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ORIGINAL ARTICLE

# Taxonomy and Regional Identification Key of the Genus *Forcipomyia* Meigen (Diptera: Ceratopogonidae) from Gangetic Region of Uttar Pradesh

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## ABSTRACT

*The genus Forcipomyia Meigen, 1818, part of the Ceratopogonidae family, includes biting midges that play big roles in both ecology and economy. They do this by pollinating plants and spreading diseases. Now, the Gangetic region of Uttar Pradesh? It's got tons of rivers, super fertile soil, and gets really humid at times. All these conditions make it a prime spot for Forcipomyia midges to thrive. This paper pulls together all the taxonomic details about Forcipomyia species found in this agricultural and river-rich zone, spotted and logged by the authors themselves. Plus, for the very first time, there's an easy-to-use artificial dichotomous key included here. This tool should give a huge hand to those trying to keep track of, control pest problems, and study the ecology in Northern India. Along with that, there are also some observations on how these species fit into different subgenera, plus where you might find them in the Gangetic area.*

***Keywords:*** *Biting midges, Ceratopogonidae, Forcipomyia, Gangetic region, Uttar Pradesh, Taxonomy, Identification Key*

## INTRODUCTION

The family Ceratopogonidae, part of the Order Diptera, includes tiny flies called biting midges. These bugs are super important medically, vet-wise, and ecologically, because some species spread illnesses in people and farm animals. Biting midges from the Culicoides and Forcipomyia groups, for example, carry viruses, protozoans, and filarial nematodes causing ailments like bluetongue and African horse sickness.

Now, the Forcipomyia genus stands out because it's packed with many different species. Some of them bite bigger insects or mammals, while others-like Forcipomyia s. str. and Lasiohelea-are major pollinators for cacao trees and other tropical plants. This makes them crucial for chocolate production and maintaining biodiversity. Because of all that, researchers are really studying biting midges more now, looking into entomology, how disease spreads through bugs, and figuring out their classifications.

Identifying species in Forcipomyia can be tough since their external features vary widely and can be affected by the environment. So, experts rely on genital morphology to tell closely related species apart. In Diptera, genital parts have unique patterns that aren't much changed by the environment, making them great for identifying species.

Male Forcipomyia have tergite IX, sternite IX, gonocoxites, gonostyli, parameres, and an aedeagus. Females have spermathecae, spermathecal ducts, cerci, a postgenital plate, accessory glands, and ovipositor structures. Differences in these parts' shapes, sizes, how much they're hardened, and where they're placed help not just in identifying species, but also in figuring out their reproductive tricks and how they evolved over time.

Genital morphology in insects is closely tied to how they mate and their success at reproducing. When mating, the match-up between male and female genitalia is key for lining up right, transferring sperm, and getting fertilization. Biting midges can do this in swarms, on water, or in cozy spots, and the guys often spin their abdomens around to make it work. These moves depend a lot on the anatomy and flexibility of their parts. Also, females store sperm in special chambers that help control fertilization when they lay eggs.

The Gangetic Plains in Uttar Pradesh, India, have some special features when it comes to climate and living things. They've got big river systems, very rich soil, lots of moisture in the air, long rainy seasons, wet soils, and plenty of stuff breaking down. All of this creates great homes for certain tiny bugs, particularly Forcipomyia larvae, which love these moist spots. Even though these critters are super important for the environment, farming, and animal health, we don't know much about their private lives or body parts in detail.

There have been some local studies of fly species before, but there wasn't one big guide to spot the Forcipomyia flies in this part of India. Through a lot of hard work in the field, the authors found some unique species and shared them in different papers. Some examples are Forcipomyia ayushii, F. ranichauriensis, and F. sambherensis, plus more listed elsewhere.

Over years of intense fieldwork, the authors isolated, described, and published details on several new species in the Forcipomyia genus, such as F. ayushii, F. ranichauriensis, F. sambherensis, F. vijayi, and others. There are more like F. etawehensis and F. barbipesi, F. barkhai, F. gondaensis, F. mananthrai, F. dibiyapurensis, F. dasguptai, F. manasi, and F. utteranchali. Currently, information about these species is spread out across different papers. So, this research brings all that info together in one place. The main goal of this study is to provide a combined diagnostic guide and useful, thorough identification keys for both male and female adults. They base this on sturdy body and genital traits. This lets entomologists easily tell these Forcipomyia species apart in Uttar Pradesh.

## GEOGRAPHY OF THE STUDY AREAS

**Sampling Localities:** Specimen collection took place in various ecological zones of the Gangetic sub-regions in Uttar Pradesh. This covered districts like Kanpur, Etawah, Agra, Firozabad, and more, plus places such as Mathura, Aligarh, and all the way up to Lucknow and Allahabad. Uttar Pradesh is about 7.33% of India's total area – that's 240,928 square km – sitting between 23°52'N–31°28'N latitudes and 77°30'E–84°39'E longitudes. These plains have a tropical climate with yearly average temperatures ranging from 25°C to 26.6°C.

## MATERIALS AND METHODS

### 1. Collection Techniques and Source of Material

- **Adult Sampling:** The researchers collected Forcipomyia adults from their naturally damp homes in Uttar Pradesh's Gangetic area. They used sweeping nets to catch daytime flies, while night flyers were lured by UV light traps set up near breeding spots. Nocturnal sampling happened overnight, and the team used Malaise traps too
- **Pupae Extraction:** To get the pupae, they sifted through soil and sand with the Magnesium Sulphate flotation method. After rinsing the tiny critters with distilled water, they were checked under a microscope for sex differences.
- **Rearing and Emergence** Next, they moved the pupae into Petri dishes filled with wet sterile sand. These dishes went into a special incubator where temps ranged from 30–35°C. Post emergence, new adults got cozy in vials with filter paper and a cotton ball soaked in a 10% sugar solution for food.

### 2. Transport and Laboratory Rearing

- Next, they moved the pupae into Petri dishes filled with wet sterile sand. These dishes went into a special incubator where temps ranged from 30–35°C. Post emergence, new adults got cozy in vials with filter paper and a cotton ball soaked in a 10% sugar solution for food.
  Finally, when collected pupae were taken to the lab, they rode in little containers of moist sand to stay comfy and dry during travel. This way, the team made sure the bugs stayed healthy all through transport.

### 3. Processing, Slide Mounting, and Taxonomic Protocol

In 70% ethanol, adult midges collected from fields and raised in labs were preserved. Then, for super detailed looks under the microscope, they got dissected and mounted on slides using Carbol

xylol with Canada balsam or Hoyer's medium – all done according to regular entomology rules. We used standard ceratopogonid literature too when describing structures and figuring out the Antennal Ratio, Palpal Ratio, and Costal Ratio.

## TAXONOMY AND RESULTS

**Taxonomic Description of Subfamily Forcipomyiinae.** Found In Gangetic Plane of Uttar Pradesh:

**Diagnostic characters of Subfamily Forcipomyiinae Lenz, 1934:96**

**Flagellum:** The scape and pedicel are well-developed and setose. The flagellum has 13 flagelomeres. Female flagelomeres are beaded, conical, globular, or simple. The last five are elongated, with the ultimate one being the longest. For males, the last four elongate, typically the tenth and the ultimate ones are longest. In both sexes, the ultimate flagelomere ends in a pointed apex in both sexes.

**Head:** Coronal suture short to long, complete or incomplete. Frontal tubercle usually absent. Temporal seate numerous. Eyes usually bare, narrowly separated to contiguous for about 3.5 facets, ommatidia moderate to large. Maxillary palp with five palpomeres, third palpomere longest, moderate to greatly swollen froming a small to large pit, bearing capitate sensilla.

Cibarial pump well developed, cornua usually upwardly directed in the female and laterally dircted in male. Female mandible and maxilla serrated with teeth, mandible strong. serrated, with 16-24 teeth. Labrum-epipharynx and hypopharynx distally pointed and schlerotized, labium narrow to broad. Female mouth parts adapted for blood sucking and plant sap

**Thorax:** densely covered with macrotrichia. Humeral pit usually absent, Parapsidal suture present. Antepronotum well developed, setose. Acrostichals scattered, dorsocentralis 13- 22 in a few rows to scattered. Scutellum with scattered Postnotum setae. bare.

costa short to long but not extends beyond 3/4 of the wing length. Radial Sector densely covered with microtrichia First radial cell obliterated, or poorly to well developed, second usually well developed and large, cross vein r-m present. Wing usually densely covered with macrotrichia, macrotrichia simple or scalelike, minute or fine microtrichia present on wing membrane. Fringe on posterior border of wing simple or compex. Alula usually without macrotrichia, squama with two elongate setae.

**Legs:** usually without colour pattern and moderately swollen. fore tibial spur broad and hairy. usually fore and mid tibial comb absent, hind tibia with two combs, first with a few long, thick spines, second comb with several small, thin spines. Pseudospurs and dense palisade setae present. Ultimate tarsomere with a pair of markedly curved claws and a well developed empodium in both sexes. In female VIII, IX abdominal segment usually narrow Spermathecae shape, spermathecal usualily one to two, oval rounded spherical in neck small to well developed. Cerci short narrow to broad. Postgenital plate well developed with two setae. In male, IX tergum oblong, triangular without and rectangular apicolateral processes. Sternum IX with usually caudomedian excavation or absent. Gonocoxite thick usually cylindrical, lobular, elongate, setose, gonostylus bare. Aedeagus usually triangular. Volsella usually two pairs. Genus forcipomyia Meigen Forcipomyia Meigen, 1818:73, 75. Type species: Tiula bipunctata Linnaeus designated by Westwood, 1840: 126. Generic name first published in synonymy with Ceratopogon but available under ICZN code Article 11 (e). Labidomyia Stephens, 1829: 52 (1829:239). Tetraphora Philippi, 1865:630. Type species: Tetraphora fusca Philippi. Prohelea Kieffer, 1911:319. Type species: Ceratopogon deciplens Kieffer, designated by Brunetti, 1920:48.

**Diagnostic characters of genus Forcipomyia**

**Antenna:** Scape well developed, with 10-20 setae in female, pedicel rounded, width more than length, with 7-25 setae in both sexes. Flagellum with 13 flagellomeres. Female flagellomeres conical, globular and simple, last five flagellomeres elongated, ultimate flagellomere longest. In male last four flagellomeres elongated, usually 10th and sometime 11th flagellomere longest. ultimate flagellomere pointed in both sexes.

**Head:** Coronal suture small to long, complete or incomplete. Clypeus narrow to broad, sometime U-shaped. Eyes usually bare and sometime pubescent, contigous to narrowly separated, moderately swollen, third palpomere moderate to greatly swollen and forming a small to large pit bearing capitate sensilla, ultimate palpomere ovoid.

Cibarial pump well developed in female, cornua directed lateral to upward, in male, laterally directed. Female with or without maxilla and mandible. Maxilla short, serrated with small teeth, mandible strong, elongated, pointed, serrated with 20-42 large teeth, distal portion of the labrum-epipharynx and hypopharynx sclerotized, labium long, narrow to broad and flappy Mouth parts usually adapted for blood sucking in female, teeth absent in males and rarely absent in female.

**Thorax:** Thorax densely covered with macrotrichia. Humeral pit present or absent and parapsidal suture present. Antepronotum well developed with 4-6 setae. Acrostichals and dorsocentralis scattered, numerous, not in rows. Scutellum thick with 10-12 long. setae. Anapleural suture usually present. Postnotum bare to densely covered with microsetae

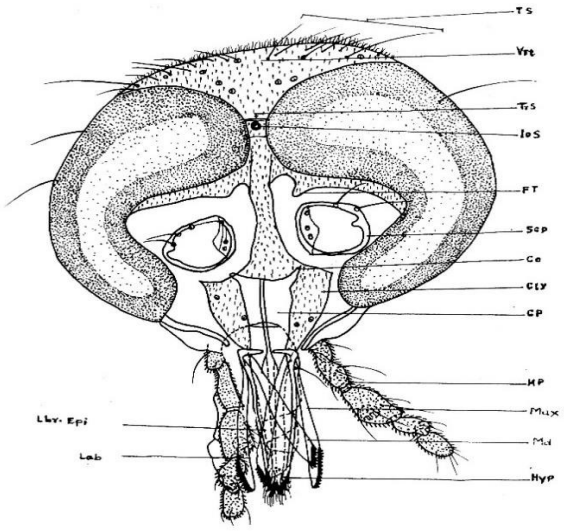


**Plate I:** Structure of Head

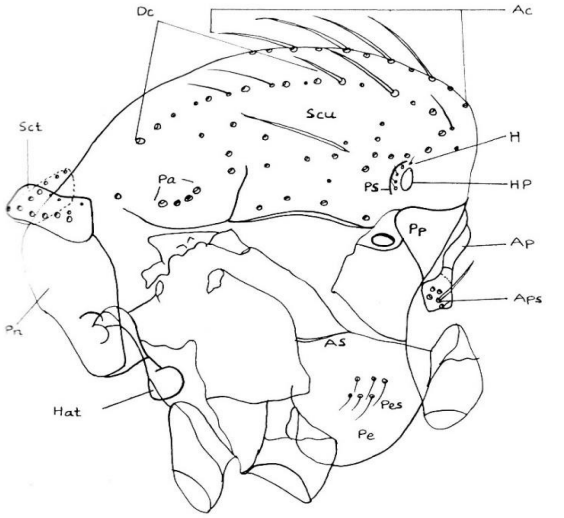


**Plate II:** Structure of Thorax of Forcipomyia

**(ABBREVIATIONS of Head** Cly**: Clypeus,** Co**: Cornua,** CP**: Cibarial pump,** FT**: Frontal tubercle,** Hyp**: Hypopharynx,** IoS**: Interocular seta,** La**: Labia,** Lab**: Labium,** Lbr-epi**: Labrum-epipharynx,** Max**: Maxilla,** Md**: Mandible,** MP**: Maxillary palp,** Pc**: Pedicel,** Pm1.5**: Palpomeres,** Scp**: Scape,** TS**: Temporal setae,** Vrt**: Vertex. Thorax AP**: Antepronotum, **Aps**: Antepronotals, **Dc**: Dorsocentralis, **H**: Humerals, **HP**: Humerals Pit, **Pa**: Prealars, **Pe**: Preepisternum, **Pes**: Preepisternals, **Pn**: Postnotum, **Pp**: Pronotum, **PS**: Parapsidal suture, **Scu**: Scutum, **Sct**: Scutellum, **TrS**: Transverse suture)

**Wing:** Costa usually ending before 1/2 of the wing length, if extends not more than 3/4 of the wing. Radial Sector densely covered with microtrichia and macrotrichia. First radial cell narrow, often obliterated, second radial cell broad, poorly to well developed. Cross vein r-m present. Wing densely covered with scale like macrotrichia, small microtrichia present on wing more complex with numerous rows of erect and suberect hairs in irregular pattern. Alula with or without macrotrichia, squama with two elongated setae.

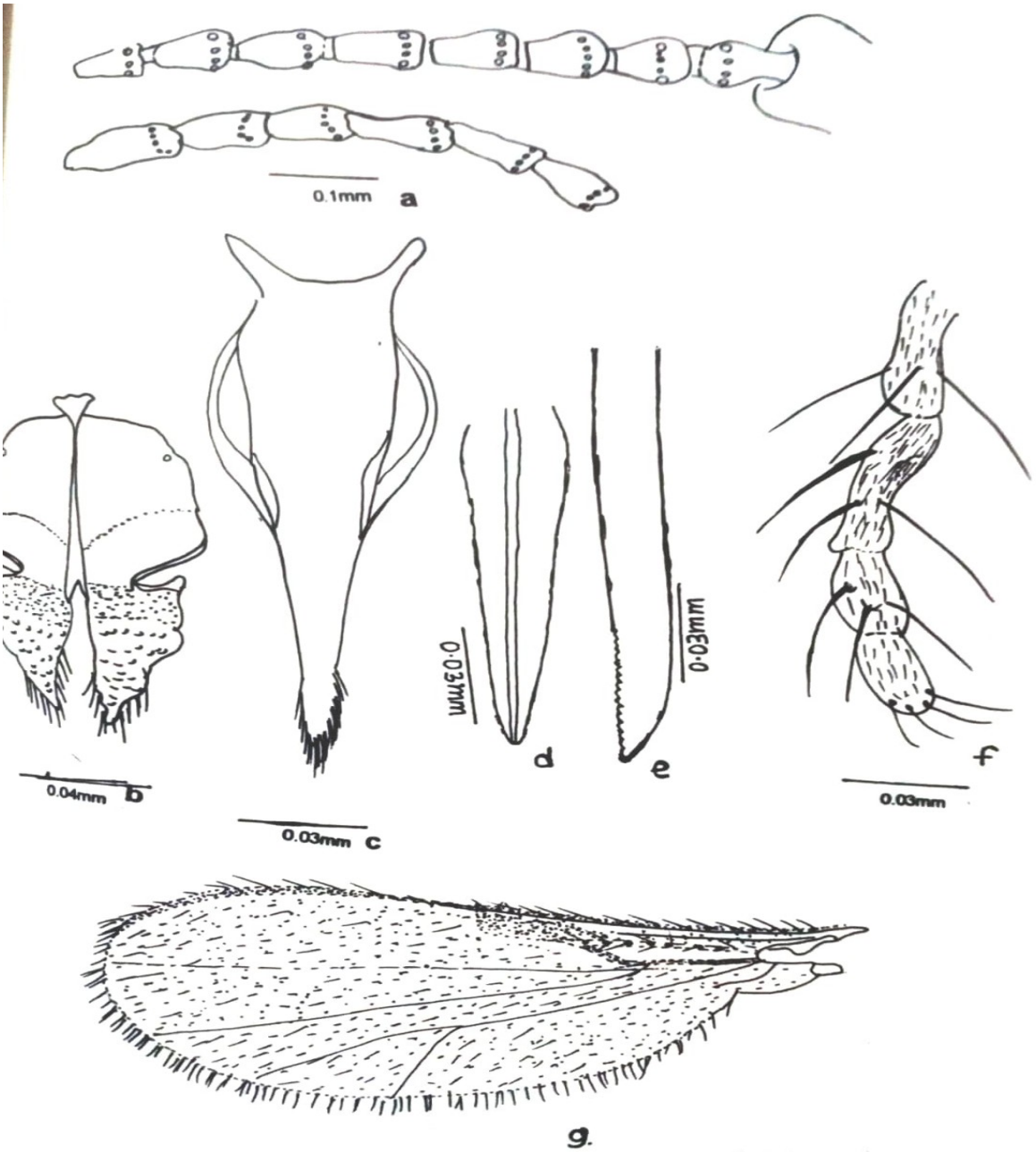


**Plate III:** Structure of Mouth Parts and Wings of Forcipomyia

**Legs:** Femora and tibia slightly swollen to slender and some time with light and dark bands. Fore tibial spur long, mid tibial spur absent, hind tibial spur broad, long and usually hairy Fore tibia with or without comb, mid tibial comb absent. hind tibia with two combs. Legs with dense palisode setae Tarsomeres without basal spines. Pseudospurs presents. Claws moderate in size and mardedly curved. Empodium well developed

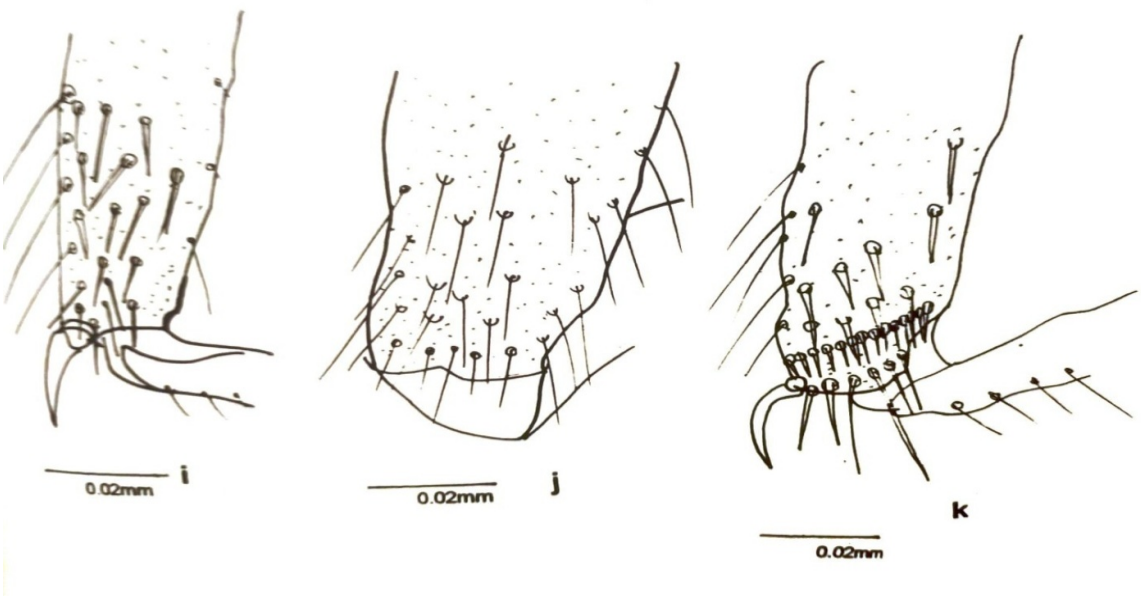


**Plate IV:** Structure Legs Forcipomyia: i. fore leg; j. mind leg; k. hind leg

**Genitalia:** IX abdominal segment narrow to broad. Abdomen usually balloons shaped. Cerci small to moderate, setose. spermathecae one to two and occasionally four, equal or unequal, and rounded, spherical, spermathecal neck absent to well developed, in some, diverticulum present. Postgenital plate well developed, with two sefae.

In the male IX tergum oblong, triangular or rectngular shaped, apicolateral processes usually absent. IX sternum moderately wide to broad and caudomedian excavation absent to very well developed, coxasternapodeme small to long. Median volsella usually straight, small to long, jointed to separated. Aedeagus triangular, rectangular and oval. Gonocoxite thick, cylindrical, lobular, setose, gonostylus triangular, elongated, cylindrecal, spatulate and sometime dumble shaped, often without setae.

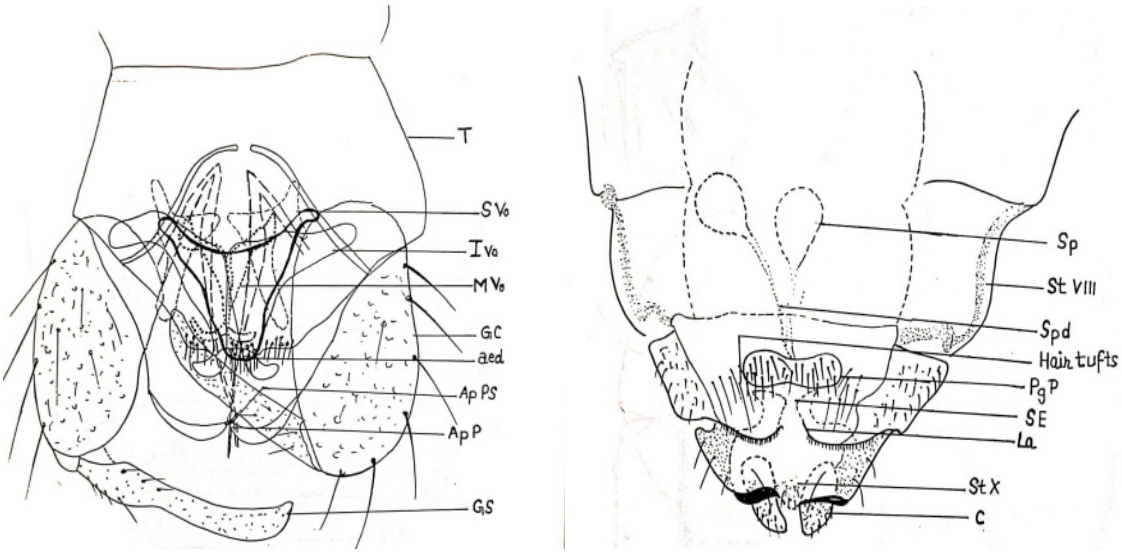


**Plate V:** Structure of male Genitalia and structure of Female Genitalia **of** Forcipomyia

**(ABBREVIATIONS** of Ae: Aedeagus, ApP: Apicolateral process, ApPs: Apicolateral process seta, Cer: cercus, Go: Gonocoxite, Gs: Gonostylus, IVo: Inferior Volsella, P: Paramere, S-IX: Sterum IX, SVo: Superior volsella, T-IX: Tergum IX, T: Tergite. G: Gland, PgP: Postgenital plate, SAC: Sub apical Cercus, SE: Spermathecal eminence, SGR: Schlerotized gland rod, Spt: Spermatheca.)

## DICHOTOMOUS KEY FOR IDENTIFICATION TO THE FORCIPOMYIA SPECIES

In Gangetic Region of U.P., Dichotomous keys are provided for identifying *Forcipomyia* species based on adult male and female morphology. These keys, organized by structural characteristics such as tergum/sternum, wing, and genital features, assist in identifying specific species, including those named sp. nov.

**1. Dichotomous key for the identification of adult males of genus *Forcipomyia*:**

1. Wing membrane with densely coverd with macrotrichia, gonostylus spatulate, aedeagus triangular, legs with light and dark colour pattern, first tarsomere of hind leg smaller than second.....*F. ayushii* sp.nov.
   Densely macrotrichia absent on wing membrane, gonostylus not spatulate, aedeagus simple, coloured light and dark bands absent on the legs.....2
2. Tergum IX with distal notch, sternum IX moderately broad with a deep caudomedian excavation ..... 3 Tergum IX without distal notch, sternum IX broad and caudomedian excavation absent ..... .....4
3. Macrotrichia decumbent, scale like, fringe highly dense, proximal part of gonostylus broader but narrow distally, median volsella short and straigt ..... ..... *F. ranichauriensis* sp. nov.
   Macrotrichia not ducumbent, not scale like, fringe simple with long and short setae alternatively, gonostylus dumble shaped, median volsella short but beak shaped ..... ..... *F. sambherensis* sp. nov.
4. Distal margin of tergum IX convex and the distal margin of IX sternum slightly convex.....5
   Distal margin of tergum IX simple and distal part of sternum IX not convex ..... .....6
5. The distal margin of tergum IX highly convex, base of median volsella separated, elongated, not fused with the base of gonocoxapodeme, first palpomere with more than three setae, palpomere Third longest.....*F. vijayi* sp. nov.
   Distal margin tegfum IX not convex, base of median volsella, fused with gonocoxapodeme, first palpomere with less than three setae.....*F. etawehensis* sp. nov.
6. Coxa sternapodeme inverted U-shaped, median volsella absent or if present, long, swollen at middle and narrow at both ends, aedeagus triangular, gonostylus folding anteriorly, second radial cell poorly developed, mid tibial spur present.....7
   Coxasternapodeme short, straight, median volsella bifurcated gonostylus elongated, distal end tapering, second radial cell well developed, aedeagus rectangular, mid tibial spur absent.....*F. barbipesi* sp.nov.
7. Distal inner end of coxasternapodeme with a lobe, aedeagus triangular, median volsella absent, 10th flagellomere longest .....*F. barkhai* sp. nov.
   Coxasternapodeme without distal lobe, aedeagus smaller, median volsella swollen at middle and narrow at both ends with tapering distal end, 11$^{th}$ flagellomere longest .....*F. gondaensis* sp. nov.
8. Volsella short, gonostyllus long, short tibial apex simple, flagellomere four ..... .....9
   Volsella elongated, gonostylus short, tibial apex having setose digital structure, flagellomeres five, .....*F. mananthrai* sp. nov.
9. Volsella short comma-shaped, gonostylus long, tibial apex simple, fore tibial spur absent, flagellomeres Four.....*F. dibiyapurensis* sp. nov.
10. Volsell short, round shape fused with gonocoxa, gonostyllus short, tibial apex simple, fore tibial spur present, flagellomere four.....*F. dasguptai* sp. nov.

**2. Dichotomous key for the identification of adult females of genus *Forcipomyia*:**

1. Cornua laterally directed, mouth parts without maxilla ..... .....2

Cornua anteriorly directed, mouth parts with well developed toothed mandible and maxilla .....3

2. Body densely covered with setae, flagellomere 1-8 conical shaped, spermathecae two, semicircular, spermathecal neck absent.....*F. ayushii* sp. nov.
   Body slightly coverd with setae, flagellomeres simple, spermathecae two, oval, with well developed neck .....*F. barkhai* sp. nov.
3. Single spermatheca with or without neck .....4
   Spermathecae two or more, variable sized, spermathecal neck present or absent .....5
4. Spermatheca rounded to spherical, with a single diverticulum, mid tibial spur absent ..... .....6
   Spermatheca single, without spermathecal neck third maxillary palp ovoid, with a large sensory pit, clypeus U-shaped, .....*F. manasi* sp. nov.
5. Spermathecae four, rounded, variable Sized .....*F. utteranchali* sp. nov.
   Spermathecae two .....
6. Spermatheca spherical, with a single diverticulum, VIII and IX abdominal segment narrow .....*F. barbipesi* sp.nov.
   Spermatheca rounded without diverticulum, spermathecal neck absent, VIII and IX abdominal segmentsimple .....*F. mananthrai* sp.nov.
7. Spermatheca two, mandible and maxilla well developed, wing membrane densely covered with macrotrichia.....*F. etawahensis* sp. nov.
   Spermatheca two, maxilla not clearly visible, wing slightly covered with microtrichia .....*F. dibiyapurensis* sp. nov.

## DISCUSSION AND CONCLUSION

In the Gangetic plain ecosystem, the morphological differences highlighted in these keys really show how diverse Forcipomyia evolution has been. You can tell different species apart by key features like a distal notch on the males' Tergum IX, or by looking at female spermathecae that range from one to four structures. The new species found are pretty unique to Uttar Pradesh. Using these classification keys is super helpful because it lets researchers quickly sort samples without always needing pricey molecular tests.

## ACKNOWLEDGEMENT

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