

Larval and adult taxonomy of kodomillet shoot fly *Atherigona simplex* (Thomson) (Diptera: Muscidae)

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Abstract

The present study provides a detailed taxonomic note on both adult and maggot stages of *Atherigona simplex*. The adult males are mainly identified with the genitalia characters *i.e.*, the hypopygial prominence with a characteristic deep notch at the middle; trifoliate process with median piece and lateral plates yellow on basal half and dark brown in apical half. The maggots are identified based on the characters of cephalopharyngeal skeleton, number of digitations in anterior spiracles and shape of the posterior spiracles. Here, the detailed morphology of first, second and third instar maggots is described and illustrated for the first time.

Keywords: kodomillet, *Atherigona simplex*, maggot, adult, taxonomy

Introduction

Muscidae is a large family of calyptrate Diptera distributed in all biogeographic regions, represented by six sub-families (Pont, 1981), comprising of about 4500 described species in 180 genera (De Carvalho *et al.*, 2005). In India, about 263 species in 35 genera are known (Meenakshi, 2008). Subfamily Atherigoninae comprises 37 species of *Atherigona* (Ramachandra Rao, 1924, Malloch, 1925, Pont, 1972, Pont, 1981, Srivastav, 1985). Shoot flies of the genus *Atherigona* are known to cause 'dead-hearts' in a number of tropical grass species of Poaceae, mainly cereals and millets (Deeming, 1971; Pont, 1972). Fletcher (1914) reported the incidence of shoot fly for the first time in South India. Among major pests in small millets, shoot flies were found to be dominant ones causing 25-90% dead-heart (DH) damage (Jotwani, *et al.*, 1969; Selvaraj *et al.*, 1974). Around 50 to 55 different species of insect pests damage during cropping period, among these shoot flies of the genus *Atherigona* (Muscidae)

were the most important in terms of causing higher yield loss, particularly in little and proso millets at 4 to 5 leaf stage (Nageshchandra, 1983). Two species, *Atherigona soccata* Rond. and *Atherigona approximata* Mall., are pests of two of the world's major cereals, sorghum (*Sorghum bicolor*) and pearl millet (*Pennisetum glaucum*), respectively.

The muscid shoot-fly *Atherigona simplex* (Thomson) (Diptera: Muscidae) is a major pest in kodomillet, *Paspalum scrobiculatum*, grown in different parts of India. Farmers growing small millets are facing serious problem of shoot fly infestation in kodomillet during the early stage of the crop. There is a need for taxonomic identification of maggot and adult stages of kodomillet shoot fly, *Atherigona simplex*. The literature pertaining to morphological description of maggots is very scant and hence the present study was taken up to taxonomically characterize the species both in adult and maggot life stages.

Material and Methods

Slide preparation procedure: Maggots were collected from the infested (dead-heart symptom) plant parts and washed thoroughly in cold water. Maggots were killed by immersing in the hot water (just off the boil) for about two to three minutes. After allowing the water to cool to room temperature, the maggots were then subjected to serial dilution of 30%, 50% and 70% ethanol. Specimens to be mounted were slit using sharp scalpel and kept overnight in 10 % caustic potash (KOH) for digestion. On the next day, internal content and fat bodies of digested maggots were removed through the slits. After clearing, the specimens were processed in 70%, 80% and absolute alcohol (Ethanol). The processed maggots were then kept length wise on glass slide; cephalopharyngeal skeleton, anterior spiracles and posterior spiracles were mounted properly on the slide (Frias *et al.*, 2006); posterior spiracles were slightly folded laterally or mounted dorsoventrally for better view. The maggots were mounted using Euparal and covered with 18mm round cover slip and dried at room temperature for about four to five days and observed under compound microscope at 10X and 40X magnifications. Morphological terminology follows Borror *et al.*, 1981; Chu and Cutkomp, 1949; Peterson, 1957; Stehr, 1987 and 1991; McAlpine, *et al.*, 1981 and 1987. The specimen mounted slides were identified by using the literature of Grzywacz *et al.*, 2013; Ogwaro and Kokwaro, 1981; Couri and Araújo, 1992.

Laboratory rearing

Field collected dead-heart plants of kodomillet were brought to laboratory and kept in polythene bags for adult emergence. The adults collected were killed using ethyl acetate and then pinned for identification. They were labelled with details such as locality, host, date of collection *etc.* The processed specimens were identified based on literature of Pont (1973, 1981); Pont and Magpayo (1995). In the instance of sorghum and millet collections both males and females were identified (Clearwater and Othieno, 1977). Images of the habitus and other important characters were illustrated to facilitate their identification and the diagnostic characters were marked by arrowheads. The examined specimens were deposited at the Department of Entomology, University of Agricultural Sciences, Bangalore, Karnataka, India.

Male genitalia

For the study of male genitalia, the specimens were dissected after relaxing and, with the help of fine needle, the abdomen was detached and placed overnight in vials containing 10% KOH. The male genitalia were carefully separated from the abdominal segments into cavity block and washed thoroughly with distilled water and then placed in glycerin. Photographs of the genitalia were made using a Leica M205C microscope mounted with a Leica DFC 450 camera and by using auto-montage software. Genitalia of each specimen were stored separately in genital vials containing a drop of glycerol and pinned underneath the respective specimen for subsequent studies.

Systematic accounts

Family: Muscidae

Subfamily: Atherigoninae

Genus *Atherigona* Rondani, 1856

Generic diagnosis

Angular head, with very long sunken face and antennal flagellomere, almost reaching lower facial margin in lateral view; arista bare; basal lateral setae of scutellum at most one third as long as sub basal lateral setae, presutural acrostichal setae often in 2-3 rows at suture; Cross vein r-m always well in basal half of cell dm.

***Atherigona simplex* (Thomson, 1869)**

Coenosia simplex Thomson, 1869: 560; Wulp, 1881: 48.

Atherigona simplex (Thomson); Stein, 1910a:77.

Atherigona bituberculata Malloch, 1925: 119.

Atherigona (Atherigona) bituberculata, Malloch; Fan, 1965: 70.

Atherigona sp.; Joshi and Khan, 1968: 238.

Results

Adult

Description: Palpi mostly dark, rarely yellow at tip. Interfrontalia shining black. Male has the fore femur partly darkened, the wing usually with a dark smudge at the tip of the subcosta, and the fore tarsus without erect hairs. The fore tibia and tarsus are mainly brown, the tibia being yellow on basal third or less (Figure 1. A-D).

Male Genitalia: The hypopygial prominence with a deep notch and base is 1.5 times wider than apex (Figure 1E). Trifoliate process with long stalk and median basally slender with apex triangular with few prominent setae. The lateral plates and median piece are yellow on the basal half and dark brown on the apical half. Lateral plates with a weak inner lobe our margin basally with sharp edge (Figure 1F).

Material examined: INDIA: Karnataka: 2♂: UAS, Bengaluru, reared on Kodomillet, 28. viii. 2021, PCG; 2♂: UAS, Bengaluru, reared on Kodomillet, 27. viii. 2021, PCG; 1♂: UAS, Bengaluru, reared on Kodomillet, 30. viii. 2021, PCG; 1♂: UAS, Bengaluru, reared on Kodomillet, 02. viii. 2021, PCG; 1♂: UAS, Bengaluru, reared on Kodomillet, 21. viii. 2021, PCG; 3 ♂, 8♀: Dharwad, UAS Campus, 10. viii. 2017 Yamanappa, R. M; 5♂, 7♀: Bengaluru, GKVK campus, 3. viii.2017, Yamanappa R. M; 6♂, 5♀: ARS Tiptur, 2.ix.2017, Yamanappa R. M.

Distribution: India: Assam, Bihar, West Bengal, Delhi, Tamil Nadu, Madhya Pradesh and Rajasthan.

Host plants: In present study specimens were reared on kodo millet, *Paspalum scrobiculatum*.

Remarks: Small dark brown coloured fly with black palpi and interfrontalia. Hypopygial prominence is small with two distinct lateral lobes. Stalk and basal half of the lateral plates and median piece of trifoliate process yellow.

Maggots

The detailed general morphology of shoot fly maggot (Fig 2A), cephalopharyngeal skeleton (2B) and posterior spiracle (C) identifying parts were labeled. .

First instar: with distinct mouth hook, suprabuccal teeth and dorsal process, Pharyngeal sclerite narrow and elongated. Dorsal cornua longer than ventral, both pointed apically and weakly pigmented. Dorsal bridge small, rounded at apex and weakly pigmented (Figure 3A). Anterior spiracle with five digitations (Figure 3D). Posterior spiracle with 2 spiracular openings surrounded by papillae (Figure 3G).

Material examined: INDIA: Karnataka: 3 first instar slides; ZARS, GKVK, UAS, Bengaluru, reared from Kodomillet, 29.xii.2021, PCG.

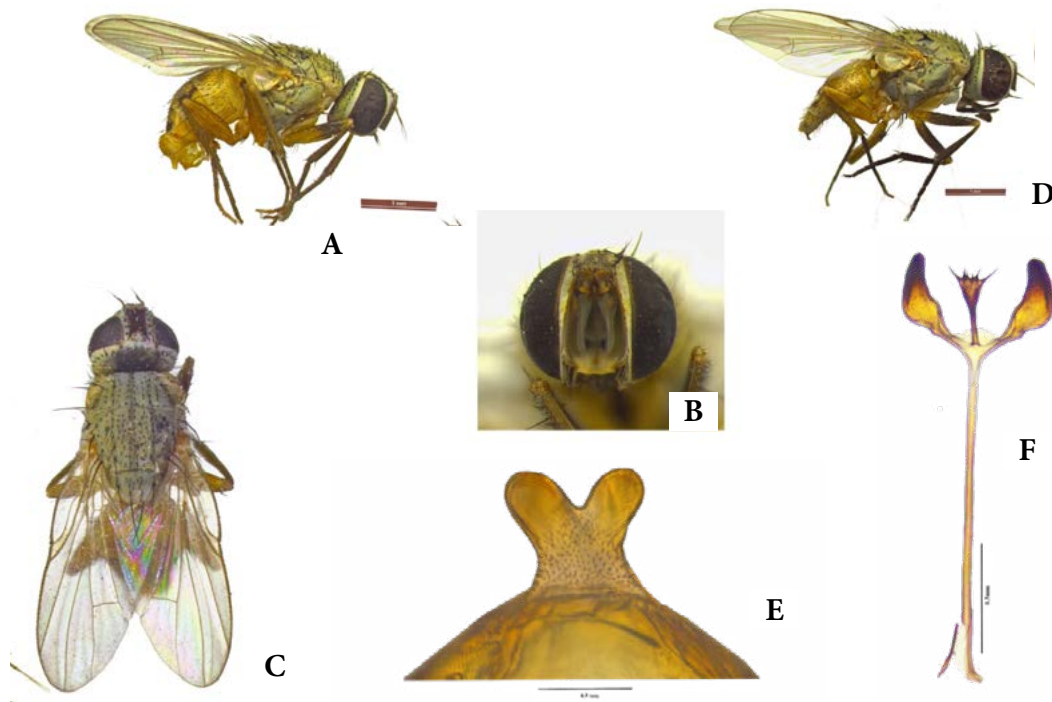


Fig 1. Adult *Atherigona simplex* (Thomson)

A. Lateral view (♂); B. Frontal view of head (♂); C. Dorsal view (♂); D. Lateral view (♀); E. Hypopygial prominence (♂); F. Trifoliate process dorsal view (♂)

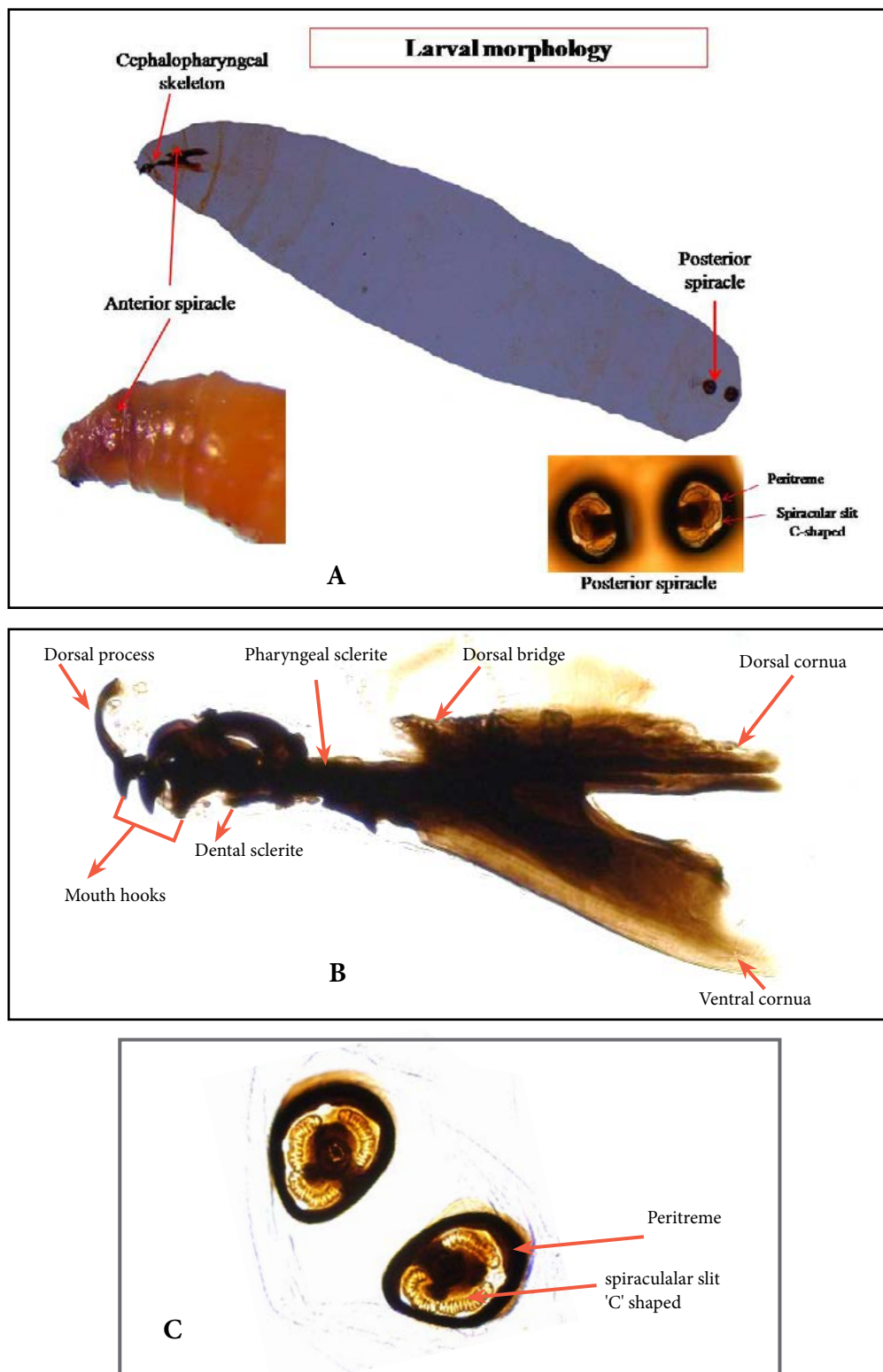


Fig 2. (A) General morphology of shoot fly maggot (B) morphology of cephalopharyngeal skeleton (C) morphology of posterior spiracle



Figure 3. Cephalopharyngeal skeletons, anterior and posterior spiracles of different instars of shoot fly *Atherigona simplex* larvae. Cephalopharyngeal skeletons of (A) 1st instar, (B) 2nd instar and (C) 3rd instar, es-epistomal sclerite, at-accessory teeth; Anterior spiracles of (D) 1st instar, (E) 2nd instar, (F) and 3rd instar; Posterior spiracles of (G) 1st instar, (H) 2nd instar, and (I) 3rd instar.

Second instar: with three pair of mouth hooks and dorsal process, dorsal and ventral cornua are of equal length (Figure 3B). Anterior spiracle with Primary and secondary arms with 9 digitations in each arm (Figure 3E). Posterior spiracle with three C-shaped spiracular openings, peritreme slightly sclerotized (Figure 3H).

Material examined: INDIA: Karnataka: 2 second instar slides; Zonal Agricultural Research Station (ZARS), University of Agricultural Sciences (UAS), Gandhi Krishi Vignana Kendra (GKVK), Bengaluru, collected from Kodomillet, 29.xii.2021, PCG. 2 second instar slides; ZARS, GKVK, UAS, Bengaluru, collected from Kodomillet, 23.xiii.2021, Prabhu C Ganiger (PCG).

Third instar: Cephalopharyngeal skeleton with a distinct mandible, Suprabuccal teeth and Dental sclerite. Dorsal and ventral cornua are of equal length (Figure 3C). Anterior Spiracle with Nine digitations (Figure 3F). Posterior spiracle with three C-shaped Spiracular slits and heavily sclerotized peritreme (Figure 3I).

Material examined: INDIA: Karnataka: 2 third instar slides, ZARS, GKVK, UAS, Bengaluru, collected from Kodomillet, 29.xii.2021, PCG. 3 third instar slides; ZARS, GKVK, UAS, Bengaluru, collected from Kodomillet, 23.xiii.2021, PCG.

The characters of cephalopharyngeal skeleton, number of digitations in anterior spiracles and shape of the posterior spiracles vary between the instars and the key distinguishing characters furnished in Table 1.

Table 1: Comparison of distinctive features of the 1st, 2nd and 3rd instar maggot of *A. simplex*

Character	1 st instar	2 nd instar	3 rd instar
Cephalopharyngeal skeletal:			
Relative length of dorsal and ventral coronua	dorsal cornua longer than ventral cornua	equal length	equal length
Pharyngeal sclerite	narrow and elongated	moderately thick and stout	thick and stout
Dorsal sclerite	poorly formed	poorly formed	strongly developed
Digitations on anterior spiracle	five	nine	nine
Posterior spiracle:			
No. of slits (spiracular openings)	two	three, C-shaped	three, C-shaped
Papillae around spiracular slits	present	absent	absent
Peritreme	weakly sclerotised	slightly sclerotised	strongly sclerotised

Discussion

The species *Atherigona simplex* is reported on Kodo millet (*Paspalum scrobiculatum*) by several authors (Pont, 1972; Davies and Reddy, 1981; Pont, 1995). The species was often recorded as *Atherigona bituberculata* by Malloch (1925) and Ramachandra Rao (1924).

In India, Ramachandra Rao (1924) recorded the fly as Varagu or Kodom fly collected from *Eriochloa* sp.. Rawat and Sahu (1969) reported the pest on wheat from Madhya Pradesh and Rajasthan, referring it to as wheat stem fly, but

Pont (1972) stated the identification to be doubtful. Davies and Reddy (1981) collected adult specimens emerged from the grasses *Echinochloa colonum* and *Eriochloa procera* from ICRISSAT, Hyderabad.

The literature pertaining to taxonomic identification and description of the species is very scanty. A brief note on the morphological and genital characters of the species was given by Pont (1972, 1995). Further descriptions on the species in the recent years is lacking. This study provides a note on the species both with respect to external morphology and genitalia characters along with illustrations. The males can

be distinguished with the trifoliate process being weakly sclerotized on the basal half, lateral plates and median piece yellow on the basal half and dark brown on the apical half; hypopygial prominence with a characteristic deep notch at the middle. Grzywacz *et al.*, (2013), Ogwaro and Kokwaro (1981) and Couri and Araújo, (1992) gave the description of *Atherigona reversura*, *Atherigona soccata* and *Atherigona orientalis* respectively.

The research needs to be carried out on different species of shoot fly maggot identification. Here, efforts were made to describe, all the instars of *A. simplex* for the first time. The characters of cephalopharyngeal skeleton, number of digitations in anterior spiracles and shape of the posterior spiracles are described and illustrated. Repeated collection

of dead-hearts from the field and checking for their adult emergence, confirmed the identity of the species.

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