" shape or in groups of two to three leaves and feed on the chlorophyll inside the folded portion. Fully grown larvae create a relatively larger exit hole in the leaf fold before emerging for pupation (Ravulapenta *et al.*, 2013). Studying the biology of the midrib folder is important for understanding its life cycle, development, survival and reproduction under local conditions. This knowledge helps identify vulnerable stages for effective control, supports Integrated Pest Management (IPM), enables timely interventions, reduces unnecessary pesticide use and contributes to sustainable pest management in sapota. Considering the points discussed above the present investigation was conducted.

Materials and Methods

The present investigation was carried out in the Laboratory, Department of Entomology, College of Agriculture, Anand Agricultural University, Vaso, Gujarat, India on during 2025.

Maintenance of Culture

The initial culture of *B. myrsusalis elearalis* was established from infested folded leaves collected from an unsprayed sapota (Variety: Kalipatti) orchard at the Horticulture Farm, CoA, AAU, Vaso. The folded leaves were opened to obtain larvae, which were reared individually in plastic vials (4.5 cm diameter × 5.5 cm height) with fresh, tender sapota leaves. The plastic vials, fitted with perforated lids for aeration were cleaned daily and the food was replaced regularly. When larvae became fully grown and ceased feeding, finely sieved loose soil was provided at the bottom of the vials to facilitate pupation. After pupation, the pupae were transferred to Petri plates (90 mm diameter) and their sex was determined at the pupal stage by examining the position of the genital slit relative to the anal slit under a stereo zoom microscope. The pupae were then kept in an oviposition cage (30 × 30 × 30 cm) for adult emergence. Emerged male and female moths were allowed to mate and oviposit inside the cage. A fresh sapota terminal shoot with tender leaves and buds was provided as an oviposition substrate with its cut end wrapped in cotton wool and placed in a conical flask (capacity: 150 mL) containing water to maintain leaf turgidity. Adults were fed with 5 per cent honey solution supplied on cotton swabs suspended inside and placed at the bottom of the cage. Twigs bearing freshly laid eggs were collected and used for further studies.

Biology

Egg

In order to study the hatching percentage, the eggs laid by the female moth were picked up with the help of a fine camel hair brush on the same day and were transferred into Petri plates (diameter: 90 mm) containing moist blotting paper at the bottom placed over a moist cotton wad. Five eggs were placed in one Petri plate with a set of ten Petri plates maintained. The blotting papers were moistened periodically. Observations on the number of eggs hatched were recorded daily in the morning until the unhatched eggs were shrunk. For the incubation period, 30 eggs were examined from the date of egg laying to the date of hatching.

Larva

With a view to determining the larval period, newly hatched larvae were placed individually on fresh and tender sapota leaves with the help of a moist fine camel hair brush in plastic vials. The plastic vials were closed individually with lids having small aeration holes. One or two terminal tender leaves were provided as food for the larvae and were changed on alternate days until pupation. 30 such plastic vials were maintained to study the larval instars. The plastic vials containing developing larvae were observed daily to study the larval instars. The presence of head capsule exuviae was the indication of a change in larval instar. The period from hatching of eggs until cessation of feeding was recorded as the larval period.

Pre-pupa and pupa

The period required from the cessation of feeding by the full-grown larvae to the formation of the pupa was recorded for 30 larvae as the pre-pupal period. The period from the formation of the pupa to the emergence of the adult was recorded as the pupal period. 30 such pupae were kept under observation.

Adult

The newly emerged adults were kept separately in the oviposition cage. A cotton swab dipped in five per cent honey solution was placed in the oviposition cage as food for the moths. The life span of each adult was recorded by counting the period from the emergence of

the adult from the pupa until death to study the longevity of adults. The longevity of both males and females was recorded for ten individuals' each. The period between the emergence of female moths from the pupa and the commencement of egg laying was recorded for ten females as the pre-oviposition period. The period during which the female moth laid eggs was recorded for ten females as the oviposition period. The period from the cessation of oviposition by a female moth until its death was recorded for ten females as the post-oviposition period.

Fecundity

The females were allowed to lay eggs until their death and the total number of eggs laid by each female during its lifetime was recorded as fecundity.

Sex-ratio (Male: Female)

The sex ratio was observed by counting the number of male and female pupae. The pupae were separated as males and females by confirming the distance between the genital and anal slits, which was less in male pupae than in female pupae.

Total life cycle

The period, in days, from the date of egg laying to the date of adult death was considered as the total life cycle.

Results and Discussion

Egg

In laboratory conditions, the female *B. myrsusalis elearalis* deposited its eggs individually though often clustered closely together on buds as well as on both the upper and lower surfaces of young leaves. It showed a clear preference for ovipositing on tender terminal leaves and developing shoot buds [Fig. 1(A)]. The newly laid egg was oval in shape, featuring vertical rib-like structures. It appeared pale yellow in color with an orange-red circular band present both at the midsection and around the operculum region [Fig. 1(B)]. The eggs were securely attached to the lower surface of both tender and mature leaves, typically positioned close to the midrib. At the time of hatching, the eggs changed in color to light grey. The unfertilized eggs were also oval in shape and appeared creamy white in color [Fig. 1(C)]. The present findings corroborate the reports of Patel (1990) and Ravulapenta *et al*. (2013) who reported the female moths laid the eggs singly or group but closely on buds on upper and lower surface of tender leaves.

Egg hatching (%)

During the laboratory study, fifty eggs were investigated following oviposition using a set of ten Petri plates with five eggs per Petri plate. As a result, hatching per cent ranged between 60 to 100 per cent with an average of 86 ± 12.80 per cent as given in Table 1. These findings are in agreement with those of Patel (1990), who reported a hatching percentage ranged between 86.67 to 100 per cent with an average of 94.29 ± 3.51 per cent.

Incubation period

The data on the incubation period are given in Table 1. The incubation period of *B. myrsusalis elearalis* ranged between 3 to 6 days with an average value of 5.16 ± 0.98 days. Similar findings were reported by Patel (1990) and Ravulapenta *et al.* (2013), who observed an incubation period ranging from 3 to 6 days with mean durations of 4.37 ± 0.96 days and 5.23 ± 0.59 days, respectively.

Larva

During the present study, *B. myrsusalis elearalis* was observed to undergo four larval instars. Changes in larval instars were confirmed by head capsule or exuviae. The freshly emerged first instar larva was dark yellow in appearance, possessing a distinct reddish-brown head capsule. It's body consisted of three thoracic and ten abdominal segments along with a well-developed prothoracic shield [Fig. 2(A)]. Immediately after hatching from the egg, the larva exhibited active movement. The duration of the first instar larvae ranged from 4 to 7 days with a mean duration of 5.53 ± 0.86 days (Table 1). The findings closely align with Patel (1990) reported first instar larval period was 5.00 ± 1.0 with range of 4 to 7 days.

Table 1: Biology of midrib folder, *B. myrsusalis elearalis* on sapota under laboratory conditions

Life stages	Minimum (Days)	Maximum (Days)	Mean ± S.D. (Days)	Sample size (n)
Egg hatching (%)	60	100	86 ± 12.80	50
Incubation period	3	6	5.16 ± 0.98	30
First instar	4	7	5.53 ± 0.86	30
Second instar	2	4	3.63 ± 0.55	30
Third instar	2	4	3.20 ± 0.66	30
Fourth instar	1	3	1.50 ± 0.62	30
Total larval period	**09**	**18**	**13.86 ± 2.71**	30

Pre-pupal period	1	2	1.40 ± 0.49	30
Pupal period	8	12	10.13 ± 1.04	30
Male longevity	3	8	5.50 ± 1.35	10
Female longevity	5	9	6.30 ± 1.15	10
Pre-oviposition period	2	3	2.40 ± 0.51	10
Oviposition period	1	3	1.90 ± 0.73	10
Post-oviposition period	1	5	2.40 ± 1.26	10
Fecundity (Eggs/female)	14	67	37.40 ± 16.98	10
Sex ratio (Male:Female)	1:0.87			
Total life span of Male	**24**	**46**	**36.05 ± 6.57**	
Total life span of Female	**26**	**47**	**36.85 ± 6.37**	

Note: S. D. = Standard Deviation; n= No. of observation

The newly moulted second instar larva was comparatively larger than the first instar. Its body colour ranged from light yellow to pale green with a dark brown head capsule and a distinct prothoracic shield. The larval body was composed of three thoracic and ten abdominal segments [Fig. 2(B)]. The duration of second instar larva varied from 2 to 4 days with an average of 3.63 ± 0.55 days. This finding is consistent with Patel (1990) and Ravulapenta *et al.* (2013), who reported second instar larval periods of 2-4 days (Av. 3.56 ± 0.58 days) and 4.10 ± 0.91 days, respectively. The third instar larva was larger and longer than the second instar. It exhibited a yellowish-green body colour with a reddish-brown head capsule and a light brown prothoracic shield. The body consisted of three thoracic and ten abdominal segments [Fig. 2(C)]. Data presented in Table 1 indicated that the duration of third instar larvae varied from 2 to 4 days with an average of 3.20 ± 0.66 days. These findings are in close agreement with those of Patel (1990) and Ravulapenta *et al.* (2013), who recorded third instar larval periods of 2-4 days (Av. 3.20 ± 0.50 days) and 3.70 ± 0.47 days, respectively. The fourth instar larva was noticeably larger than the third instar and appeared pale green in colour. It possessed a reddish-brown head capsule along with a light brown prothoracic shield [Fig. 2(D)]. The body was differentiated into three thoracic and ten abdominal segments. Each thoracic segment bore a pair of true legs, making a total of three pairs. The first and second abdominal segments lacked prolegs, whereas the third to sixth abdominal segments each carried a pair of prolegs. Prolegs were absent on the seventh, eighth and ninth abdominal segments, while the terminal or tenth abdominal segment possessed a pair of anal legs. In addition, three pairs of brown spots were distinctly visible on the dorsal side of each segment, arranged in the dorsal, sub-dorsal and supra-spiracular regions. The duration of fourth instar larva varied from 1 to 3 days with an average of 1.50 ± 0.62 days. This finding is in agreement with Patel (1990), who reported a duration ranging from 1 to 3 days with a mean of 1.76 ± 0.72 days. The data presented in Table 1 indicated that the total larval developmental period of *B. myrsusalis elearalis* ranged from 9 to 18 days with a mean duration of 13.86 ± 2.71 days when reared on sapota. The present findings are supported by Patel (1990) and Shukla and Patel (2012), who recorded total larval developmental periods of 12-16 days (Av. 13.52 ± 1.16 days) and 15.71 ± 1.01 days, respectively.

Pre-pupa

One to two days after moulting, the fourth instar larvae gradually changed in colour from pale green to creamy white [Fig. 3(A)]. During this period, the larvae ceased feeding and became sluggish and wrinkled, indicating the onset of the pre-pupal stage. The duration of the pre-pupal stage varied from 1 to 2 days with an average of 1.40 ± 0.49 days (Table 1). The present findings are in accordance with those of Patel (1990) and Shukla and Patel (2012), who recorded mean pre-pupal periods of 1.56 ± 0.51 and 1.61 ± 0.54 days, respectively.

Pupa

The fourth instar larva pupated after the pre-pupal stage, usually inside an earthen cocoon [Fig. 3(B)], though some naked pupae were found on leaves or within rearing vials. The obtect pupae were initially reddish-brown, darkening before adult emergence with nine visible dorsal segments, ventrally visible antennae and wings extending to the fifth abdominal segment and spiracles on the second to eighth abdominal segments [Fig. 3(C)]. The present findings are in agreement with the earlier observations of Patel (1990) and Ravulapenta *et al.* (2013), who reported that the freshly formed obtect pupae of *B. myrsusalis elearalis* were reddish brown in colour and gradually turned darker or black prior to adult emergence. In pupae, the distance between the genital pore and anal pore was shorter in males and longer in females, providing a

distinguishing feature for sex differentiation [Fig. 3(D,E)]. The duration of the pupal stage varied from 8 to 12 days with an average of 10.13 ± 1.04 days. The present findings are comparable with those of Patel (1990) and Shukla and Patel (2012), who reported mean pupal durations of 8.32 ± 1.57 and 9.13 ± 1.36 days, respectively. Similarly, Ravulapenta *et al.* (2013) recorded average pupal durations of 8.90 ± 0.91 days in males and 11.50 ± 1.00 days in females.

Adult

Freshly emerged adults of *B. myrsusalis elearalis* had greyish-black lateral compound eyes, a pair of filiform antennae located dorsally between the eyes and coiled siphoning mouthparts beneath the head when at rest. A white spot at the centre of each forewing was observed in some adults, although it was absent in others. In the resting position, the adults kept their wings fully expanded. Males possessed a dark almond coloured head, thorax and abdomen and both pairs of wings were slightly dark almond in colour. The tip of the abdomen was pointed in male adults [Fig. 4(A)]. Females possessed a light almond coloured head, thorax and abdomen and both pairs of wings also exhibited a similar light almond colouration. The tip of the abdomen was blunt in appearance [Fig. 4(B)]. The morphological characteristics of male and female adults of *B. myrsusalis elearalis* observed in the present study are in complete agreement with the findings reported by Patel (1990) and Ravulapenta *et al.* (2013).

Adult longevity

Male and female adult longevity ranged from 3 to 8 and 5 to 9 days with mean durations of 5.50 ± 1.35 and 6.30 ± 1.15 days, respectively (Table 1). The findings on adult longevity are in close agreement with those of Ravulapenta *et al.* (2013), who reported that the average longevity of male and female moths of *B. myrsusalis elearalis* was 5.50 ± 0.62 days and 6.85 ± 0.91 days, respectively.

Pre-oviposition, oviposition and post-oviposition period

The data presented in Table 1 indicated that the pre-oviposition, oviposition and post-oviposition periods ranged from 2 to 3, 1 to 3 and 1 to 5 days with mean durations of 2.40 ± 0.51, 1.90 ± 0.73 and 2.40 ± 1.26 days, respectively. The present findings are more or less similar to those reported by Patel (1990), who observed that the pre-oviposition, oviposition and post-oviposition periods ranged from 2 to 3, 1 to 3 and 1 to 5 days with mean durations of 2.50 ± 0.53, 1.80 ± 0.79 and 2.10 ± 1.29 days, respectively. Likewise, Shukla and Patel (2012) recorded average pre-oviposition, oviposition and post-oviposition periods of 2.53 ± 0.49, 1.90 ± 0.70 and 2.95 ± 0.98 days, respectively.

Fecundity

The fecundity varied from 14 to 67 eggs with an average of 37.40 ± 16.98 eggs per female (Table 1). These results are in agreement with those of Patel (1990) and Ravulapenta *et al.* (2013), who reported mean fecundities of 35.7 ± 17.00 and 39.58 ± 10.75 eggs per female, respectively.

Sex Ratio

Sex differentiation was carried out based on the morphometric characteristics of the pupae. The sex ratio of *B. myrsusalis elearalis* was 1:0.87 (Male:Female). These findings are supported by Patel (1990) and Ravulapenta *et al.* (2013), who observed a male: female ratios of 1:0.89 and 1:1.38 ± 0.35, respectively.

Total Life Cycle

Looking to data presented in Table 1, indicated that the total life span in male varied from 24 to 46 days with an average of 36.05 ± 6.57 days while in female varied from 26 to 47 days with an average of 36.85 ± 6.37 days. The present findings are consistent with earlier researchers. Patel (1990) documented a total life span from egg to adult death ranged from 25-44 days in males (Av. 33.77 ± 5.53 days) and 26-46 days in females (Av. 34.17 ± 6.16 days). Similarly, Shukla and Patel (2012) reported an average total life cycle of 34.78 ± 4.63 days in males and 37.83 ± 5.44 days in females.

Conclusion

The biological studies on the midrib folder, *B. myrsusalis elearalis* on sapota revealed that the pest completes its life cycle through four developmental stages: egg, larva, pupa and adult. The average egg hatchability was recorded at 86 ± 12.80 per cent with a mean incubation period of 5.16 ± 0.98 days. The larval stage of *B. myrsusalis elearalis* consisted of four instars before pupation with a total average duration of 13.86 ± 2.71 days**.** The larvae changed in size and coloration through each instar, progressing from dark yellow with a reddish-brown head in the first instar to pale green in the fourth instar. The durations of the first, second, third and fourth instars averaged 5.53 ± 0.86**,** 3.63 ± 0.55**,** 3.20 ± 0.66 and 1.50 ± 0.62 days, respectively. All instars had a body composed of three thoracic and ten abdominal segments. The mean duration of the pre-pupal and pupal stages was 1.40 ± 0.49 and 10.13 ± 1.04 days, respectively. The average longevity of male and female adults was 5.50 ± 1.35 and 6.30 ± 1.15 days, respectively indicating a slightly

longer life span in females. The pre-oviposition, oviposition and post-oviposition periods averaged 2.40 ± 0.51, 1.90 ± 0.73 and 2.40 ± 1.26 days, respectively. The mean fecundity was 37.4 ± 16.98 eggs per female and the male to female sex ratio was 1:0.87. The total life span averaged 36.05 ± 6.57 days in males and 36.85 ± 6.37 days in females. Furthermore, the larval and adult life span and the site of pupation of *B. myrsusalis elearalis* would be useful in the planning of integrated management strategy under field conditions.

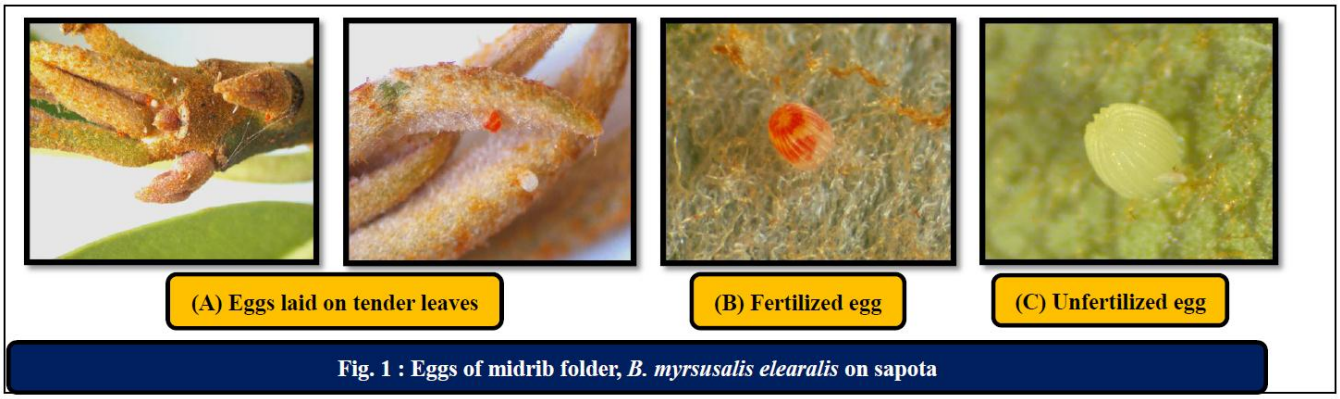

Fig. 1 : Eggs of midrib folder, *B. myrsusalis elearalis* on sapota

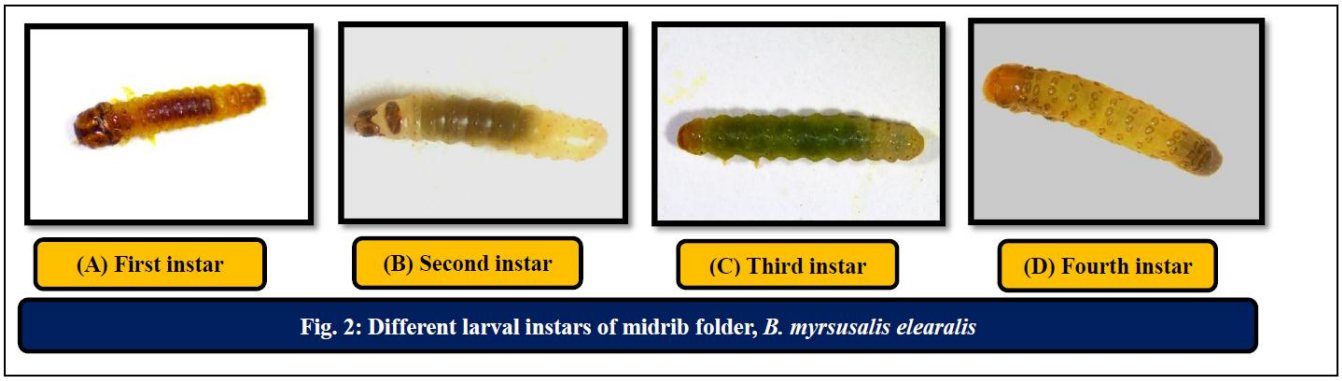

Fig. 2: Different larval instars of midrib folder, *B. myrsusalis elearalis*

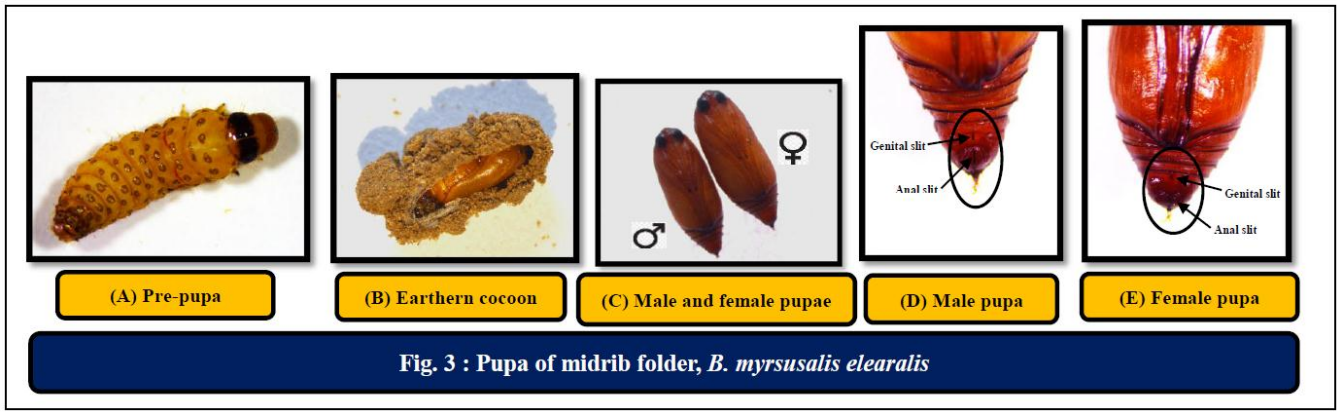

Fig. 3 : Pupa of midrib folder, *B. myrsusalis elearalis*

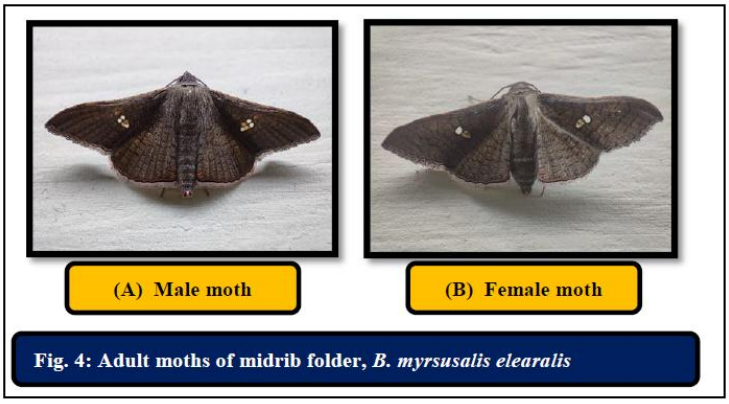

Fig. 4: Adult moths of midrib folder, *B. myrsusalis elearalis*

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