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New species of flesh fly (Diptera: Sarcophagidae) *Sarcophaga* (*Liosarcophaga*) *geetai* in India

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Abstract
Sarcophaga (Liosarcophaga) geetai, flesh fly is a new species of genus *Sarcophaga* reported from Aurangabad City, Maharashtra state of India. *Sarcophaga geetai* was found in the campus of Dr. Babasaheb Ambedkar Marathwada University, Aurangabad during the Ph.D. research work, on different species of forensic importance. The fly is of medical importance, causing myiasis and useful in determination of post mortem interval.

Keywords: New species, Flesh fly, Sarcophagidae, *Sarcophaga geetai*, India.

Introduction
Sarcophagidae is wide and globally distributed family with approximately 173 genera and 3000 species [1], most of which occur either in tropical or temperate regions. In India, the family Sarcophagidae represents 117 species under 38 genera of three subfamilies [2-3]. The genus *Sarcophaga* includes more than 22 recorded species belonging to 6 subgenera, out of that 8 species identified in India belongs to *Liosarcophaga* subgenus [2]. *Liosarcophaga* is mainly found in palaearctic region in comparison to other regions. Adults of Sarcophagidae often found attracted on flower's nectar [4], feed on other sweet substances, including sap and honeydew [5]. Sarcophagid flies are attracted to carrion lying in any location, typically found around and associated with carcasses throughout the early and late stages of decomposition [6]. Maggots typically feed on carrion and exposed meat or may feed on excrement, these flies are also responsible for causing myiasis in human and animals, hence, are of medical importance and useful in the determination of post mortem interval.

Material and Methods
The Ph.D. research work on different species of forensic importance was conducted in the campus of Dr. Babasaheb Ambedkar Marathwada University, Aurangabad. During the work, the adult flesh flies were attracted on decaying meat samples. Adults were trapped by insect collecting net and brought to the laboratory (Fig: 1) and were released in to the adult rearing box, where they were fed on fresh liver/ meat and sweetened water with honey. Adults males were dissected to observe their genitalia with the help of stereoscope ERMA Optical works, Tokyo, No. 44883, and observations are made on the basis of the comparative morphology and genital structures under Magnus Trinocular Microscope MLX-DX, Olympus (India) PVT. LTD. No. 4B525145. The photographs were taken by Sony cyber-shot camera 16.1 MP. 5X optical zoom.

Results
Flies of this new species are generally similar to other flies of Sarcophagidae, grayish to black silvery in color; eyes large without hairs, frons narrower in male and wider in female; Proclinate orbital bristles only in female, thorax with three dark blackish longitudinal stripes reaching up to hind thorax; 2 post-humeral bristles; mesothoracic spiracles present, Notopleural bristles strong with additional hairs, R_1 bare, Wings generally hyaline, wing vein M_{1+2} curved sharply forward and approaches to R_{4+5} to the anterior margin of wing, R_{4+5} closed, Mid tibia with 1 anterodorsal bristle; Hind coxa with fine hairs in posterior surface; Abdomen with silvery-gray pollen forming more tessellate pattern, but without shining metallic blue or green, second abdominal sternite not covered by lateral margins of first and second tergites; fifth sternites strongly modified in male.

Male genitalia with 2-3 segments and are generally complex, diverse and carry the most diagnostic characters for specific identification, the penis is very large and complicated built, inner forceps larger than outer forceps, series of tubercles at the posterior margin, posterior spiracles are situated in a deep cavity of caudal region.

***Sarcophaga (Liosarcophaga) geetai* sp. n.**

Taxonomy

Type's material

HOLOTYPE (male): India: M.S./ Marathwada region/ Aurangabad, +19.89 (19°53'24"N), +75.32 (75°19'12"E), 14-IX-2013. Male and female was collected at the time of mating. ALLOTYPE (Female): same locality, same data as holotype. PARATYPES: 1 (male), 1 (female) same locality, same data, holotype & allotype deposited in the forensic entomology laboratory, Dr. BAMU, Aurangabad.

Distribution: Aurangabad city, State of Maharashtra, India**.**

Etymology: Named in the respected of mother of Prof. Sureshchandra Popat Zambare.

Key to subgenus *Liosarcophaga* male species

The description and terminologies which are used to describe external morphology, phallic region and classification are as per [2, 7-8].

1- Lateral process of apical plate of paraphallus long and slender; inner forceps gradually tapering and pointed at end ……2

- Lateral process of apical plate of paraphallus short and oval; inner forceps wide medially and pointed at end ……..……..... *saputaraensis* (Nandi)
- Lateral process of apical plate of paraphallus long and slender(Fig.2) ; inner forceps wide medially with straight surface from outer side without notch; having long hair like structure on the inner surface except one fifth at the end without hair; pointed end (Fig.4)……..……..……..……(New Species)

2- Lateral process of apical plate of paraphallus bifurcated ……..……..……..……. 3

- Lateral process of apical plate of paraphallus not bifurcated…….…… *amplicercus* (Shinonaga and Tumrasvin)
- Lateral process of apical plate of paraphallus long unequally bifurcated long one with rounded end and short one with pointed end (Fig.2)…….….. (New Species)

3- Lateral process of apical plate of paraphallus is apically divided into two equal halves…….…….…… 8

- Lateral process of apical plate of paraphallus is apically divided into two unequal halves ……..……. 4
- Lateral process of apical plate of paraphallus, long, slender and apically unequally bifurcated.……..…..……(New Species)

4- Ventralia stongly curved; lateral plate of paraphallus wide and blunt at end...……..……*sarupi* (Nandi)

- Ventralia almost straight; lateral plate of paraphallus narrow and pointed at end...…….. 5
- Ventralianot exactly straight, wide; lateral plate of paraphallus wide slightly elongated and membranous (Fig.2)……..……..…..…(New Species)

5- Ventralia elongated and bilobed ……..….6

- Ventralia not elongated and single ……..…….7
- Ventralia elongated and single ….…..…. (New Species)

6- Posterior paramere and lateral plate of paraphallus blunt at end ……. ….. *idmais* (Séguy)

- Posterior paramere and lateral plate of paraphallus pointed at end …..…*jaipurensis* (Nandi)
- Posterior paramere curved; and pointed end…….…..……..... (New Species)

7- Posterior paramare widened at subterminal end ventralia and lateral plate of paraphallus almost uniform throughout and elongated…...…….…….....*harpax* (Pandellé)

- Posterior paramare widened medially; ventralia and lateral plate of paraphallus widened medially and abruptly pointed……..……... 10
- Posterior paramere widened at proximal region, curved, pointed end with three long hairs at the upper part of distal end one of the hair almost in the middle and other one near to the distal end and the third one in between and many small hairs in lateral side of the posterior paramere (Fig.2)…….…….…..... (New Species)

8- Anterior paramere broad, abruptly pointed and curved at apex; lateral plate of paraphallus long ……..…… 9

- Anterior paramere slender, gradually pointed and almost straight at apex; lateral plate of paraphallus short …….……..……..…..…*brevicornis* (Ho)
- Anterior paramereslender with notch near to the end, curved, pointed at apex; lateral plate of paraphallus wide and slightly elongated pointed apically …..….. (New Species)

9- Ventralia short, wide and equal to lateral plate of paraphallus ……....……. 11

- Ventralia very elongated and shorter than lateral plate of paraphallus…. ……...*portschinskyi* (Rohdendorf)
- Ventralia very well developed, longer than lateral plate of paraphallus, the apical part of ventralia is blunt not pointed…..……...…… (New Species)

10- Anterior paramere wide at middle and curved apically ……..……*josephin sp.*

- Anterior paramere uniform and straight, ventralia is short (Fig. 3); fifth sternite Y shaped with strong hairs formed brush like structure in inner side of the two arms with two long strong hairs in the apex of the two arms called stout spine (Fig. 5) Inner forceps with notch (Fig.6)…..……...…*dux* (Thomson)
- Anterior paramere wide in a proximal and narrow in distal end with notch curved apically(Fig.2); fifth sternite Y shaped with numerous strong highly pigmented hairs forming brush like structure in inner side of the two arms; thin and long hairs on the apex of the two arms, stout spine in the apex are absent (Fig.7)…….….(New Species)

11- Inner forceps slightly s-shaped, curved and sharply protruded; process of apical plate of paraphallus blunt at end….……..…..… *tuberose* (Pandellé)

- Inner forceps straight and slightly widened at subterminal end; process of apical plate of paraphallus pointed at end000.....……. *aegyptica* (Selem)

Description

MALE: Body Length 9 – 13 mm

Head

Width of frons less than half that of one eye; frontal vita black; its width is narrow at the vertex and wider at parafrontal

region, parafrontal and parafacial whitish with silvery pollen; the former without scattered hairs; row of a short hair near the eye margin, some of the frontal hairs of this row are long in front of the eyes; antennae black silvery pollen reaching up to about 0.8 of length of vibrissae, first segment blackish, very small; second antennal segment about three times longer than first one; third segment brown, silvery pollen; about two times longer than second segment; arista long, plumose along basal half; facial ridge black with silvery pollen; vibrissae long, the distance between vibrissae about half of the distance between two eyes; parafrontal bristles 10-11, posterior 1 reclinate, anterior 3 below base of antennae and fourth one in the same level with the base of antennae; gena silver with gray hairs; post gena black with gray hairs; ocellar triangle black with short hairs; outer vertical bristle short, inner vertical bristles well developed, post vertical about half of inner vertical; ocellar and postocellar bristles well developed; postocellar bristles half of inner vertical; row of regular postocular setae besides postocular cilia, rest of the area with grayish hairs; palpi slender and black; proboscis black with brownish tinge basally; black setulae around vibrissa and about 10-14 black bristles below vibrissae.

Thorax

Blackish with three black longitudinal stripes along the three thoracic segments and two short lateral stripes on the first two of the thoracic segments; acrostichal bristle (*ac* 0+1); dorsocentral bristle (*dc* 5+5), (posterior 2*dc* stout); intra-alar bristle (*ia* 1+3); presutural bristle (*ps* 1); humeral bristle (*h* 3); post- humeral bristle (*ph* 2); notopleural bristle (*np* 4); post-alar bristle (*pa* 2); supra-alar bristle (*sa* 3); mesopleuron (*mpl* 6); hypopleural bristle bristles (*hpl* 9); upper part of propleura bare black with silvery pollen; prostigmatic and propleural bristles well developed and accompanied with short hairs. Spiracles are brown in color.

Wings

Hyaline with brown veins; R1 bare; R4+5 with about 9 short setae located dorsally and extending up to about two-third from the basal node to r-m and 4-5 short setae along ventral surface of its anterior margin; squama white; halter brown.

Legs

Black; fore trochanter with long bristles; fore femur with a pair of bristles along posterodorsal surface and a row of bristles along ventral surface; fore tibia with a row of 3 bristles along basal one-third of anterodorsal surface and one bristle on posterolateral surface at about one-third the distance from the distal end; mid trochanter with long bristles but very small hairs; mid femur with one row of bristles along anteroventeral surface on distal half and row of setae along the other half of posteroventral on proximal region; on the dorsal side of distal region 1 short and 2 long bristles reaching up to tibia, mid tibia with 1 bristle on anterodorsal surface on distal one-third and 1 bristle each on one-third and two-thirds the distances from the distal end on posterodorsal surface; hind trochanter with hair like structure; hind femur with two rows of bristles along anterodorsal surface, a row of bristles along anteroventral surface; hind tibia with a row of 3 long and few short bristles a long anterodorsal surface, 2 long bristles on middle portion of postrodorsal surface and numerous long hairs along anterior and posterior margins of ventral surface at about three-fifth from the distal end.

Abdomen

Black with silvery gray checkered pattern; median marginal bristles on second and third abdominal tergites absent but second tergite with 6 and third with 2 lateral marginal bristles, fourthtergite with 2 short median and a pair of lateral marginal bristles, fifth tergite with row of 14 marginal bristles; first to four sternites with short hairs; fifth sternite Y shaped with numerous strong highly pigmented hairs forming brush like structure in inner side of the two arms; thin and long hairs on the apex of the two arms but stout spine in the apex absent; first and second genital segment brown with short hairs but without marginal bristles; inner forceps wide medially with pointed end, proximal half with straight surface from outer side without notch, having long hair like structure, the inner surface of a proximal end also having hair like structure except one fifth of the inner forceps at the pointed end without hair; outer forceps almost triangular, inner side with arcuate shape and convex from outside with long hairs apically; anterior paramere almost slender with notch near to the end, curved and pointed at apex, posterior paramere widened at distal region, curved, pointed end with three long hair at the upper part of anterior end, one of the hair almost in the middle and other one near to the distal end and the third one in between, theca longer than paraphallus both are sclerotised, apical plate of paraphallus with apical process, lateral process of apical plate of paraphallus long and slender unequally bifurcated, long one wide and strong with round end and small one is short with pointed end, lateral plate of paraphallus wide membranous with point end; styli of glands long with an anterior bulge in upper side possess comb-like structure; ventralia not pointed and not exactly straight, very well elongated, apical part of ventralia is blunt.

Female: Body Length 7 – 10 mm, under laboratory condition females is oviparous and the eggs hatched within 15 to 20 minutes.

Head

Almost similar to the male with the following differences; width of frons similar to that of one eye; antennae black silvery, pollen reaching up to about 0.9 length of vibrissae, the distance between vibrissae less than male; fronto-orbital bristles 2 in female; ocellar triangle black with long hairs; outer vertical bristle well developed, inner vertical bristles well developed, post vertical about half of inner vertical; ocellar and postocellar bristles well developed; postocellar half of inner vertical.

Thorax

Almost similar to male with the following differences; the number of hypopleural bristles is 9 and the absence of apicoscutellar bristles.

Legs

Legs are similar to the male.

Wings

Wings are similar to the male.

Abdomen

Big in size and shorter than male; morphologically appearance similar to male but the median marginal bristles in the third tergite are absent; first sternite with numerous short hair like structure, second sternite with 10 marginal bristles. third to fifth with 10 bristles but in each sternite there are 4 long marginal bristles out of 10 bristiles; seventh deeply concave interiorly with 14 short bristles, eighth membranous without hair, anal sternite with long hairs, terminalia very small brown.

Discussion

Varied vegetation and climatic condition in different regions of India resulted in wide distribution of sarcophagid species, amongst numerous species of sarcophagid, only males have been recorded and the females are still unknown. The morphological identification keys of Sarcophagidae species depends on the external structure, spinulation, characteristic and feature of male terminalia [9-10], and few identification keys for larvae are anterior, posterior spiracles and structure of cephalopharyngeal skeleton are species specific [11]. The characters of this new species were compared with previous known literature [8, 12-16]. According to, the morphological identification keys, this new species of Sarcophagidae family belongs to genus Sarcophaga and subgenus *Liosarcophaga.* Some different characters mentioned in the identification keys of male species indicate its close resembles to *Sarcophaga dux* belonging to the same genus and subgenus. The species recorded all over the world [4, 7, 17- 22] are totally different from this new species.

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Fig 1: Copulating adult Sarcophaga *geetai* at the time of collection

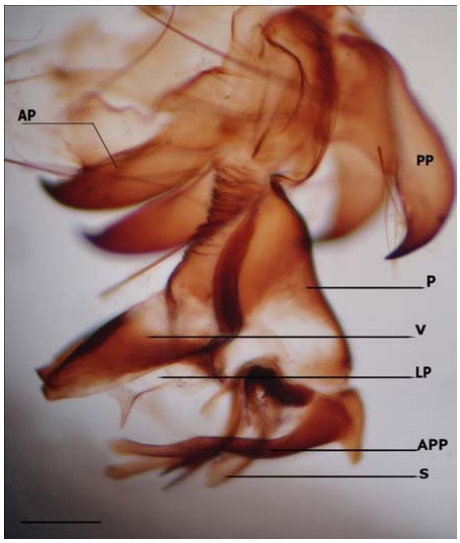

Fig 2: Penis of *S. geetai* (lateral view)

AP= Anterior paramere
PP= Posterior paramere
P= Paraphallus
V= Ventralia
LP= Lateral plate of paraphallus
APP= Apical Plate of paraphallus
S= Styli of glans
Scale bar = 0.1mm

Fig 3: Penis of *Sarcophaga dux* (lateral view) Scale bar = 0.1mm

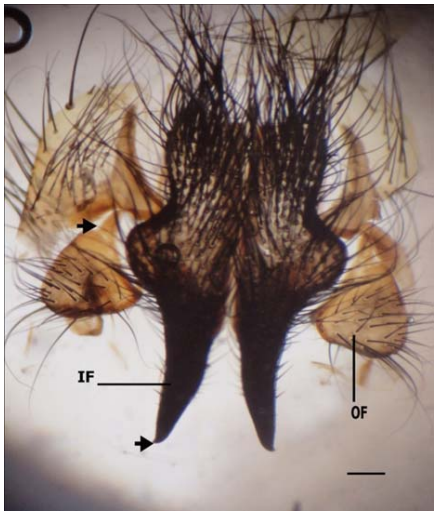

Fig 4: Inner and outer forceps of *S. geetai* (posterior view)

IF= Inner forceps
OF= Outer forceps
Arrows shown the inner forceps without notch and outer forceps with horn like structure different from *P. dux*
Scale bar = 0.2mm

Fig 5: Fifth sternite of *S. dux* Scale bar = 0.2mm

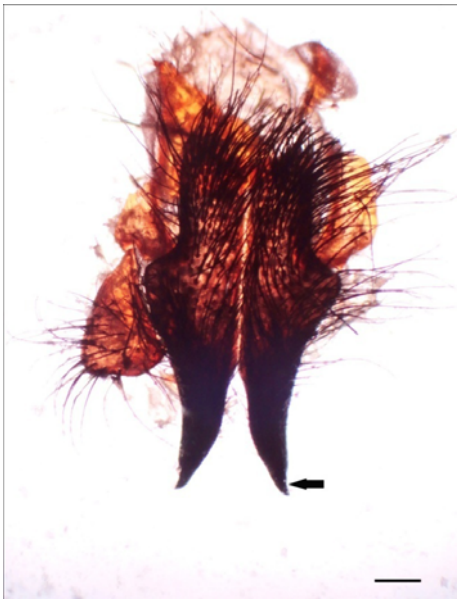

Fig 6: Inner and outer forceps of *S. dux* (posterior view)

Arrow shown the notch in inner forceps
Scale bar = 0.2mm

Fig 7: Fifth sternite of *S. geetai*

Scale bar = 0.2mm

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