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Taxonomic Studies on the Genus, *Mythimna* Ochsenheimer, 1816 (Lepidoptera: Noctuidae: Noctuinae: Leucaniini) in Karnataka, India

Basavaraj N. Hadimani[1]*, Prabhu C. Ganiger[1], Ajayakumar[2], Sadashiva Tippimath[1], K. Chandrakumara[1] and Dhanyakumar Onkarappa[1]

[1]Department of Entomology, University of Agricultural Sciences, GKVK, Bengaluru (Karnataka), India.

[2]Department of Agricultural Economics, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka (Karnataka), India.

(Corresponding author: Basavaraj N. Hadimani)*

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ABSTRACT: Armyworm *Mythimna* Guenée is one of the most important pests on graminaceous crops and pastures in South and South East Asia (*i.e., M. separata* Walker is well known to cause serious damages on rice in India). A comprehensive and comparative studies were carried out on taxonomic account of species of the genus *Mythimna* Guenée is provided with two species are recognized in the genus *viz., M. separata,* and *M. reversa.* Morphological characters *viz.,* frons, vertex, antennae, labial palpi, compound eyes, ocelli, proboscis, wing venation, Male and female genitalic attribute, identification keys with photographs and illustrations are provided and discussed in detail.

Keywords: Armyworm, Faunistics, Taxonomy, *Mythimna*, Noctuidae.

INTRODUCTION

There are two groups of armyworms, *i.e.*, the genus *Spodoptera* and *Mythimna*. The genus *Mythimna* belongs to tribe Leucanini (Lepidoptera: Noctuidae: Noctuinae), comprises species involved in what are referred to as 'armyworm' outbreaks (Carnegie & Dick 1972; Chandler & Benson 1991; Holloway *et al.*, 1987). They have been given this common name due to their sporadic occurrence in large numbers in a manner similar to the African armyworm, *Spodoptera exempta* (Walker), which is a serious pest of many graminaceous crops (Brown, 1962; Lin *et al.*, 1965). *Mythimna* Ochsenheimer, 1816 (Lepidoptera: Noctuidae) includes species that are widely distributed. The genus has been recorded for almost all continents. Adults and immature are cryptic and difficult to identify, presenting longitudinal lines characteristic of noctuids that feed on grasses (Fibiger & Lafontaine 2005). Species are usually identified after examination of the genitalia, which have unique characters used in group systematics (Hacker *et al.*, 2002; Lafontaine & Schmidt 2010). The larvae of *Mythimna* spp. migrates in thousands like an 'army' from field to field and hence the name 'Army worm'. Sometimes, the armyworm appears in epidemic form and its outbreak results in severe to complete crop losses. *Mythimna* Ochsenheimer, 1816 is a cosmopolitan genus that comprises approximately 270 species, grouped in subgenera and species-groups according to genitalia characters (Nagano *et al.*, 1971; Yoshimatsu & Hreblay 1998; Yoshimatsu & Legrain 2001). This classification has been accepted in the most recent taxonomic studies, though it remains problematic (Hacker *et al.*, 2002; Lafontaine & Schmidt 2010). Larvae of *Mythimna* spp. feed on pasture grasses, sugarcane and maize (Ganesha & Rajabalee 1996). The moths of *Mythimna* spp. are nocturnal and hide during the day. The larvae start feeding at the onset of darkness and are rarely seen during the day (Carnegie, 1977). The mode of attack of these species varies in different parts of the world. Blanket trash lining has been found to favour *M. phaea* Hampson and *M. polyrabda* Hampson in South Africa (Carnegie & Dick 1972) and *M. separata* (Walker), *M. convecta* (Walker) and *M. loreyimima* (Rungs) in Australia (Chandler & Benson, 1991). The Oriental armyworm, *Mythimna separata* (Walker) (Lepidoptera: Noctuidae) is a pest of several cereal crops in Asia and Australia between 45°N to 45°S latitude, and 60°E to beyond 170°W longitude which includes 27 countries or islands ranging from humid tropical to temperate regions (Sharma & Davies 1983). Prior to 1950, it was a minor pest in India, but has since caused serious damage periodically on sorghum [*Sorghum bicolor* Moench (L.)], pearl millet [(*Pennisetum glaucum* (R.Br.) L.)], rice (*Oryza sativa* L.), maize (*Zea mays* L.), wheat (*Triticum aestivum* L.), and sugarcane (*Saccharum officinarum* L.). Yield losses are influenced largely by the stage at which damage occurs and the gregarious behaviour of the larvae. Varied practices of farming systems result in heavy incidence of cutworm cause economic loss Heavy crop losses have been experienced in India, Bangladesh, China, Japan, Australia, and New Zealand (Sharma & Youm 1999).

Outbreaks of *M. separata* have been recorded in Andhra Pradesh (1977, 1978, and 1981), Karnataka (1980), Himachal Pradesh (1983) and Haryana (1984) (Sharma & Davies 1983; Singh *et al.,* 1987; Thakur *et al.,* 1987) in India. *Mythimna unipuncta* has been reported from the Nearctic and Neotropical regions, and certain parts of Africa and Europe. Records of *M. unipuncta* by (Box, 1953) from South East Asia, Australasia and some Pacific Islands are now known to refer as *M. separata* (Edwards, 1992). The *M. separata* occurs throughout India. It was first reported from Patna in 1889 subsequently from Bengal (1891-93), Uttar Pradesh and Poona (1928). It is present all over India (Sharma *et al.,* 1982). Larvae of *M. separata* exhibit voracious feeding habits, causing characteristic windowpane-like patterns on rice leaves and extensive damage to maize and sorghum crops (Jiang *et al.,* 2014). Current management methods heavily rely on insecticides, but their repeated use can lead to pesticide resistance and harm to beneficial organisms, including pollinators, birds, and fish (Whitehorn *et al.,* 2012; Godfray *et al.,* 2014). Moreover, pesticide use contributes to environmental pollution, biodiversity loss, and disruption of ecosystem services (Karuppuchamy & Venugopal 2016; Tiwari *et al*., 2018). The *M. separata* has caused damage in parts of North and South interior Karnataka. In about 15 districts, crops across 1.77 lakh hectares have been damaged by these insects. In Chitradurga and Davanagere districts, armyworm outbreak noticed on maize, groundnut, finger millet, foxtail millet and jowar affecting area around 1,05, 120 and 56,872 ha, respectively (State Department of Agriculture, 2017). The *Mythimna* complex based on genitalia both of male and female characters was discussed and mentioned in detailed by Calora (1966); Holloway *et al.* (1987) and Yoshimatsu (1994). Comprehensive taxonomic studies in India have been limited, with the exception of those reported by Hampson (1894). To develop effective pest control methods and gain insights into the biology of the pest, it is essential to clarify the species' identity and composition. Thus, the current investigation was conducted to unravel the uncertain exist amid the species complex of *Mythimna* genus. This was achieved through field surveys, and the findings are presented in this paper.

MATERIAL AND METHODS

The extensive collection-cum-survey tours were made from different locations in Karnataka, representing major host plants growing areas of state. Light source of 200W mercury vapour lamp was used with white cloth (10 ft. × 6 ft.) background in the fields for collection of adult moths. The moths which were attracted to light trap were collected. The processing and preservation of collected moths were done following the standard procedure for Lepidoptera. External morphological structures were studied using a Nikon SMZ 1000 Stereo-zoom microscope. The *Mythimna* were identified based on characters like orbicular and reniform spot, characters of male genitalia like the shape of uncus, tegumen, valve, ampulla, cucullus, juxta, aedeagus and also with female genitalia characters like corpus bursae, ductus bursae, signum, ventral plate, anterior and posterior apophyses.

For preparation of genitalia slides, the adults were sexed based on wing coupling *i.e.,* single frenulum in male and two or three frenula spines in females. Then, the abdomen was detached from thorax with a needle and forceps, as cutting of last few segments often damaged the constituent parts of male and female genitalia. The separated abdomen was then placed in a cavity block containing 10% KOH solution and left overnight. The abdomen was then washed in a cavity block with distilled water to remove excess KOH. The abdomen was then placed in another cavity block containing 10% ethanol. Using a pair of fine forceps, the genitalia was then separated gently from the abdomen. The separated genitalia structures were then placed on a clear microscope slide in 98% pure glycerol medium, covered with a cover slip and thereafter photographed and identified. Aedeagus was separated from the main genitalia by carefully keeping juxta and transtilla intact. Later, vesica was everted from the aedeagus by using syringe. Aedeagus and female genitalia were stained with acid fuchsin or chlorazol black for a few minutes. Specimens were initially identified based on their genitalia structures with reference to relevant literature Hampson (1894); Holloway *et al.* (1987); Yoshimatsu (1994). The terminologies of Klots (1970) were adopted to describe the genitalia. After examining the specimen parts, it was transferred to into a micro-vial containing 98% glycerol and pinned below the respective specimen. The forewing length was measured from the outer edge of the tegula to the tip of the wing apex. Photography of adult moths was made with the help of a canon 80D digital camera with 100mm lens. Photographs of male and female genitalia structures were made using a Leica 250C microscope mounted with a Leica DFC 450 camera and by using automontage software at Taxonomy laboratory. All images were processed using Adobe Photoshop®CS6. The voucher material is deposited at the insect collection museum, Department of Entomology, University of Agricultural Sciences, GKVK, Bengaluru.

RESULTS AND DISCUSSION

Examinations of the genitalia revealed the presence of two species. Based on the descriptions given by (Calora, 1966; Edwards, 1992; Holloway *et al.,* 1987; Rungs, 1955; Viette, 1963; Yoshimatsu, 1994), the species were identified as *Mythimna separata* and *M. Reversa* from Karnataka. The former was the predominant species.

Genus *Mythmina* Ochsenheimer

Ochsenheimer, 1816, *Schmett Eur.,* 4:78

Type species: *Phalaenaturca* Linnaeus.

Distribution: Universally distributed except the Australian region.

Diagnosis: The adults of this group are superficially very similar, average-sized, hairy-eyes, without bright coloration; usually pale ochreous white to ochreous,

striate with dark transverse markings usually in consupicuous or reduced to dots.

Remarks: Genus *Mythmina* was erected by Ochsenheimer on type species *turcas* Linnaeus in 1816, which was subsequently designated by Samouelle in 1819. This genus was reviewed by Yoshimatsu (1994) and consequently in 2001, where he described a new species from Taiwan along with checklist. In the present work, two species *viz*., *reversa* Moore and *separata* (Walker) have been studied and photographed.

Table 1: A checklist of armyworm genus *Mythimna* Ochsenheimer, 1816 from India.

Sr. No.	Scientific Name	Distribution
1.	*Mythimna fraterna* (Moore, 1888)	Himachal Pradesh (Kangra)
2.	*Mythimna hackeri* (Hreblay & Yoshimatsu 1996)	Sikkim
3.	*Mythimna legraini* (Plante, 1992)	West Bengal
4.	*Mythimna sinuosa* (Moore, 1882)	West Bengal (Darjeeling), Arunachal Pradesh
5.	*Mythimna khasiensis* Hreblay, 1998	Meghalaya (Khasi Hills)
6.	*Mythimna bicolorata* (Plante, 1992)	West Bengal
7.	*Mythimna fasciata* (Moore, 1881)	West Bengal (Darjeeling)
8.	*Mythimna furcifera* (Moore, 1882)	West Bengal (Darjeeling)
9.	*Mythimna pastellina* (Hreblay & Legrain 1996)	West Bengal (Darjeeling), Sikkim, Assam
10.	*Mythimna languida* (Walker, 1858)	India
11.	*Mythimna lineatipes* (Moore, 1881)	Meghalaya (Cherrapunji)
12.	*Mythimna nainica* (Moore, 1881)	Uttarakhand (Nainital)
13.	*Mythimna percisa* (Moore, 1888)	Himachal Pradesh (Kangra: TL)
14.	*Mythimna insularis* (Butler, 1880)	Punjab
15.	*Mythimna irrorata* (Moore, 1881).	NW Himalaya.
16.	*Mythimna multipunctata* (Hampson, 1918)	Meghalaya (Shillong)
17.	*Mythimna pallidicosta* (Hampson, 1894)	NE India.
18.	*Mythimna renimaculata* (Hreblay & Legrain 1996)	NW Himalaya
19.	*Mythimna pastea* (Hampson, 1905)	Meghalaya (Khasi Hills)
20.	*Mythimna opaca* (Staudinger, 1900)	Kashmir
21.	*Mythimna bifasciata* (Moore, 1888)	Himachal Pradesh (Kangra), NW Himalaya
22.	*Mythimnagriseo fasciata* (Moore, 1881)	Himachal Pradesh (Dalhousie)
23.	*Mythimna decipiens* (Yoshimatsu, 2004)	Himachal Pradesh (Kangra)
24.	*Mythimna nigrilinea* (Leech, 1889)	Punjab (Solun)
25.	*Mythimna cana* (Hampson, 1891)	Nilgiris
26.	*Mythimna obscura* (Moore, 1882)	West Bengal (Darjeeling)
27.	*Mythimna rudis* (Moore, 1888)	Himachal Pradesh (Kangra)
28.	*Mythimnan epos* (Leech, 1900)	India
29.	*Mythimna perirrorata* (Warren, 1913)	Meghalaya (Khasi Hills)
30.	*Mythimna binigrata* (Warren, 1912)	Meghalaya (Khasi Hills)
31.	*Mythimna distincta* (Moore, 1881)	Himachal Pradesh (Kangra), West Bengal
32.	*Mythimna speciosa* (Yoshimatsu, 1991)	West Bengal (Darjeeling)
33.	*Mythimna moorei* (Swinhoe, 1902)	West Bengal
34.	*Mythimnabi strigata* (Moore, 1881)	West Bengal (Darjeeling)
35.	*Mythimna rufistrigosa* (Moore, 1881)	Punjab (Umbala)
36.	*Mythimna kerala* (Hreblay & Legrain 1999)	Kerala
37.	*Mythimna rubida* (Hreblay, 1996)	West Bengal (Darjeeling), Himachal Pradesh
38.	*Mythimna laxa* (Hreblay & Yoshimatsu 1996)	Sikkim
39.	*Mythimna lepida* (Hreblay, 1996)	Meghalaya (Khasi Hills)
40.	*Mythimna modesta* (Moore, 1881)	West Bengal (Darjeeling)
41.	*Mythimna consimilis* (Moore, 1881)	West Bengal (Darjeeling)
42.	*Mythimna decisissima* (Walker, 1865)	West Bengal (Darjeeling), Sikkim
43.	*Mythimna dharma* (Moore, 1881)	West Bengal (Darjeeling), Sikkim.
44.	*Mythimna ignita* (Hampson, 1905)	Meghalaya (Khasi Hills)
45.	*Mythimna formosana* (Butler, 1880)	West Bengal (Darjeeling)
46.	*Mythimna albivitta* (Hampson, 1891)	Nilgiris
47.	*Mythimna subsignata* (Moore,1881)	NW Himalaya
48.	*Mythimna metaphaea* (Hampson, 1905)	Tamil Nadu (Palni Hills)
49.	*Mythimna albovenosa* (Hreblay, 1999)	Kerala (Munnar)
50.	*Mythimna vittata* (Hampson, 1891)	Nilgiris
51.	*Mythimna separata* (Walker, 1865)	India
52.	*Mythimna v-album* (Hampson, 1891)	Nilgiris
53.	*Mythimna munnari* (Hreblay, 1999)	Kerala (Munnar)
54.	*Mythimna mediana* (Moore, 1881)	Himachal Pradesh (Solan)
55.	*Mythimna reversa* (Moore, 1884)	India

(Hampson, 1894) (Anonymous, 2024; URL: https://www.mothsofindia.org/mythimna-sinuosa)

Key to the studied species of genus *Mythmina* Ochsentieimer

1. Forewing pale brown with white specks, cucullus has long spine like process at tip and sacculus quadrate shape..... .....***separata***

—Forewing brown coloured without white specks, cucullus has short spine like process at tip and sacculus triangular shape…….…….…….…. ***reversa***

***Mythimna separata* (Walker, 1865)**

Leucania separata Walker, 1865, 626.

Mythimna separata Sugi, 1970, 217.

Pseudaletia separata Holloway, 1976, 9; Sugi, 1982, 358.

Pseudaletia separata Poole, 1989, 844.

Mythimna separata Yoshimatsu, 1993

Description: Adult moth with frons ochreous brown, vertex ochreous white, mixed with fuscous tipped scales. Forewing pale brown, entirely irrorated with fuscous. Orbicular and reniform pale brown, a small white spot at the lower angle of discal cell, beyond which is fuscous, postmedial line represented by fuscous spots on veins, terminal lines represented by fuscous spots on interspaces, fringes cream with a pale brown transverse band in the middle. Hindwing white with fuscous outer half, the veins dark brown, fringe cream. Underside of hindwing white with slightly fuscous outer area, terminal line represented by fuscous spots on interspaces, fringe white.

Male genitalia: Uncus very short, strongly curved ventrally on subbasal portion, broadened at the middle in dorsal view and slightly curved dorsally on distal 1/3 with hairs on distal 2/3. Tegumen inverted U-shape, slender longer than vinculum, vinculum broad central portion, saccus small and rounded. Valva except cucullus with very strongly rounded produced ventral portion, costa slightly raised at middle. Ampulla very small, slender, strongly curved ventrally and beyond the posterior margin, sacculus moderately broad. Valvula broad and very strongly produced ventroposteriorly with moderately broad membraneous, cucullus large with an acutely pointed long process dorsoposteriorly strongly rounded swollen ventrally with many diffused coronal spines. Juxta elongated. Aedeagus cylindrical, vesica very long, about four times as long as aedeagus when everted, was bearing dense spinules on entire surface.

Female genitalia: Apophyses anterior and posterior were moderately long. Ductus bursae sclerotized and abruptly curved dorsally with many longitudinal striae; ostium bursae unmodified. Corpus busae rounded Appendix bursae membranous with sclerotized ventral surface. Papilla analis was bilobed.

Length of forewing:18.2-21 mm (male) and 19.5-22.7 mm (female).

Materials examined: INDIA: Karnataka:2♂, Hosakote, 21.xi.2017, Prabhu Ganiger; 1♀, Hosakote, 21.xi.2017, Prabhu Ganiger.; 2♀, Chamarajanagar, 27.xi.2017, Prabhu Ganiger.; 2♂, Chamarajanagar, 27.xi.2017, Prabhu Ganiger.; 2♂, Benagaluru, GKVK campus, 7.xii.2017, Prabhu Ganiger; 1♀, Hassan, 29.xi.2018, Basavaraj N. H.; 1♂, Hassan, 16.xi.2018, Basavaraj N. H.; 2♂, Mandya V.C. Farm, 22.xi.2018, Basavaraj N. H.; 2♂, Bengaluru, GKVK campus, 19.i.2019, Basavaraj N. H.;

Remarks: *Mythimna separata* had forewing with pale brown in male whereas reddish yellow to pale brown in female. Cucullus rounded swollen ventrally with many diffused coronal spines. Uncus short and broad at middle. Long spine like process presents at tip of cucullus.

***Mythimna reversa* (Moore, 1884)**

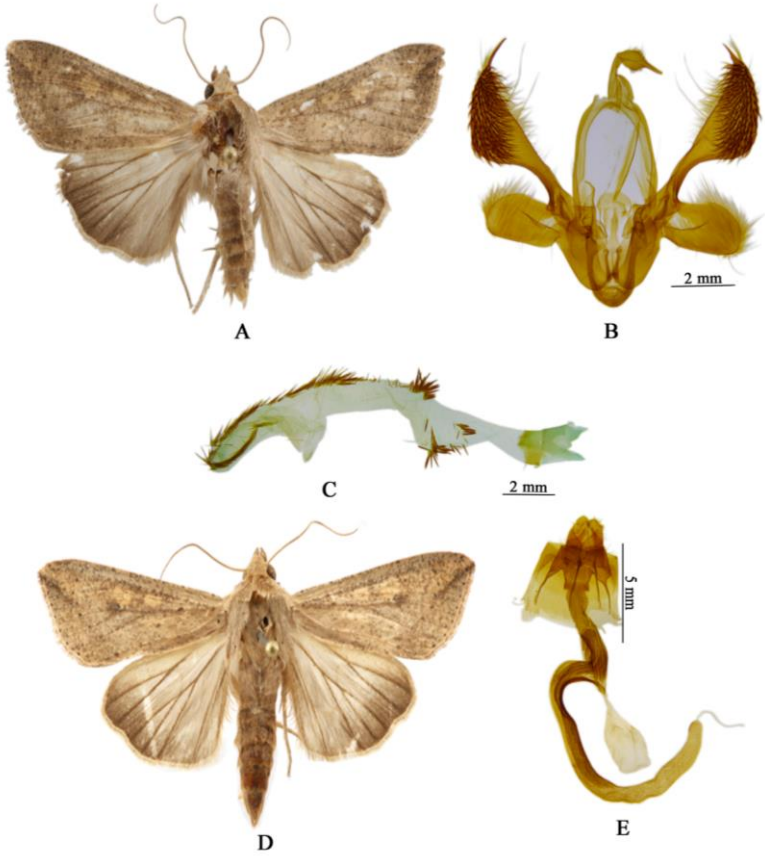
Aletia reversa Moore, 1883:6.

Hypopteridia reversa Holloway, 1976: 9.

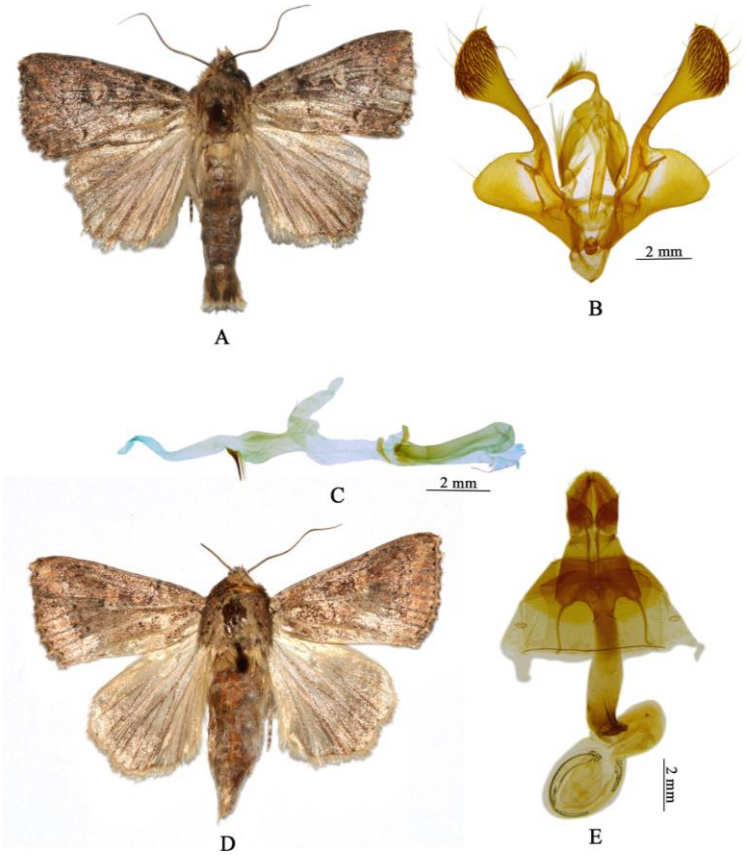
Mythimna reversa Holloway, 1989: 59.

Description: The forewing is marked pinkish brown in female, whereas dark brown in male, particularly strongly in the cell, where the reniform and orbicular appear distinctly paler. postmedial line represented by black spots on postmedial line represented by fuscous spots on veins, terminal lines represented by black triangular spots on interspaces, fringe grayish brown. Hindwing pale brownish with fuscous outer half, the veins light brown, fringe cream. Abdomen dark brown.

Male genitalia: Uncus long, slender, strongly curved ventrally on the subbasal portion, beyond which is haired. Tegumen broad longer than vinculum, vinculum broad at basal portion, saccus small and rounded. Valva except cucullus with very strongly rounded at ventral portion, Ampulla small, slender, strongly curved ventrally, sacculus moderately broad triangular shape. Valvula broad and very strongly produced ventroposteriorly with moderately broad membraneous area, cucullus large with pointed at dorsoposteriorly, strongly rounded swollen ventrally with many diffused coronal spines. Juxta rectangular band. Aedeagus cylindrical, vesica three times longer than aedeagus when everted, was bearing large spinules on diverticulum.



A. Adult male; **B.** Male genitalia; **C.** Aedeagus; **D.** Adult female; **E.** Female genitalia.
Fig. 1. *Mythimna separata* (Walker, 1865)



A. Adult male; **B.** Male genitalia; **C.** Aedeagus; **D.** Adult female; **E.** Female genitalia.
Fig. 2. *Mythimna reversa* (Moore, 1884)

Female genitalia: Apophyses posterior longer than apophyses anterior. Ductus bursae less sclerotized, ostium bursae unmodified. Corpus busae oval in shape, Appendix bursae membranous with sclerotized ventral surface. Papilla analis unmodified.

Length of forewing: 17-19.7 mm (male) and 17.2-19.5 mm (female).

Materials examined: INDIA: Karnataka: 2♂, Bengaluru, GKVK campus, 17.vii.2018, Basavaraj N. H.; 1♂, Bengaluru, GKVK campus, 10.xi.2018, Basavaraj N. H.;1♂, Bengaluru, GKVK campus, 15.xi.2018, Basavaraj N. H.;1♀, Bengaluru, GKVK campus, 19.i.2019, Basavaraj N. H.; 3♀, Bengaluru, GKVK campus, 26.i.2019, Basavaraj N. H.; 1♂, Bengaluru, GKVK campus, 17.i.2019, Basavaraj N. H.

Remarks: In this species male genitalia everted from abdominal segment; forewing coloration varies from pinkish brown to brown. Orbicular spot and postmedial line very prominent in forewing. Female were darker than male.

Moreover, the misidentifications are linked with the fact that all species have a similar habitus. There is a need to carry out systematic studies on the genus *Mythimna* and *Leucania*. Earlier authors both genus *Mythimna* and *Leucania* were grouped together. Few authors (Hampson, 1894) mentioned these two genera are grouped together and, in others (Edwards, 1992; Holloway *et al.*, 1987; Yoshimatsu, 1994), they are kept separately. According to Rungs (1953); Viette (1963) described *Leucania* spp. do not possess a corona on the cucullus while *Mythimna* spp. have a corona. The most common misidentifications in the *Mythimna* genus, particularly within the subgenus *Pseudaletia*, stem from the high degree of morphological similarity among species, necessitating careful examination of genitalia for accurate identification (Madruga *et al.*, 2022). Male genitalia of the available specimen were compared with true diagram of Ramamani & Subbarao (1965); Yoshimatsu (1994) found identical and confirmed as *Mythimna separata and M. reversa*. Smetacek (2008) recorded *M. separata* and *M. reversa* from Nainital district Kumaon Himalaya, India. However, this study reveals that *M. separata* and*M. Reversa* also present in Karnataka.

CONCLUSIONS

Accurate taxonomic identification of *Mythimna* species is crucial due to their economic importance as pests, but is complicated by their cryptic nature and morphological similarities. The present study revealed the distribution of two species of Armyworms *i.e.*, *M. seperata* and *M. reversa* in Karnataka. A well-defined taxonomy is necessary for rapid and precise identification, which is critical for effective pest management these pests based on biological control or other methods such as the use of pheromones.

FUTURE SCOPE

Taxonomic identification of different species of *Mythimna* (Lepidoptera: Noctuidae) is promising due to advancements in molecular techniques, integrative taxonomy, and ecological studies. Additionally, extensive survey and collection of more specimens from different parts of Karnataka is needed to establish the distribution and pest status of each species. The larval stage is the primary damaging phase. Therefore, studying larval morphology and chaetotaxy is crucial for early-stage identification. Further, study is a needed to carry out systematic studies on the genus *Mythimna* using molecular biology tools could help to determine the identity of the different species and provide information on the origin of the genus *Mythimna*.

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Author contribution: Conceived and designed the investigation, data curation and formal analysis were performed by BNH, PCG, ST and AK. The first draft of the manuscript was written by BNH, PCG, ST, DO, while KC and AK commented on its improvement. All authors read and approved the final manuscript.

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