



Morphological description of a new species of Genus *Sarcophaga* s. lat. (Diptera: Sarcophagidae) from Jammu and Kashmir, India

Rohit Kumar¹ · Madhu Bala¹ · Fahd Mohammed Abd Al Galil^{2,3}

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Abstract

Based on the characters of adult's external morphology and terminalia, a new species of the genus *Sarcophaga* (s. lat.) (Diptera: Sarcophagidae) is reported from India. Adults of *Sarcophaga (Lioproctia) mailansis* **sp. nov.** were collected from Kathua, Jammu and Kashmir, North India. An adult female was captured from decomposing chicken meat that had been used as bait for flesh fly collection. The female larviposits on chicken liver and are reared in ideal conditions to produce adult specimens. The morphological descriptions and illustrations of male, female and immatures of *Sarcophaga (Lioproctia) mailansis* **sp. nov.** are provided in this article, that aid in identification of this medically and forensically relevant flesh fly species.

Keywords Flesh flies · *Sarcophaga* · Species novo · Morphology · Terminalia

Introduction

The Family Sarcophagidae Macquart, 1834 includes several forensically significant flies. There are over 3,000 species of flies in this family, divided into 173 genera with a global distribution (Pape et al. 2011). *Sarcophaga* Meigen, 1826 is the major genus in the family Sarcophagidae, accounting for about 30% of the family's species diversity (Partington 1837; Pape 1996; Buenaventura and Pape 2017; Whitmore et al. 2018; Kumar et al. 2021). *Sarcophaga* species are important for both medicinal and forensic purposes (Sukontason et al. 2014). Many species of *Sarcophaga* larvae are known to induce myiasis in animals and humans (Das et al. 2010; Priscilla et al. 2018) and have been linked to criminal investigations (Cherix et al. 2012; Sukontason et al. 2014; Kumar et al. 2021). The larvae of the fly feed on living or necrotic host tissue, body fluids, or food that has been consumed. Human myiasis most commonly affects the skin, although it can also affect the nasopharynx, digestive

tract, ear canal, eyes, and genitourinary tract (Priscilla et al. 2018).

The comparative analysis of these flies from India was compiled and published by Senior-White et al. (1940). Many additional researchers have since documented numerous new records and Sarcophagidae species throughout the country. Furthermore in 2002, Nandi taxonomically documented 163 species gathered from various locations in India and neighboring nations. Chakraborty et al. (2017) published a checklist of Indian Sarcophagidae, tracing a total of 126 species of flesh flies. Among those, the genus *Sarcophaga* is accounted for over 70% of the species reported and 4 species of the subgenus *Lioproctia* Enderlein (1928), have been described. Barták et al. (2019) reported fresh data on the oriental Sarcophagidae based on a review of all previous records, listing 138 species that were found in India. Sarcophagidae is also a significant forensic indicator in PMI estimate as they may identify a corpse from a distance of several kilometers within minutes of death (Goff 2000). The majority of Sarcophaginae subfamily species feed on decaying flesh, however a few species also feed on open wounds in humans and animals, causing myiasis (Abd Al Galil and Zambare 2016). Concerns about the identification of these flies are growing as they become involved in medical and forensic investigations. The species features three black longitudinal stripes on the notum, undeveloped subscutellum, and abdomen, as well as a checkered pattern on the surface (De Carvalho and Mello-Patiu 2008). The majority of adults in the subfamily Sarcophaginae look nearly identical (Nandi 2002).

✉ Madhu Bala
madhubaladhakane@gmail.com

¹ Department of Zoology and Environmental Sciences,
Punjabi University, Patiala, India

² Department of Biology, Faculty of Sciences, University
of Bisha, P.O. Box 551, Bisha 61922, Saudi Arabia

³ Department of Biology, Faculty of Applied Sciences, Thamar
University, Dhamar, Yemen

The species of flesh flies are difficult to identify precisely due to their morphological similarities and the lack of identifying keys. Female flesh flies are generally located on decaying bodies to be used as a larviposition site, but due to their similar appearance, they are difficult to distinguish (Vairo et al. 2015). The male is the most diagnostic trait for species identification; hence most identification keys are based on males (Nandi 2002). The objective of this study is to describe both the adult male and female of *Sarcophaga (Lioproctia) mailansis* **sp. nov.**, as well as to provide authentic identifying characters for species identification that may be significant for medicinal and forensic purposes.

Materials and methods

Study site

Experimental site The experiment was conducted close to a forest in the rural Maila village (32.50° N to 75.29° E) of district Kathua, Jammu and Kashmir (India). In the winter, the field is mostly utilized to raise wheat crops. The predominant flora of the region includes mango trees (*Mangifera indica*), neem trees (*Azadirachta indica*), and curry trees (*Murraya Koenigii*).

Biological material The chicken meat 1 kg was used as a bait to collect adult *Sarcophagids*.

Collection & preservation The gravid females of *Sarcophaga (Lioproctia) mailansis* **sp. nov.** were attracted to decaying chicken meat, used as bait to collect flesh flies. Collected flies were reared in the rearing boxes (1"×1"×1"). The females were fed upon powdered sugar and water with cotton wick in a conical flask. The females were also provided with Chicken liver (10 g) as the oviposition medium. After depositing larvae the first instar larvae were transferred in a 1L glass rearing jar with 20 g of chicken meat as a food source. A piece of muslin cloth was used to seal the glass jar by placing a rubber band to prevent the larval escape. The feeding stages were reared till the prepupation stage (post-feeding stage), when the larvae started leaving the food media, the larvae were transferred to the new jar containing 2 cm of dried soil for pupation and kept till adults emergence. After emergence, the adults were collected and killed by placing them in killing jars having ethyl acetate vapors.

Identification For species identification, the male abdomen was detached and soaked in a 10% KOH solution for 24 h. The internal genitalia was dissected from the abdomen under a stereo zoom microscope (model no. R1-90-01) and preserved in the clove oil for clearance purposes and later on used for identification and photography. The photographs

were taken by Canon EOS 1200D DSLR Camera 18MP/5X optical zoom. All the characters of adults were compared carefully by comparing the morphology and genital structure of all described closely related species and then concluded as a new species.

Terminology given by Nandi (2002); Chaiwong et al. (2009); Zhang et al. (2014) and Kurahashi and Samerjai (2018) is followed for adult characteristics.

Systematics

Genus *Sarcophaga* Meigen, 1826

Subgenus *Lioproctia* Enderlein, 1928

Diagnosis Large-sized, black flies with checkered pattern on abdomen as found in most *Sarcophaga*. The Subgenus *Lioproctia* Enderlein includes: a well-developed predorso-central bristles; a preacrostichal bristle; bare upper part of propleuron, few short setae on parafacial; Male terminalia includes beak shape inner forceps with strong spines; short and lobulated ventralia; juxta longer than the short styli (Nandi 2002).

Distribution: Oriental, Palaearctic, Australasian and Oceanian regions.

Biology: Collected on bushes and breed on various dead animals.

Sarcophaga (Lioproctia) mailansis **sp. n.**

Type material Holotype male found in Maila Village, Kathua City, Jammu and Kashmir Province, North India, (32.50° N, 75.29° E; 489 m) collected from decomposing chicken meat, collected by Rohit Kumar, 14 May 2020, deposited in the Sarcophagidae Collection, Department of Zoology and Environmental Sciences, Faculty of Forensic Entomology, Punjabi University, Patiala, India. Paratypes include 4 adult females, 4 males with the same collection data as the holotype.

Etymology: The name of this species is the name of the village (Maila) from where this species was collected.

Diagnosis Large-sized fly, male larger to female; parafacial with 4–6 short setae; female with about 11 frontal bristles; silver-white propleuron; 7 mesopleural bristles; R_{4+5} ventrally with 4–5 short setae; tergite 5 with a row of 12–14 strong median marginal bristle; fifth sternite Y shaped in male with open window; 6th sternite almost rectangular in female; Genital Segment 2/epandrium in male yellowish-brown; Surstylus oval and elongated in male; postgonite grooved laterally in a subapical arc; anterolateral margin of juxta without spine.

Male about 1.5 cm; head frontal stripe black, parafrontal and parafacial plate silver-white, parafrontal greyish tinged, having 11–13 frontal bristles, with an orbital bristle (Fig. 1b); ocellar bristles strong, inner vertical bristle double the length of outer vertical bristle (Fig. 1e); antennae long, do not reach vibrissae; postpedicel greyish with brown pollinosity; pedicel dark brown about 1/4

the length of postpedicel; arista long, plumose and dark brown (Fig. 1b); gena silver grey with moderate black and white hairs; postgena with long white hairs (Fig. 1a); parafacial with 4–5 hairs near bottom edge of eye; palpus slender, greyish with brown pollinosity, bearing black bristles; occiput with regular row of postocular bristles (Fig. 1e).

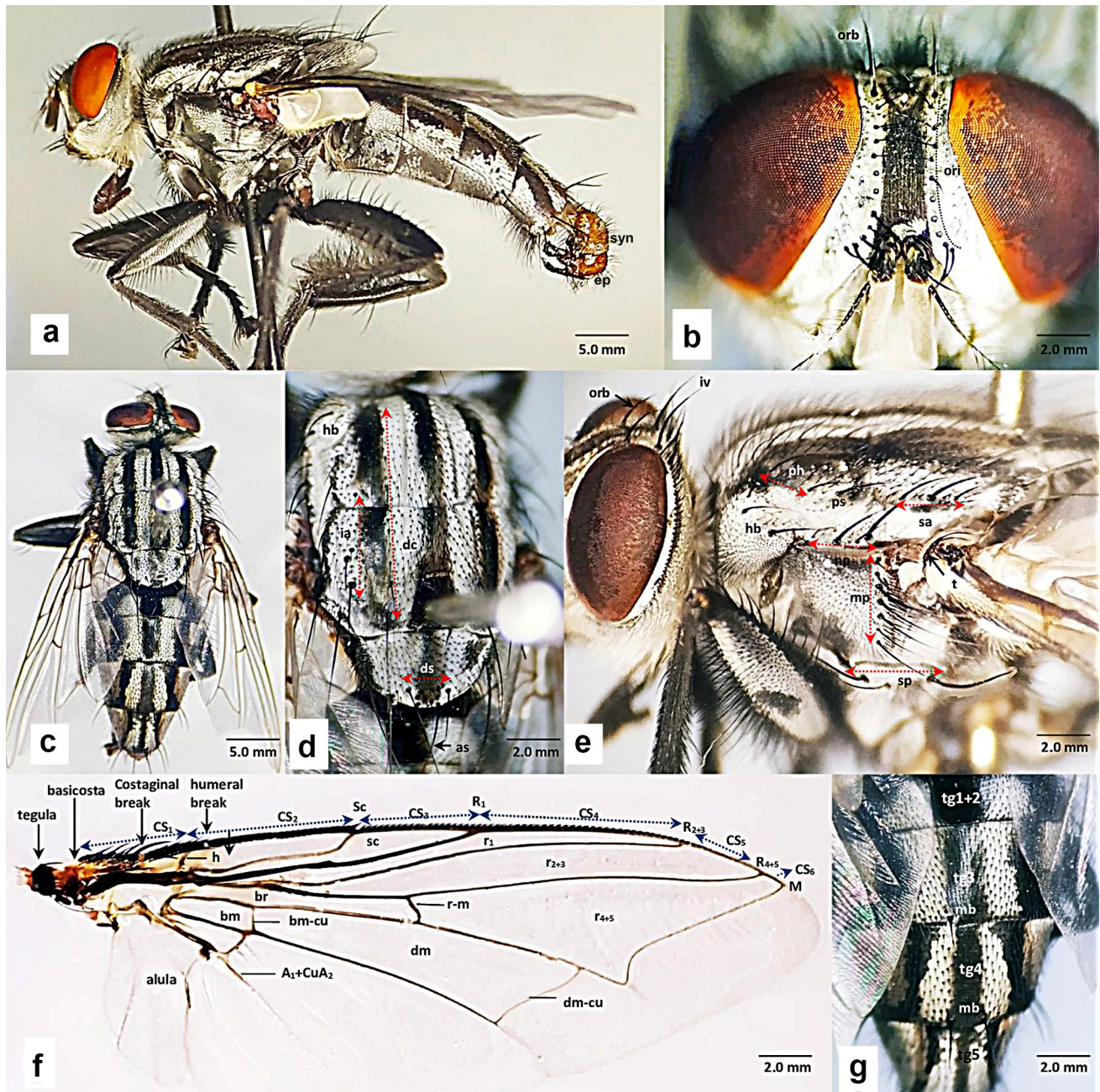


Fig. 1 *Sarcophaga (Lioproctia) mailansis* sp. nov., adult male. **a** male, lateral view. **b** male head, frontal view. **c** male, dorsal view. **d** male thorax, dorsal view. **e** male thorax, lateral view. **f** wing, dorsal view. **g** abdomen, dorsal view. Abbreviations: as- apical scutellar bristle, CS- costal section, dc- dorso-central bristle, ds- discal scutellar bristle, ep-

epandrium, hb- humeral bristle, ia- intra-alar bristle, iv- inner vertical bristle, mb- marginal bristle, mp- mesopleural bristle, orb- orbital bristle, ori- frontal bristles, ph- posthumeral bristle, ps- pre-sutural bristle, sa- supra-alar bristle, sp- sternopleuron, syn- syntergosternite 7 + 8, tg- tergite, t- tegula

Thorax silver-white with grey pollinosity, having 3 contrasting black longitudinal stripes; propleuron silver-white, upper part bare, lower part with an strong bristle and few hairs; anterior spiracle fuscous brown; posterior spiracle yellowish-brown (Fig. 1d, e); acrostichal 1 + 1 (1 very short); dorsocentral 7 + 5 (posterior 2 post dc strong); humeral 3; posthumeral 2; presutural 1; notopleural 4 (2 strongly developed); intra-alar 1 + 3 (3 very short, 1 long); supra-alar 3 (middle strongly developed); postalar 2; scutellum with 4 bristles, discal 1 (short), apical 1 (strong and long) and marginal 2 (1 short + 1 strong and long); sternopleural 1 + 1 + 1; hypopleural 11; mesopleural 7 (7 strong with fine hairs) (Fig. 1d, e).

Wings entirely fuscous hyaline; epaulet blackish with 2 long marginal bristles; basicosta bare and pale yellowish; subcostal sclerite bare and brown; CS_1 with 2 long bristles at costaginal break; CS_2 with humeral break, incised at SC with spike of spines (Fig. 1e, f); CS_1 to CS_4 with short spines at anterior margin; CS_5 is about 3/4 of CS_3 ; CS_5 almost bare, except the base with few spines (Fig. 1f); R_1 bare; R_{4+5} with a row of about 9 short setae extends dorsally from the basal node to below halfway of r-m; ventrally 4 setae before the emergence of R_{4+5} and R_{2+3} ; r_{4+5} closed; bend of m with right angle (Fig. 1f); lower and upper calypter bare and creamy white; halter yellowish-brown.

Legs black with silver-white tinged; coxa silver-grey; fore coxa with 2 rows of fine bristles; trochanter with few setae; fore femur with 2 parallel rows of strong postero-dorsal (pd), antero-dorsal bristles (ad) and a row of long bristles with fine hairs ventrally; fore tibia with a row of 3 short ad bristle on basal one-third and 1 ad with 1 dorsal (d) apically, 1 posterior (p) on apical one-third; both tibia and tarsus black; tarsus with two large pulvilli and elongated divergent claws, with long hairs (Fig. 1a). mid coxa with a row of long bristles; trochanter dark brown with setae; mid femur hairy with 4 short anterior bristle (a) at middle, a row of 5 antero-ventral (av), and a row of 12–14 postero-ventral bristles (pv) present subapically; mid tibia with 3 ad (1 medially + 2 apical), 3 pd (1 medially + 2 apical) and 1 p at middle (Fig. 1a). hind coxa with 2 strong bristles and few fine hairs; hind femur silver-grey with a row of about 6 strong ad, 11 av and 4–6 anterior bristles on middle, hind tibia with a row of about 6 regular ad, 2 apical p and 2 pd bristle (1 medially + 1 sub basal), postero-ventral margin with long hairy fringes (Fig. 1a).

Abdomen slender, black with silver-white assortment, forms a checkered abdominal pattern (Fig. 1g). Tergite (1 + 2) with a pair of lateral marginal bristle; tergite 3 with a median and 2 pairs of lateral marginal bristle; 4th with a pair of median and 3 pairs of lateral marginal bristle; tergite 5 with a row of 12 strong median marginal bristle (Fig. 1g); tergite 6 is undivided; sp 6 is located within the membrane, surrounded by few hairs; sternite

1–4 covered with hairs; fifth sternite Y shaped with open triangular window (Fig. 2c), short sternal arms with short hairs on dorsal and distal surfaces, and a cluster of strong bristles on the inner lateral bud, basal marginal arc is formed by two distinct proximolateral lobes with tiny horns (Fig. 2c); First genital segments (GS1/syntergosternite 7 + 8) yellowish-brown, second genital segments (GS2/epandrium) brown, both with medium size hairs (Fig. 2a); cerci long and curved, slightly divergent at the apex, posteriorly with sharp notch, distal half with scattered short spines, basal half with dense long hairs (Fig. 2a, b), right cercus is slightly shorter than the left (Fig. 2a, b); surstyli oval and elongated, slightly convex at basal and distal end, almost bare, except lateral margin with few long hairs (Fig. 2b); aedeagus large; ejaculatory apodeme fan-shaped (Fig. 2e); hypandrium surrounded by serrated sclerotized membrane (Fig. 2i); pregonite broad, slightly curved, distally blunt with many short hairs, laterally with wide projection at middle (Fig. 2f); postgonite, nearly straight, grooved laterally in a subapical arc and with 1 long hair at base (Fig. 2d and e); phallus wide, tubiform and sclerotized (Fig. 2d, g); juxta translucent, atypical, rounded with blind extremity, antero-laterally, membranous, serrated and spineless, laterally with distinct spine near base (Fig. 2g, h); lateral stylus stout, slender and sclerotized (Fig. 2g, h); vesica wide, tubular and heavily sclerotized with blunt end, ventrally appeared arc-shaped (Fig. 2d, e, h); ventralia translucent, elongated with bifid apex and ventro-laterally stretched (Fig. 2d, h).

Female about 1.4 cm; head almost same as male, but with about 11 frontal bristles; 3 short interfrontal bristles; 1 orbital and 2 fronto-orbital bristle; 1 ocellar bristle (Fig. 3a); outer vertical bristle 3/4 to inner vertical bristle (Fig. 3d); antennae long, do not reach vibrissae; postpedicel light brown with grey pollinosity, pedicel and arista same as male (Fig. 3a); parafacial with 5–6 hairs near bottom edge of eye; palpus slender and blackish; gena, postgena, and arrangement of bristle and setae on occiput are same as male (Fig. 3a, d).

Thorax almost same as male; anterior spiracle fuscous brown; posterior spiracle light yellowish-brown (Fig. 3b, d); acrostichal 1 + 1 (1 very short); dorsocentral 7 + 5 (posterior 2 post dc stout); humeral 3; posthumeral 2; presutural 1; notopleural 4 (2 strongly developed); intra-alar 1 + 3 (3 short, 1 long); supra-alar 3 (middle long); postalar bristle 2; scutellum with 4 bristles, discal 1, apical 1 and marginal 2; sternopleural bristle 3; hypopleural 9; mesopleural 7 (7 strong with fine hairs) (Fig. 3b, d).

Wings hyaline; epaulet and basicosta same as male; costal spines strongly defined, basal costal spine larger to others; CS_1 with 2 long bristles at costaginal break; CS_2 same as male; R_{4+5} with a row of about 11–14 short setae extend dorsally from basal node to exceedingly halfway of r-m; ventrally

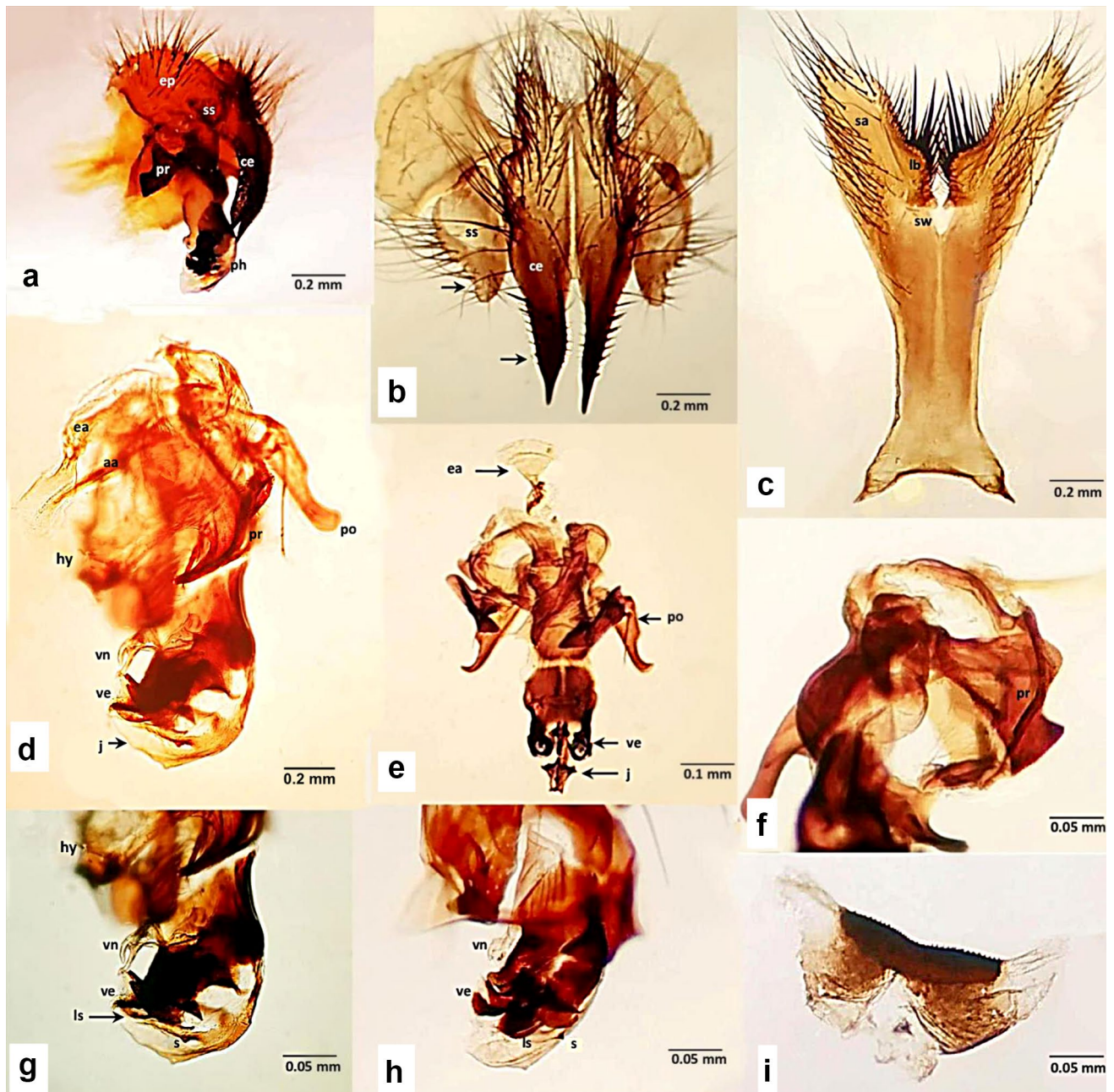


Fig. 2 *Sarcophaga (Lioproctia) mailansis* sp. nov., male Terminalia. **a** last genital segment, lateral view. **b** cercus and surstylus, caudal view. **c** fifth sternite, ventral view. **d** phallus, lateral view. **e** phallus, ventral view. **f** basiphallus, postero-lateral view. **g** phallus, lateral view. **h** distiphallus, anterolateral view. **i** serrated sclerotized membrane. Abbreviations: aa-

aedeagal apodeme, ce- cercus, ea- ejaculatory apodeme, ep- epanthrium, hy- hypandrium, j- juxta, lb- inner lateral bud, ls- lateral stylus, ph- phallus, po- postgonite, pr- pregonite, s- spines, sa- sternal arm, ss- surstylus, sw- sternal window, tg- tergite, ve- vesica, vn- ventralia

with 5 setae before R_{4+5} and R_{2+3} emergence (Fig. 3g); R_1 bare; CS_5 shorter to CS_3 ; CS_5 with spines on basal two-third margin; r_{4+5} closed; lower and upper calypter bare, creamy white; halter yellowish-brown (Fig. 3d).

Legs almost same as male except few characters, fore tibia with a row of 4 ad bristles on base, 1 pd at middle and a row of 4–5 pd apical half, 1 p + 1 ad + 1 pd + 1 pv

located apically; both tibia and tarsus black; tarsus with two short pulvilli and less divergent claws, with few short hairs (Fig. 3d). mid femur hairy, with 4 short a (anterior bristle) at middle, two rows of 4 av (antero-ventral) and 6 pv (postero-ventral) bristles and 2 strong pd (postero-dorsal bristle) sub-apically; mid tibia with a row of 4 p near basal, with 3 ad (2 medially + 1 apical) and 1p at middle, 2 pv and 2 v located

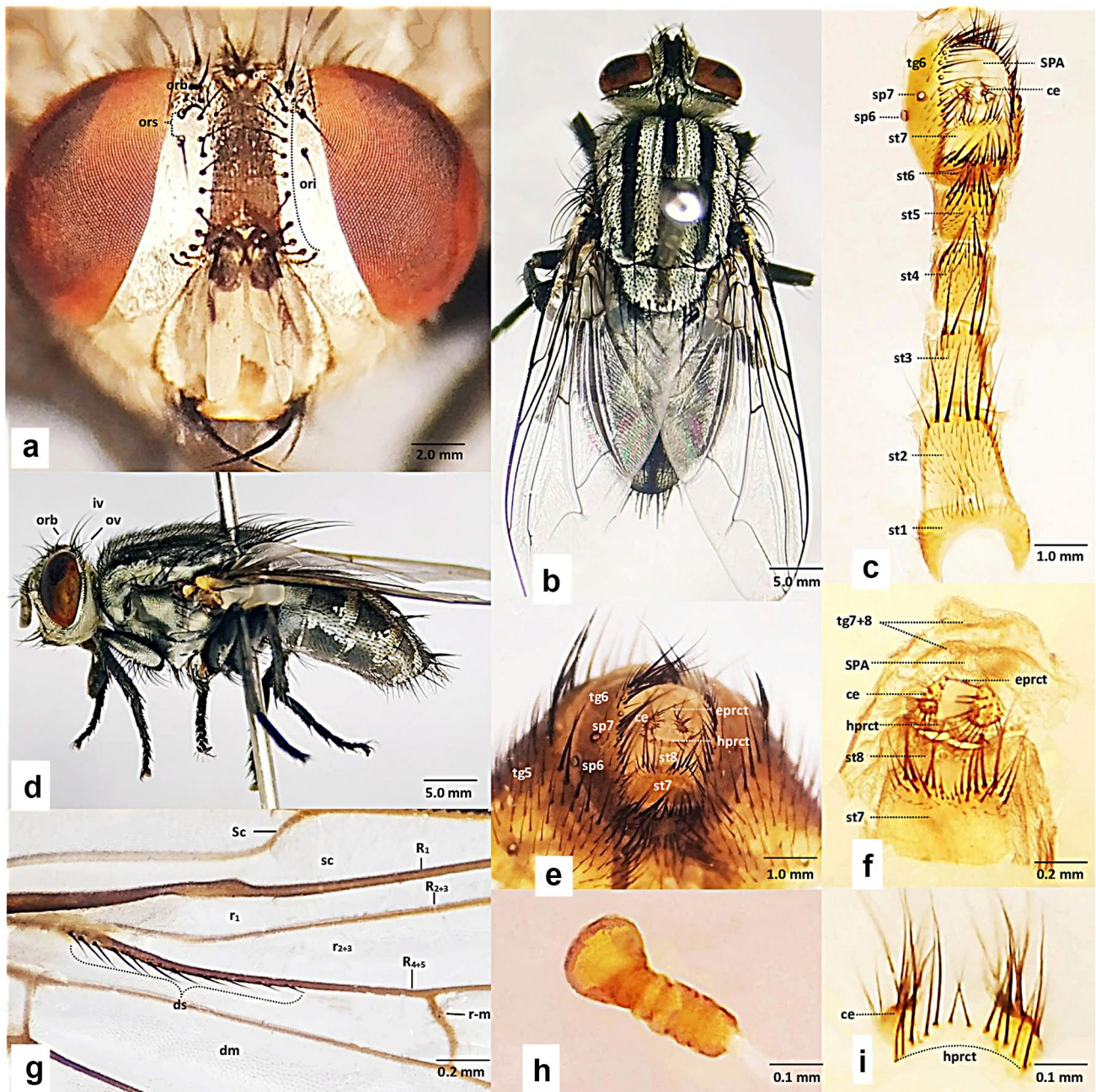


Fig. 3 *Sarcophaga (Lioproctia) mailansis* sp. nov., adult female. **a** head, frontal view. **b** female, dorsal view. **c** sternites 1–7, ventral view. **d** female, lateral view. **e** terminalia, posterior view. **f** terminalia, ventral view. **g** wing, dorsal view. **h** spermathecae. **i** terminalia, cerci and hypo-

proct. Abbreviations: ce- circus, ds- dorsal setae, eprct- epiproct, hprct- hypoproct, iv- inner vertical setae, oc- ocellar bristle, ori- frontal bristle, orb- orbital bristle, ors- fronto-orbital bristle, ov- outer vertical setae, sp- spiracle, SPA- secondary pigmented area, st- sternite, tg- tergite

apically (Fig. 3d). hind coxa with few bristles and fine hairs; hind femur with a row of about 8 ad, 4 pv and 4 ad medially, 1 d (dorsal), 2 v and p (posterior bristle) subapically; tibia with a row of about 5 regular ad (antero-dorsal bristle), 2 ad and 1 v apically, 2 dorsal and 1 pd medially, 1 sub-basal pd; postero-ventrally without hairy fringes (Fig. 3d).

Abdomen black, oval with silver-white patches forming a checkered pattern. tergite (1 + 2) with 2 pairs of lateral marginal bristle and 2 strong dorsolateral bristle with hairs; tergite 3 with 2 lateral marginal bristle; tergite 4 with a pair of median and 3 lateral marginal bristle; tergite 5 with a row of about 12 to 14 strong marginal; tergite 6 well divided

with dense stout bristle on posterior margin; spiracles 6 and 7 within the sclerite; tergite 7 + 8 well-differentiated, transparent without any hair (Fig. 3c, e); sternite 1–6 covered with short hairs (Fig. 3c); sternite 2 with 6 bristles at posterior margin; sternite 3 with 4 bristles; sternite 4 with 8 bristles (middle 2 short); sternite 5 with 2 parallel rows of bristles posteriorly; 6th sternite rectangular and with a row of dense bristles at posterior margin (Fig. 3c); sternite 7 slightly grooved medially, lobulated, almost bare except posterior margin with strong bristles and few hairs; sternite 8 well-differentiated, membranous and without hair (Fig. 3c and f); hypoproct with 12 fine setae (middle 2 short) (Fig. 3f, i); epiproct not apparent (Fig. 3e, f). Cerci triangular shaped with long hairs (Fig. 3e, f); spermathecae knob shaped, divided into an oval head and cylindrical neck with striated segmental constrictions (Fig. 3h).

Variation The Male body length varies from 1.5 to 1.8 cm. Female body length ranges from 1.3 to 1.6 cm. Female frons wider than male frons. R4 + 5 have a row of about 8–10 short setae dorsally in males, and 11–14 short setae in females. Male abdominal tergites 3–5 are largely black to slightly greyish-brown in coloration. Males have lengthy hairy fringes on their hind tibia, whereas females do not.

Key to male species of *Lioproctia*

- 1- Ventralia trilobed; juxta grooved with two projections; pregonite pointed apically

*beesoni* (Senior-White)

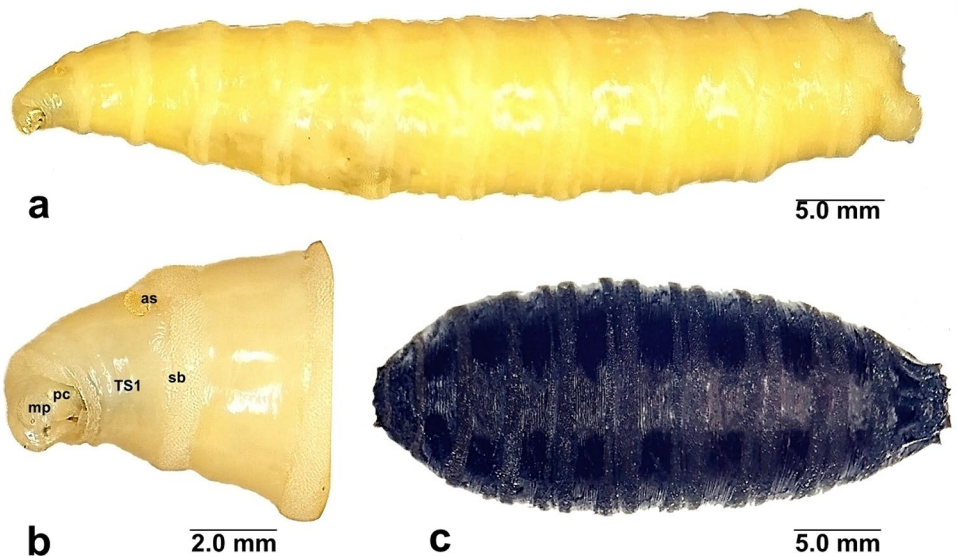
- Ventralia bilobed; juxta without groove and blind; pregonite wide apically.....

2
- 2- Upper part of propleuron black; third tergite without median marginal bristle; GS2/epandrium brownish-black; Surstulus triangular; anterolateral margin of juxta with few spine (Nandi 2002).....
*annandalei* (Senior-White 1924)
- Upper part of propleuron silver-white; third tergite with a pair of median marginal bristle; GS2/epandrium yellowish-brown; Surstulus oval and elongated; anterolateral margin of juxta without spine.....
*mailansis* sp. nov.

Description of immature stages

Sarcophaga mailae sp. nov. larvae are nearly cylindrical, muscoid-shaped, vermiform, elongated, tapering at the anterior end, and thickened at the posterior end (Fig. 4a). Mature larvae possess pseudocephalic lobes with antennal complexes and a conspicuous antennal mound on the basal ring (Fig. 4b). On the pseudocephalon, numerous oral ridges can be found ventro-laterally. Some organs, such as the mouth hooks, posterior spiracles, spine bands, and perianal cavity papillae, were clearly visible under a light microscope. Third instar mouthhooks are large at the base and progressively taper, with a blunt and anteriorly slightly curved tip. Anterior spiracles consist of 21 to 23 spiracular lobes. Spines can be seen above the spinose band (Fig. 4b). Spines range

Fig. 4 Immatures of *Sarcophaga mailae* sp. nov. **a** third instar, ventral view **b** third instar, anterior view **c** pupa, ventral view **d** pupa, anterior View. Abbreviations: as- anterior spiracle, mp- maxillary palpus, pc- pseudocephalon, sp- spinose band, TS- thoracic segment



in structure from straight to bifurcate. The posterior spiracles are housed within the deep spiracular cavity and are not completely visible from posterior. Pupa rounded and dark black in color (Fig. 4c). All heavily sclerotized protrusions of pupal stage i.e. anterior spiracles are clearly visible by using ultra microscopy (Fig. 4d).

Discussion

According to the morphological identification keys, *Sarcophaga (Lioproctia) mailansis* **sp. nov.** belongs to the genus *Sarcophaga* and shares morphological similarities with the species of the subgenus *Lioproctia* Enderlein (1928), such as a bare upper propleuron, a few short setae on the parafacial, beak-shaped inner forceps with strong spines, lobulated ventralia, etc. Other identifying characters mentioned by Nandi (2002) for male Sarcophagidae species indicate near striking similarities of new species with the *Sarcophaga (Lioproctia) annandalei* (Senior-White 1924) which belongs to the same genus and subgenera include bilobed and membranous ventralia, rounded cup-shaped juxta and wide pregonite apically, and so on.

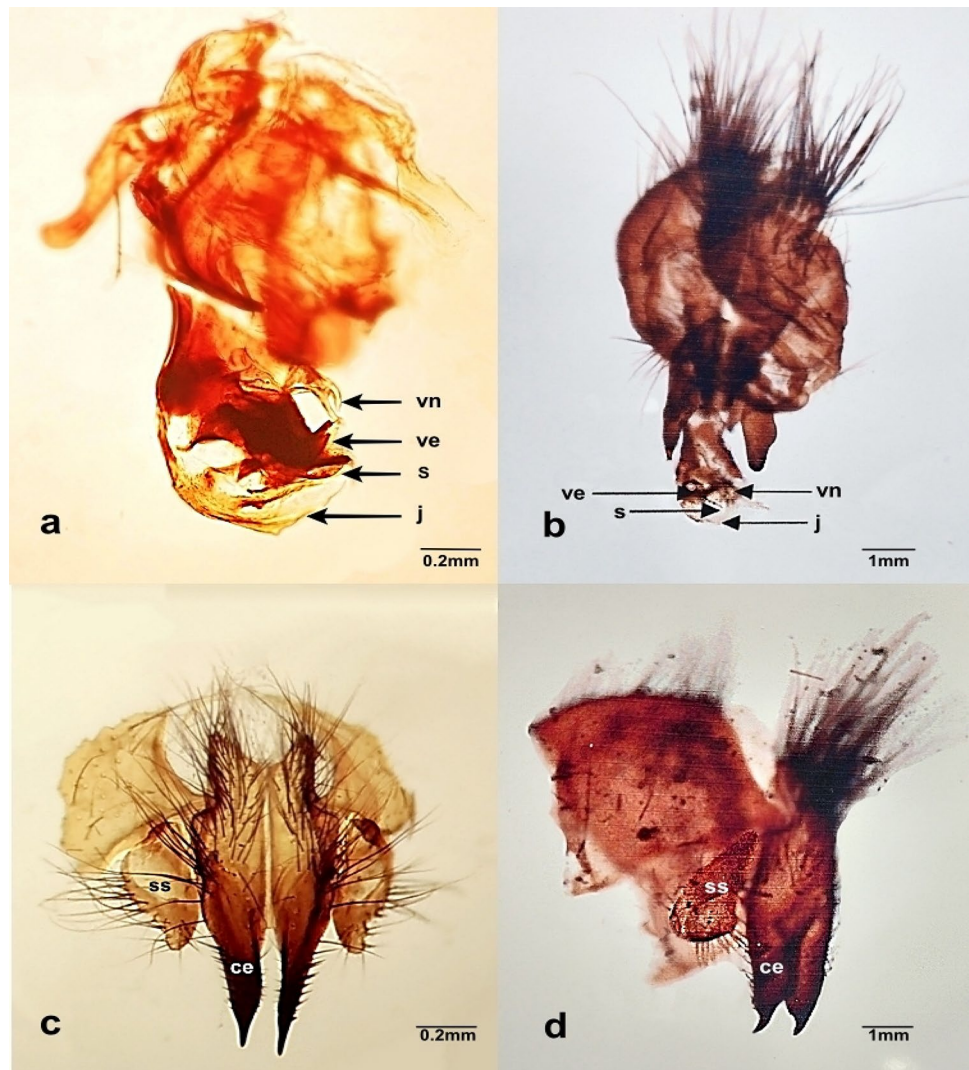
However, chaetotaxy revealed significant differences in bristle number, size, and placement in both species. The male abdominal 4th tergite of *Sarcophaga (Lioproctia) mailansis* **sp. nov.** exhibits well-developed median marginal bristles. It has a row of around 7 to 9 setae running from the basal node to below halfway up the r-m, but *S. annandalei* does not seem to have. R_{4+5} in *S. annandalei* with a row of 10 short setae dorsally that runs more than half the distance from the basal node to the r-m (Sharma et al. 2018). CS_5 in *S. annandalei* is nearly half the length of CS_3 , which in described species is about 3/4 the length of CS_3 (Nandi 2002). Furthermore, the females of *Sarcophaga (Lioproctia) mailansis* **sp. nov.** different from *S. annandalei* in that they have all scutellar bristles, 11–13 frontal bristles, and three fronto-orbital bristles, rectangular sixth sternite, sternite 8 membranous without hair, and so on (Fig. 3).

The species was also compared to other Sarcophagidae species found in neighbouring countries. Except for a few species that show some resemblance to the new species, the Sarcophagid species of these countries are distinct from the new species. At the posterior view, the terminalia of *Sarcophaga (Lioproctia) mailansis* **sp. nov.** are similar to those of *Sarcophaga (Lioproctia) annandalei* (Senior-White 1924), *Sarcophaga (Lioproctia) serratocudo* Pape and Kurahashi (2004), and *Sarcophaga kiyokoae* Chaiwong et al. (2009). However, chaetotaxy and the diverse characters of male terminalia distinguish all of these species from new species (i.e. the shape of fifth sternite, cerci, surstylus, ventralia, and antero-lateral margin of distiphallus) listed

in Table 1. *Sarcophaga (Lioproctia) mailansis* **sp. nov.**, *S. annandalei*, and *S. kiyokoae* exhibit a lateral bud on the sternal arm with a cluster of stiff bristles. *Sarcophaga (Lioproctia) mailansis* **sp. nov.** exhibits more divergent sternal arms than *S. kiyokoae*'s fifth sternite. The sternal window in new species is open, whereas the *S. kiyokoae* species is closed. It has a rounded anterolateral border of the juxta with a blunt end, which is most likely comparable to *S. annandalei* and *S. kiyokoae*. Furthermore, the membranous juxta anterolateral margin of distiphallus is identical to that of *S. annandalei* (Fig. 5a, b) (Nandi 2002). At the rear, the cerci and surstyli of new species resemble those of *S. kiyokoae*. *Sarcophaga (Lioproctia) mailansis* **sp. nov.**, on the other hand, has a more divergent apex of cerci than *S. kiyokoae*. Scrutinizing the shape of surstyli, anterolateral membrane of juxta in *Sarcophaga (Lioproctia) mailansis* **sp. nov.** is also different from other described species as listed in Table 1 and illustrated in Fig. 5. In addition, in new species a well-sclerotized distinct spine developed laterally on juxta.

Females of the family Sarcophagidae are extremely difficult to distinguish since lack of keys and similar appearance, creating a barrier during forensic analysis. Mostly gravid females appear on the dead carcass to lay their first instars. As a result, as detailed by several experts, authentic identification of female flesh flies is required for use in forensic investigations (e.g. Bänziger and Pape 2004; Van der Niet et al. 2011; Cherix et al. 2012; Giroux et al. 2010; Zhang et al. 2014). Female flesh flies are frequently difficult to distinguish (Richet et al. 2011; Meiklejohn et al. 2013; Zhang et al. 2014; Vairo et al. 2015). The color of the gena, postgena, orbital and postocellar setae, chaetotaxy of the thorax and abdomen, and the position of the spiracles 6 and 7, might help identify some female Sarcophagidae (Vairo et al. 2015). In most Sarcophagidae cases, tergite 7 is nearly missing, and tergite 8 is mainly present but reduced to bare lateral plate (Shewell 1987). Tergite 7 + 8 is merged and amalgamated in some species e.g. *S. nanensis* (Kurahashi and Samerjai 2018). Both tergite 7 and 8 are present and well-differentiated in *Sarcophaga (Lioproctia) mailansis* **sp. nov.** Tergite 8 is present in a lateral position with a separate bare pigmented plate/secondary pigmented area (Fig. 3c, f). A significant feature of identification is the presence or absence of hypoprocts and epiprocts, as well as whether they are divided or undivided (Vairo et al. 2015). Two strong bristles are also present on the epiproct of some species, such as *Sarcophaga (Sarcophaga) gracilior* (Chen 1975) (Zhang et al. 2014). The microstructure of spermatheca differs from genus to genus and species to species, which can aid in the identification of Sarcophagid species. Spermatheca in *S. nanensis* has an electric bulb-like shape and is divided into a global

Fig. 5 Comparison of male terminalia. **a** phallus of *Sarcophaga (Lioproctia) mailansis sp. nov.*, lateral view. **b** phallus of *Sarcophaga (Lioproctia) annandalei*, lateral view (Sharma et al. 2018). **c** cercus and surstylus of *Sarcophaga (Lioproctia) mailansis sp. nov.*, caudal view. **d** cercus and surstylus of *Sarcophaga (Lioproctia) annandalei*, caudal view (Sharma et al. 2018). Abbreviations: ce- cercus, j- juxta, s- stylus, ss- surstylus, ve- vesica, vn- ventralia



head and an extended long neck (Kurahashi and Samerjai 2018). Vairo et al. (2015) described the diverse structures of spermatheca, which are elongated and striated in the genus *Oxysarcodexia* and *Sarcophaga*, rounded in *Peckia (Sarcodexia) lambens* and *Peckia (Euboettcheria) florencoi*, and divided into distal and proximal parts in *Peckia*

(*Pattonella*) and *Microcerella*. *Sarcophaga (Lioproctia) mailansis sp. nov.* spermathecae has two parts: a knobbed head and a long cylindrical neck (Fig. 3h). Considering all distinctive characters, we described both the male and female of *Sarcophaga (Lioproctia) mailansis sp. nov.* from India, which may aid in their identification.

Table 1 Comparison of male terminalia of *Sarcophaga (Lioproctia) mailansis sp. nov.* with other species

Species	fifth Sternite	Surstylus	Ventralia	Distiphallus anterolateral margin	Juxtal anterolateral spine
<i>Sarcophaga (Lioproctia) mailansis sp. nov.</i>	Y-shaped, open sternal window	Oval and elongated	Bilobed	Membranous appearance	Without spine
<i>Sarcophaga (Lioproctia) annandalei</i>	V-shaped, closed sternal window	Triangular	Bilobed	Membranous appearance	Less than 5 spines
<i>Sarcophaga (Lioproctia) serratocudo</i>	U-shaped incision, bearing strong bristles	Triangular	Single lobed	Membranous appearance	7 to 8 spines
<i>Sarcophaga kiyokoae</i>	Y-shaped, closed sternal window	Rectangular	Single lobed	Without membranous appearance	4 spines

Conclusion

We described a new species *Sarcophaga (Lioproctia) mailansis* sp. nov. collected from J and K (India). The diagnosis for the species group was provided, as well as identifying characters for both male and female species.

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Data availability Its available with corresponding author.

Declarations

Ethical approval Not applicable.

Conflict of interest All the authors declare no conflict of interest.

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