



E-ISSN: 2320-7078  
P-ISSN: 2349-6800  
JEZS 2017; 5(4): 1912-1921  
© 2017 JEZS  
Received: 10-05-2017  
Accepted: 11-06-2017

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## A taxonomic approach to the genus *Culicoides* (Diptera: Ceratopogonidae) with six new records of its species from coastal-saline zone of West Bengal

**Emon Mukhopadhyay, Surajit Hazra, Jayita Sengupta, Panchanan Parui and Dhriti Banerjee**

#### Abstract

The study describes six new records of species of *Culicoides* from cattle farms in coastal saline districts of Haora, North and South 24 Parganas in West Bengal. These insects favour to live in moist tropical areas, coastal regions ideal for their occurrence. *Culicoides* midges are haematophagous and vector of virulent pathogens, feeding on blood of livestock animals and spreading diseases. Very few instances of cattle diseases are reported from West Bengal. Various strewn researches on taxonomic studies of genus *Culicoides* from West Bengal at different times by different authors create ambiguity. This manuscript is a brief taxonomic narrative of *Culicoides* midges from coastal saline parts of West Bengal aiding in species identification. Further studies based on this would benefit in recording symptoms of disease occurrence vectored by biting midges, spread awareness on cattle management and develop precautionary measures to protect livestock in various parts of West Bengal and India.

**Keywords:** *Culicoides*, Coastal-saline, West Bengal, Vector

#### 1. Introduction

Ceratopogonidae are small nematocerous Diptera with the genus *Culicoides* causing serious nuisance to human beings, livestock, equines transmitting Blue tongue virus (BTV), Epizootic hemorrhagic disease virus (EHDV), African horse sickness virus (AHSV), Akabane, Aino, Equine encephalitis virus (EEV) <sup>[1,2]</sup>. They are very small in size (1-3mm) <sup>[2]</sup>, with a stout body and wings are folded flat over the abdomen when at rest. They are often mistaken with the family Chironomidae because of its small and similarity in wing venation pattern.

*Culicoides* midges are found all over the world mostly in the tropical and subtropical regions except in extreme cold environment. Eleven out of thirteen *Culicoides* vectors known from India are reported from West Bengal with a total record of 57 species <sup>[3]</sup>. During the last four decades a number of outbreaks of Bluetongue Disease (BTD) have been reported from India where *Culicoides* species have been suspected to be the vector. According to livestock census 2012 report, 28 percent of the dairy farming industry is based in West Bengal which provides a parallel source of livelihood for villagers apart from agriculture. Recently instances of cattle diseases are reported from various parts of West Bengal, especially from the southern districts, mostly in the new alluvial zone and few in red laterite and coastal parts <sup>[4-7]</sup>.

Coastal regions rich in organic matter with moist climate provide ideal conditions for habitat and development of a vector insect. The aim of our study is to undergo long term field surveys in various coastal parts of West Bengal and report evidences of *Culicoides* insects.

#### 2. Materials and Methods

##### A. Study Area

Our study concentrates on the coastal saline belt of West Bengal occupying 7.6 percent of the State. West Bengal has the highest area of coastal saline lands in India lying between 87°25' E and 89°E latitude and 21°30' N and 23° 15' N longitude. The region is characterized by deep, fine loamy to fine textured soils and constitutes districts of Purba Medinipur, South 24 Parganas, southern fringes of North 24 Parganas and Haora. The major part of the coastal area in West Bengal falls within the boundaries of South and North 24 Parganas popularly known

as Sundarbans. The area comprises predominantly of alluvial plain which gradually merged with the deltaic plain located in the south-east direction. In the district of Medinipur coastal sand dunes, coastal plains and deltaic flood plains are found. In Haora, natural levee and coastal plain predominate. In the Sundarban region, the river Hugli with its tributaries meander into its confluence into the Bay of Bengal and are divided into a number of branches, enclosing the delta. The coarse sediments carried by rivers get deposited on the riverbed raising it gradually and finer sediments in suspension are transported to the sea. The tides carrying saline water and the tidal floods have great influence on the formation and development of coastal soils of the state. The climate of this region is classified as hot humid with three distinct seasons, viz. winter, summer and monsoon. The average minimum and maximum temperature in the region during winter, summer and monsoon seasons are: 13.6 and 31.6, 18.6 and 38.3, and 23.5 and 34.1°C, respectively. The mean annual rainfall is about 1800 mm, received mostly from south-west monsoon from July to mid-September<sup>[8]</sup>. The moist environment and marshy landscape of the coastal West Bengal provides ideal conditions for the habitation and survival of the *Culicoides* midges.

Insects were collected from cattle farms in Dumki, Godabar, Jaganathpur, Kalatala Hat, Karunarhati, Mathur, Modhukhali in South 24 Parganas, Jhupkhali, Kumar Khali, Nalokora, Sandeshkhali in North 24 Parganas and Ichapur, Maubesia in Haora. The distribution sites were geo-referenced by GPS handset GARMIN Oregon 550. A distribution map (Figure 1) of *Culicoides* in West Bengal based on these locations was created using ARC GIS 10.5 (ESRI, Redlands, CA, USA).

### B. Sample Collection, Preservation and Identification

Sample collection was performed using sweep nets in early morning, afternoon and just before sunset for a period of two years from June 2014 to May 2016. The study sites were sampled during three seasons (pre monsoon, monsoon and post monsoon) for 90 man days. After collection, they were transferred in 70% ethanol and kept in a cool place. In the laboratory, *Culicoides* species were sorted and different parts of the specimen were mounted on glass slides in phenol-balsam mixture and identified through Leica DFC 295 binocular light microscope with the aid of morphological descriptions of different authors<sup>[9-18]</sup>.

## 3. Results

### A. Morphological features

*Culicoides* midges have piercing and sucking mouthparts, with females sucking blood of animals, while males feeding on plant juices. Their maxillary palpus is five segmented, the third segment is swollen and on the distal part of the medio-ventral surface is present a specialized sensory pit or group of sensilla, which is an important taxonomic tool. The foretibia of leg bears a small spur with a tuft of modified hairs, while the tip of hind tibia bears an anterior spur and two transverse rows of modified spines used for classification. There are claws on all legs, simple in females, bifid in males. Wings remain densely covered with macrotrichia, with pigmentations giving it a pattern of dark or light spots with two complete radial cells. Abdomen of female has a pair of small, rounded cerci below the ninth tergum with 1 to 3 sclerotized spermathecae. The male abdomen is slender and possess prominent genitalia at the terminus. The ninth segment consists of an irregular ring fused with the tergum and sternum. Genital appendages are two segmented-the

basistyle and the dististyle and arise laterally from the base of tergum<sup>[9]</sup>.

## B. Taxonomic studies

### I. Systematic list

Order Diptera

Suborder Nematocera

Superfamily Chironomoidea

Family Ceratopogonidae

Subfamily Ceratopogoninae

Tribe Culicoidini

**Genus *Culicoides*** Latreille, 1809

1809. *Culicoides* Latreille, *Paris and Strasbourg* 4: 399 pp.

Type species: *Culicoides punctatus* Latreille 1809 (= *Ceratopogon punctatus* Meigen 1804)

**Subgenus *Avaritia*** Fox, 1955

1. *Culicoides imicola* Kieffer, 1913

2. *Culicoides dumdumi* Sen and Das Gupta, 1959

3. *Culicoides fulvus* Sen and Das Gupta, 1959

**Subgenus *Diphaomyia*** Vargas, 1960

4. *Culicoides huffi* Causey, 1938

**Subgenus *Trithecooides*** Wirth and Hubert, 1959

5. *Culicoides anophelis* Edwards, 1922\*

6. *Culicoides palpifer* Das Gupta and Ghosh, 1956

**Subgenus *Hoffmania*** Fox 1948

7. *Culicoides (Hoffmania) peregrinus* Kieffer, 1910

\* *C. anophelis* has been recorded earlier from the coastal saline region of West Bengal.

### II. Systematic Account

The diagnostic characters and morphological keys for identification are based on the descriptions of Sen and Das Gupta, (1959); Das Gupta, (1962); Wirth and Hubert, (1989); Nandi and Mazumdar (2014, 2015).

### Key to the subgenera of Genus *Culicoides*

1. Second radial cell of wing with post stigmatic pale spot covering only the tip of the cell.....Subgenus *Avaritia*.

Tip of second radial cell pigmented.....2.

2. Distal half of first and second radial cell covered with a distinct dark spot.....Subgenus *Diphaomyia*.

Radial cells light in colour.....3.

3. Wing light in colour, two pale areas, one over R-M cross-vein and another on second radial cell.....Subgenus *Trithecooides*.

Wing dark in colour .....4.

4. Wing with irregular light and dark spots, a streak like pale spot behind medial fork.....Subgenus *Hoffmania*.

**Subgenus *Avaritia*** Fox, 1955

1955. *Avaritia* Fox, *Journal of Agriculture of the University of Puerto Rico* 39:214-285.

Type species: *Ceratopogon obsoletus* Meigen 1818

**Diagnosis.** Eyes contiguous. Wing with large pale spot over R-M crossvein, broadly meeting costal margin and fused posteriorly with pale streak in cell m<sub>2</sub>. Apices of veins M<sub>1</sub>, M<sub>2</sub>, M<sub>3+4</sub> and Cu<sub>1</sub> dark at wing margin; Hindtibial comb with 5

spines, the one nearest the spur usually longest. Two spermathecae, a vestigial one, usually with a narrow sclerotized neck (Plate 1).

**Key to the species of Subgenus *Avaritia***

1. Third palpal segment slightly swollen with a sunken sensory pit and sensilla grouped in a circle on the surface.....*C. imicola*.  
Third palpal segment slender.....2.
2. A small, shallow sensory pit on palpus located at the tip of the third segment.....*C. fulvus*.  
Sensory pit large and round.....3.
3. Sensory pit located at the tip of a swollen third palpal segment.....*C. dumdumi*.

**1. *Culicoides imicola* Kieffer, 1913**

1313. *Culicoides imicola* Kieffer, *Resultats scientifiques. Diptera* (5): 1-43.

1959. *Culicoides minutus* Sen and Das Gupta, *Annals of the Entomological Society of America* 52:617-630.

1962. *Culicoides pseudoturgidus* Das Gupta, *Science and Culture* 28:537-539.

**Material examined.** 1♀, collected from cow shed, 22.3411° N, 88.8031° E, Kumar Khali, North 24 Parganas, 12.ix.2014, Coll. S. Hazra.

**Diagnosis.** Poststigmatic pale spot in cell r<sub>5</sub> large and quadrate; cell m<sub>1</sub> with pale spot near base and a second long one narrowly continued to wing margin, expanded posteriorly nearly to vein m<sub>2</sub>, cell m<sub>4</sub> with large pale spot on posterior margin; anal cell with proximal third pale (Plate 2).

**Distribution:** India: West Bengal: North 24 Parganas: Dumdum, Sandeshkhali, Hooghly: Chinsura, Kolkata: Hastings, Thakurpukur; Karnataka: Bidar: Kamthana; Kerala: Maharashtra: Marathwada; Tamil Nadu.

**2. *Culicoides fulvus* Sen and Das Gupta, 1959**

1959. *Culicoides fulvus* Sen and Das Gupta, *Annals of the Entomological Society of America* 52:617-630.

**Material examined.** 1♀, collected from cow shed, 22.3911°N, 88.8411°E, Jhupkhali, North 24 Parganas, 20.ix.2014, Coll. S. Hazra.

**Diagnosis.** Poststigmatic pale spot in cell r<sub>5</sub> large and oval; cell m<sub>1</sub> with large oval pale spot in basal portion, nearly touching veins M<sub>1</sub> and M<sub>2</sub>, anal cell pale at base, a definite pale streak connecting basal area with irregular, double pale spot in distal portion of cell. Spermathecae with necks scarcely developed (Plate 3).

**Distribution:** India: West Bengal: Kolkata: Baguihati, North 24 Parganas: Dumdum, Sandeshkhali; Tamil Nadu.

**3. *Culicoides dumdumi* Sen and Das Gupta, 1959**

1959. *Culicoides dumdumi* Sen and Das Gupta, *Annals of the Entomological Society of America* 52:617-630.

**Material examined.** 1♀, collected from cow shed, 22.362686°N, 88.876689°E, Sandeshkhali, North 24 Parganas, 10.ix.2015, Coll. S. Hazra.

**Diagnosis.** Wing with small poststigmatic pale spot in cell r<sub>5</sub> covering distal half of second radial cell; cell m<sub>1</sub> with two

faint elongate pale spots; cell m<sub>2</sub> with indistinct pale streak on basal half; anal cell with faint pale streak at base and two more distinct pale spots in distal portion (Plate 4).

**Distribution:** India: West Bengal: Kolkata: Baguihati, North 24 Parganas: Dumdum, Sandeshkhali.

**Subgenus *Diphaomyia* Vargas, 1960**

1960. *Diphaomyia* Vargas, *Revista de Biologia Tropical* 8:35-47.

Type species: *Culicoides baueri* Hoffman, 1925

**Diagnosis.** Wing usually with 2nd radial cells dark to tip; distal half of the first radial cell and all the second radial cell included in a dark spot; pale spot over R-M crossvein often lying entirely distal of vein; a light pale streak on vein M<sub>1</sub>; cell m<sub>2</sub> generally with two pale spots, one pale marking just anterior to medio-cubital fork. Hind tibial comb with 4 spines. Two spermathecae, elongate necks almost half as long as spermathecae (Plate 5).

**4. *Culicoides huffi* Causey, 1938**

1938. *Culicoides huffi* Causey, *American Journal of Hygiene* 27:399-416.

**Material examined.** 1♀, collected from cow shed, 22.2371°N, 88.1481°E, Mathur, South 24 Parganas, 20.ix.2015, Coll. S. Hazra.

**Diagnosis.** Eyes narrowly separated. Third palpal segment swollen, with very broad, shallow sensory pit. A small round poststigmatic pale spot on costal margin in cell r<sub>5</sub> just past end of second radial cell; a second small elliptical poststigmatic pale spot lying slightly distal of first and immediately anterior to vein M<sub>1</sub>; cell m<sub>1</sub> with 2 small pale spots; cell m<sub>2</sub> with one pale spot anterior to M<sub>2</sub> and another lying immediately behind medial fork; anal cell with small pale area at base and a transverse, more or less double, pale spot in distal part of cell; ends of veins without pale spots (Plate 6).

**Distribution:** India: West Bengal: North 24 Parganas: Habra, South 24 Parganas: Kalatala Hat.

**Subgenus *Trithecoides* Wirth and Hubert, 1959**

1959. *Trithecoides* Wirth and Hubert, *Pacific Insects* 1:1-38.

Type species: *Culicoides flaviscutatus* Wirth and Hubert, 1959

**Diagnosis.** Second radial cell of wing is included in a pale spot. Wing markings consisting of 2 anterior pale areas, 1 over R-M crossvein; second over apex of second radial cell. Hind tibial comb with 4 spines, second from spur longest. Three well-developed, sclerotized spermathecae always present (Plate 7).

**Key to the species of the Subgenus *Trithecoides***

1. Second and third palpal segments short and very stout with sensilla scattered all over the distal part of the third segment.....*C. anophelis*.  
Third palpal segment slender.....2.
2. Third palpal segment with sensilla located distally in a shallow pit like area.....*C. palpifer*.

**5. *Culicoides anophelis* Edwards, 1922**

1922. *Culicoides anophelis* Edwards, *Bulletin of*

**Material examined.** 2♀, collected from cow shed, 22.2701°N, 88.6211°E, Dumki, South 24 Parganas, 16.v.2016, Coll. S. Hazra. 1♀, collected from cow shed, 22.1541°N, 88.5721 °E, Godabar, South 24 Parganas, 11.vi.2014, Coll. S. Hazra.

**Diagnosis.** Wings generally with dark streaks along veins and moderately pale areas in cells; 2 large, very pale spots, one centering on R-M crossvein and other on apex of second radial cell; apex of wing narrowly pale (Plate 8).

**Distribution:** India: West Bengal: Jalpaiguri, Kolkata: Thakurpukur, Gobra, Kestopur; South 24 Parganas:Port Canning, Nikarighata, North 24 Parganas: Dumdum; Andhra Pradesh : Chittoor, Parakasma; Assam: Golaghat; Bihar: Karnataka; Kerala; Madhya Pradesh; Tamil Nadu.

#### 6. *Culicoides palpifer* Das Gupta and Ghosh, 1956

1956. *Culicoides palpifer* Das Gupta and Ghosh, *Bulletin of the Calcutta School of Tropical Medicine and Hygiene* 4:122.

**Material examined.** 1♀, collected from cow shed, 22.3031°N, 88.1371°E, Jagannathpur, South 24 Parganas, 13.xi.2014, Coll. S. Hazra. 2 ♀, collected from cow shed, 22.4181°N, 88.8081°E, Nalkora, North 24 Parganas, 14.xi.2015, Coll. S. Hazra. 1♀, collected from cow shed, 22.1761°N, 88.6321°E, ModhuKhali, South 24 Parganas, 18.vi.2014, Coll. S. Hazra. 1♀, collected from cow shed, 22.3691°N, 88. 88.0931°E, Ichhapur, Haora, 2.iv.2015, Coll. S. Hazra.

**Diagnosis.** Wing with 3 large, very dark areas on anterior margin; dark along veins and with indistinctly paler areas in cells; 2 pale spots on costal margin, one centering over R-M crossvein, the other on apex of second radial cell; apex of wing broadly pale (Plate 9).

**Distribution:** India: West Bengal: Haora: Basudebpur; Kolkata: Thakurpukur; North 24 Parganas: Kachrapara, Sandeshkhali, South 24 Parganas: Kalatala Hat, Nikarighata; Assam; Karnataka.

#### Subgenus *Hoffmania* Fox, 1948

1948. *Hoffmania* Fox, *Proceedings of the Biological Society of Washington* 61:21-28.

Type species: *Culicoides inamollae* Fox and Hoffman 1944 (= *Culicoides insignis* Lutz 1913).

**Diagnosis.** Wing with second radial cell ending in a pale spot; small dark spot often present over R-M crossvein or at end of R<sub>4</sub> + 5; the cross vein R-M dark, within a large light spot; beyond the first radial cell usually there are only two large light spots; cell m<sub>1</sub> usually with one light spot; vein M<sub>2</sub> with one light spot; cell m<sub>2</sub> with one apical light spot; branches of the medio-cubital fork usually white all along. Hindtibial comb with 6 spines, second from spur longest. Spermathecae 2 plus vestigial third; ovoid with short necks (Plate 10).

#### 7. *Culicoides peregrinus* Kieffer, 1910

1910. *Culicoides peregrinus* Kieffer, *Memoirs of the Indian Museum* 2:181-242.

1932. *Culicoides assamensis* Smith and Swaminath, *Memoirs of Indian Medical Research* 25:182-186.

**Material examined.** 3♀, collected from cow shed, 22.4511°N, 88.5661°E, Karunarhati, South 24 Parganas, 2.v.2016, Coll. S. Hazra. 1 ♀, collected from cow shed, 22.4241°N, 88.0931°E, Maubesia, Haora, 22.iv.2016, Coll. S. Hazra.

**Diagnosis.** Eyes touching in a point. Second palpal segment very stout, as stout as third; third segment slender on distal half, stout basally, with an irregular sensory pit at base of slender portion. Dark areas along anterior wing margin and narrowly along veins much darker than rest of wing; double pale spot overlapping midportion of vein M<sub>2</sub> separated into separate spots by dark line along vein; a round pale spot lying immediately in front of mediocubital fork; small round pale spot near wing margin in distal part of cell m<sub>4</sub> (Plate 11).

**Distribution:** India: West Bengal: Birbhum: Bolpur, Haora: Basudebpur, Kolkata, Jhargram, South 24 Parganas: Nikarighata; Andhra Pradesh: Chittoor, Prakasam; Assam; Karnataka; Maharashtra: Marathwada; Orissa Coast: Puri; Tamil Nadu.

#### C. Distribution trend analysis

The distribution pattern from June 2014 to May 2015, shows one record of *C. palpifer* from Haora, two records of *C. palpifer* from South 24 Parganas, one record of *C. imicola*, of *C. fulvus* and *C. anophelis* from North 24 Parganas (Figure 2). From June 2015 to May 2016, the distribution pattern shows one record of *C. peregrinus* from Haora, two records of *C. anophelis*, one record of *C. huffi* and three records of *C. peregrinus* from South 24 Parganas, one record of *C. dumdumi* and two records of *C. palpifer* from North 24 Parganas (Figure 3). The distribution trend in the sampling sites for a period of two years shows maximum distribution from South 24 Parganas, followed by North 24 Parganas and Haora (Figure 4) and also shows the ranking of seven species based on their numbers with a total of five records of *C. palpifer*, four of *C. peregrinus*, three of *C. anophelis*, one record of *C. huffi*, *C. imicola*, *C. fulvus* and *C. dumdumi* (Figure 5).

#### 4. Discussion

The present research summarizes seven species of genus *Culicoides* under four subgenera- *Avaritia*: *C. imicola*, *C. fulvus* and *C. dumdumi*, *Diphaomyia*: *C. huffi*, *Trithecooides*: *C. anophelis* and *C. palpifer*, *Hoffmania*: *C. peregrinus* from coastal saline areas of West Bengal. The first taxonomic study on *Culicoides* was done by Kieffer, (1910) and was followed by Patton, (1913); Dover, (1921); Edwards, (1922); Smith, (1929); Mukherji, (1931); Smith and Swaminathan, (1932) and Macfie, (1932). After a long breach, Sen and Dasgupta, (1959); Dasgupta, (1962) did comprehensive studies on Indian *Culicoides* in and around Kolkata. In the recent years, taxonomic studies of different *Culicoides* species are ongoing in various parts of West Bengal [15-18], with very few incidences from coastal parts showing dispersed archives of different subgenera of the genus by different authors. Accordingly we assembled all these literatures and restructured the diagnostic characters and morphological keys on *Culicoides* midges which would give a new dimension to this field.

These insects spread diseases in almost all the zoogeographical regions of the world. *Culicoides imicola* is

distributed across the Afrotropical, Saharo-Arabian and Oriental regions, *C. fulvus*, *C. palpifer* and *C. peregrinus* are found in Australian, Oceanian and Oriental region, *C. huffi*, *C. anophelis* are restricted to Oriental region while *C. dumudumi* is endemic to India<sup>[19]</sup>. All these species are reported as vectors with the exception of *C. anophelis* and *C. huffi* from India<sup>[3, 20]</sup>. 27 Bluetongue Virus (BTV) serotypes have been recorded worldwide<sup>[21]</sup> and evidence of at least 22 BTV

serotypes has been found in India<sup>[22]</sup>. BTD was never prominently detected in the eastern part of the country. West Bengal had no reports on any outbreaks or active disease incidents earlier, but on-going studies on the midge biology and vector competence are recently been observed<sup>[4-7]</sup>. All the evidences report nearly 260 disease outbreaks in last 50 years<sup>[4-7, 20, 22-26]</sup>.

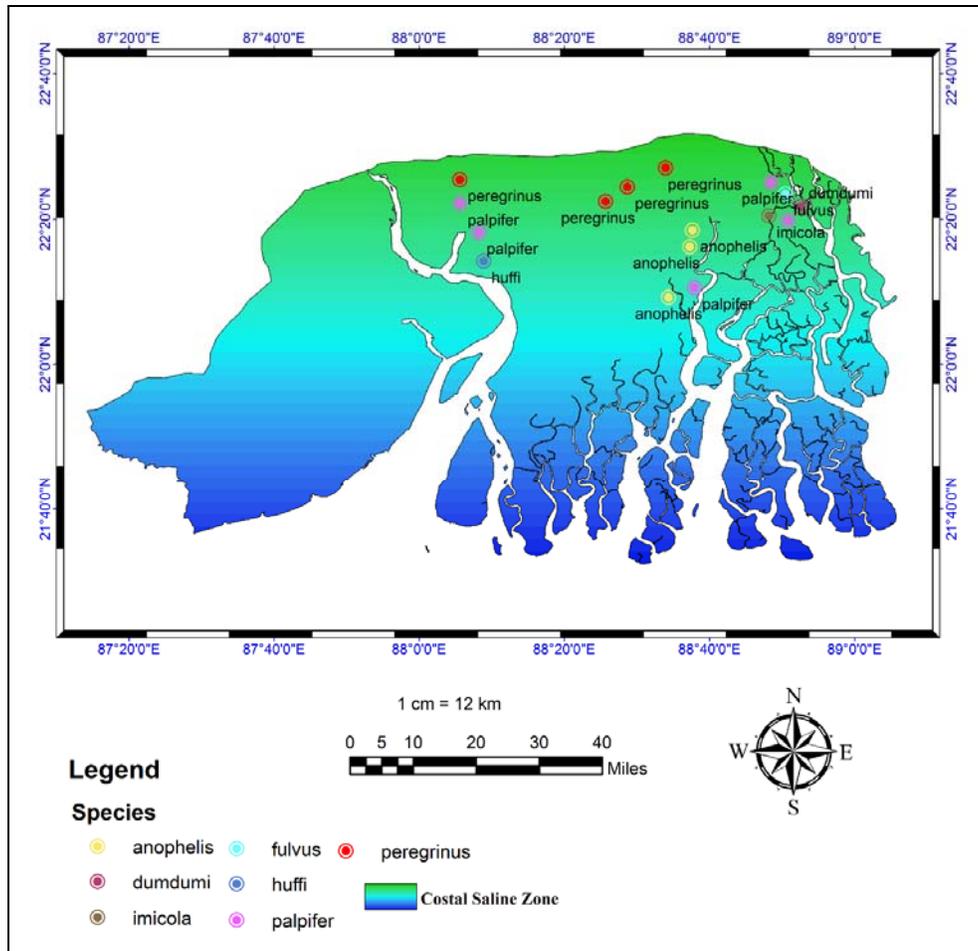


Fig 1: Distribution map showing seven species of genus *Culicoides* from coastal saline region of West Bengal

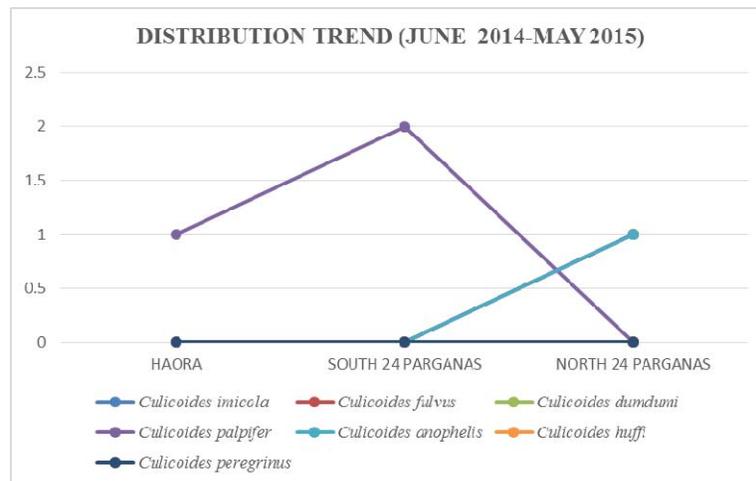


Fig 2: Distribution trend analysis of *Culicoides* midges from June 2014 to May 2015.

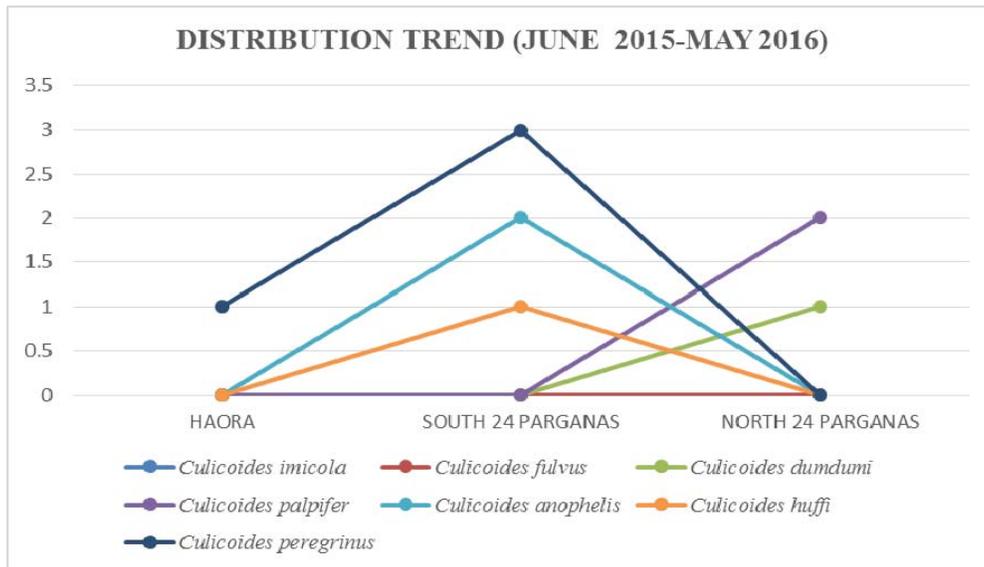


Fig 3: Distribution trend analysis of *Culicoides* midges from June 2015 to May 2016.

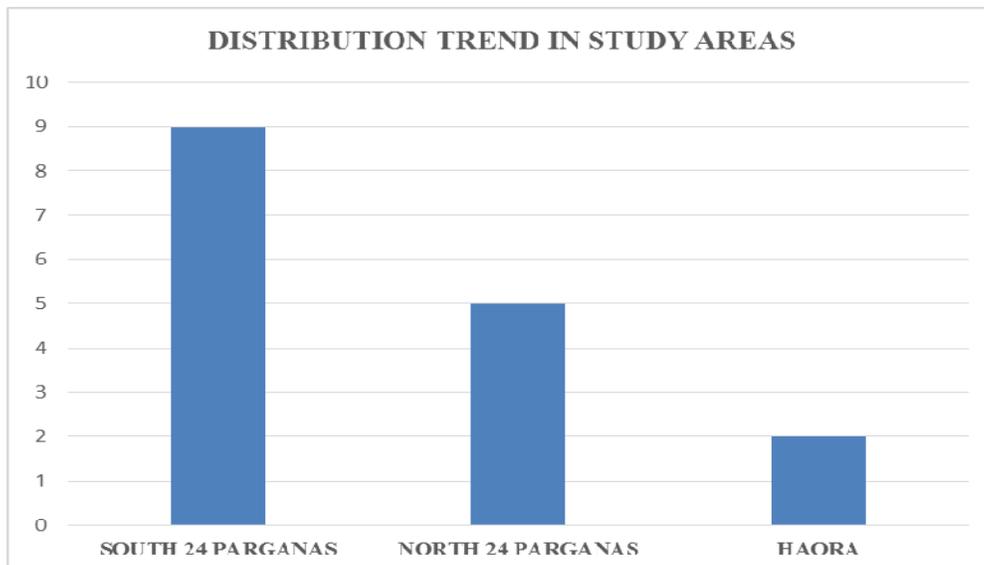


Fig 4: Distribution trend analysis showing total sampling records in three study areas.

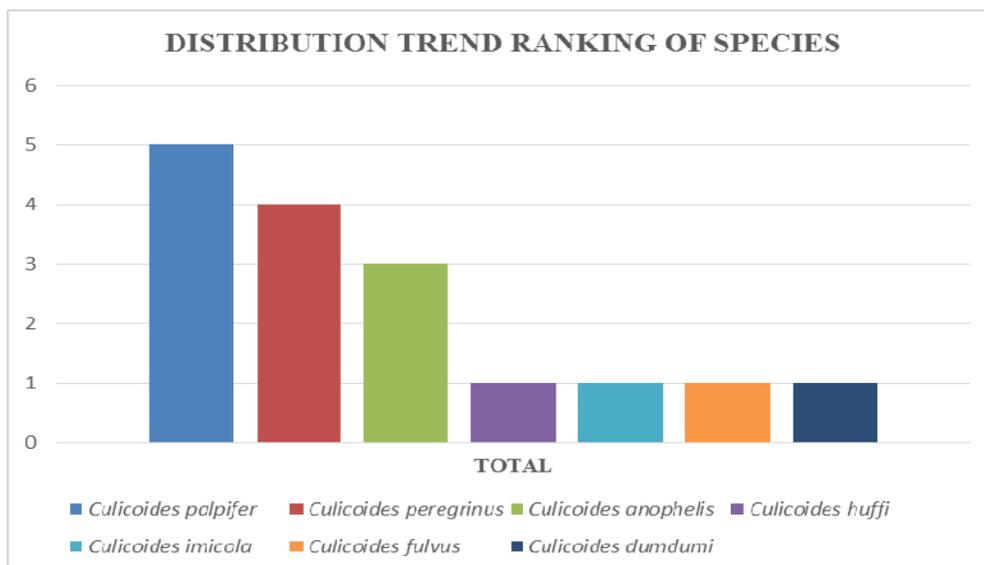


Fig 5: Distribution trend ranking of species based on total sampling records.

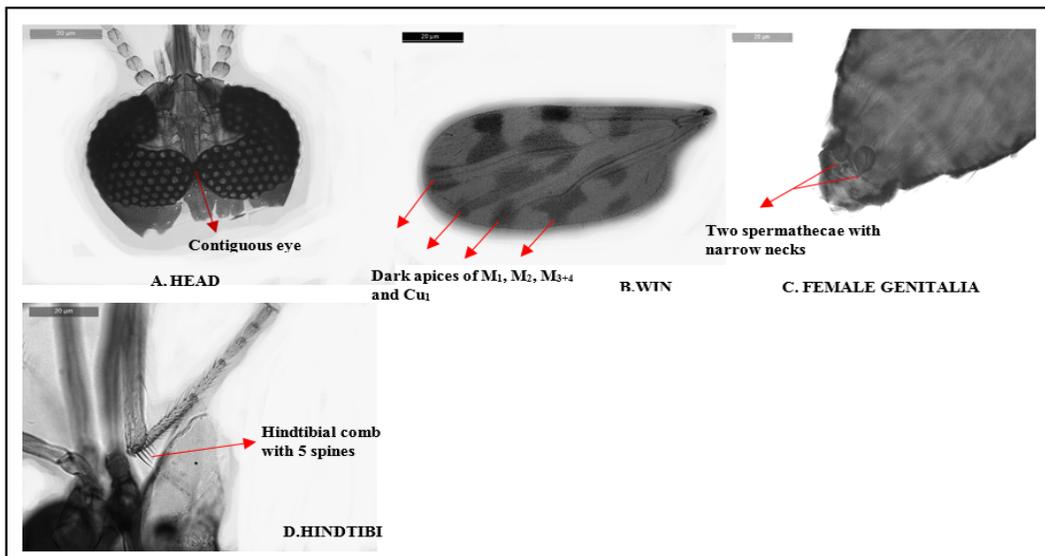


Plate 1: Subgenus *Avaritia* Fox,

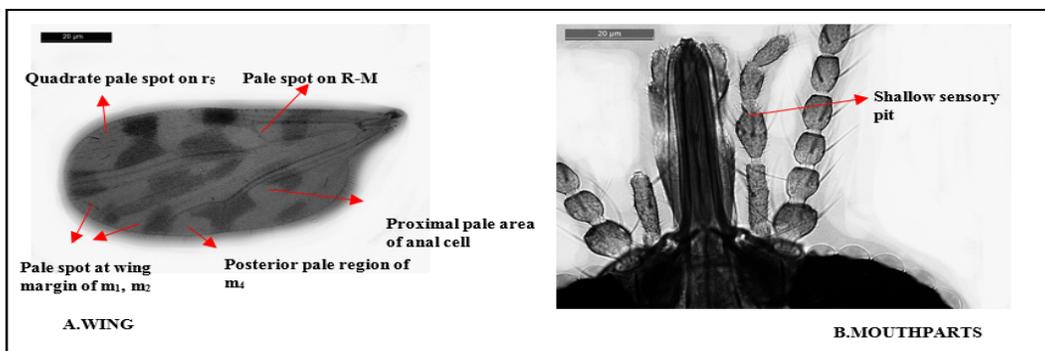


Plate 2: *Culicoides imicola* Kieffer, 1913

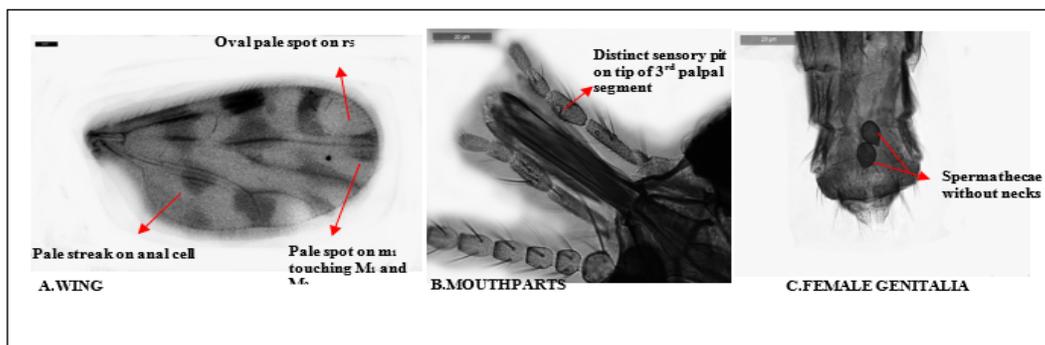


Plate 3: *Culicoides fulvus* Sen and Das Gupta, 1959

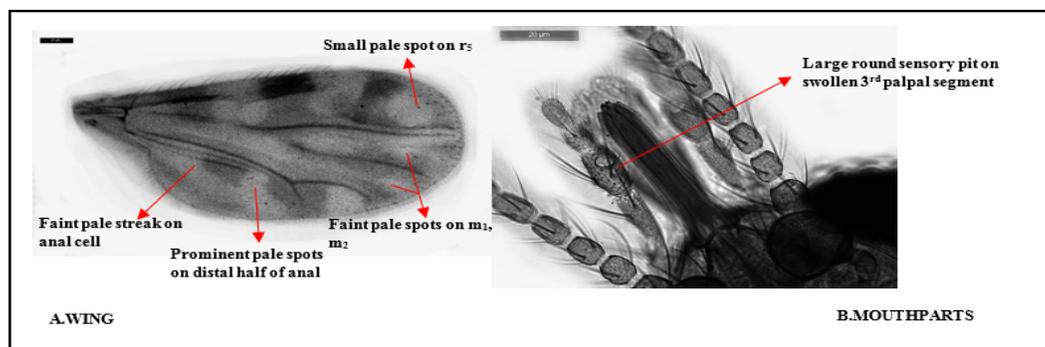


Plate 4: *Culicoides dumdumi* Sen and Das Gupta, 1959

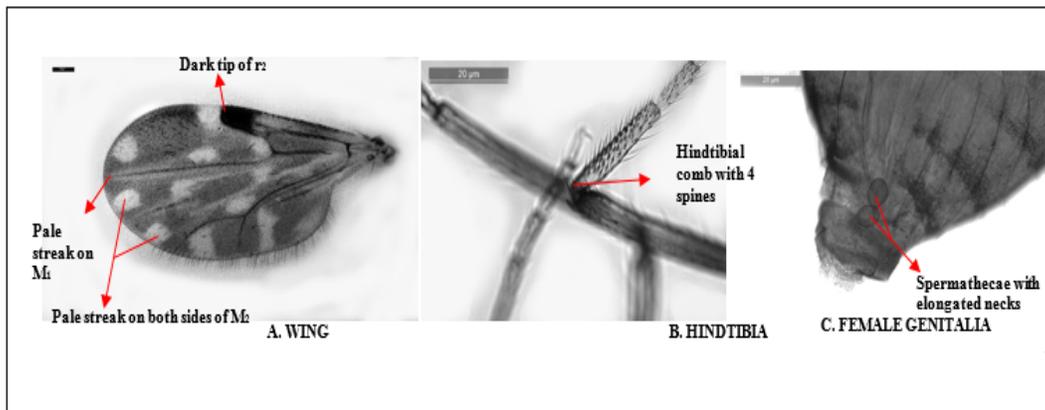


Plate 5: Subgenus *Diphomyia* Vargas, 1960

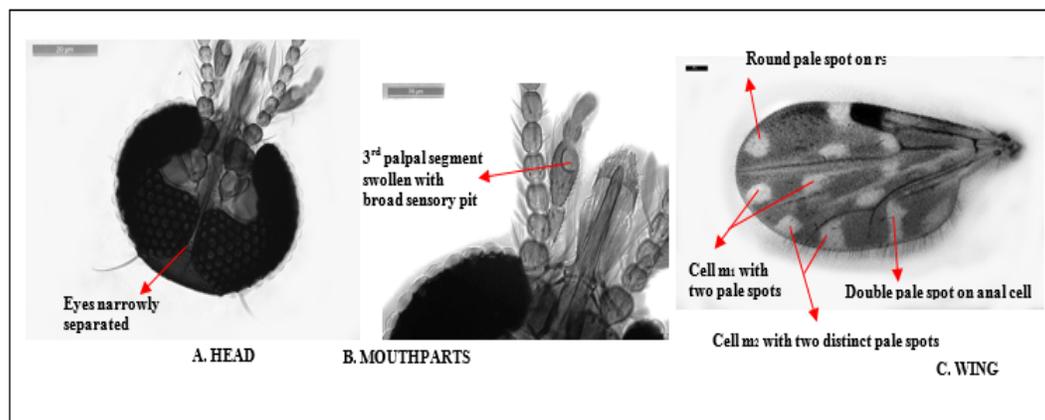


Plate 6: *Culicoides huffi* Causey, 1938

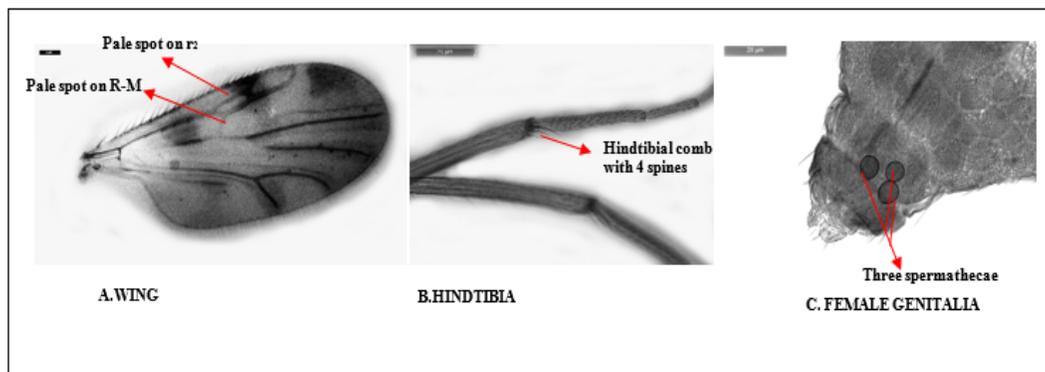


Plate 7: Subgenus *Trithecooides* Wirth and Hubert, 1959

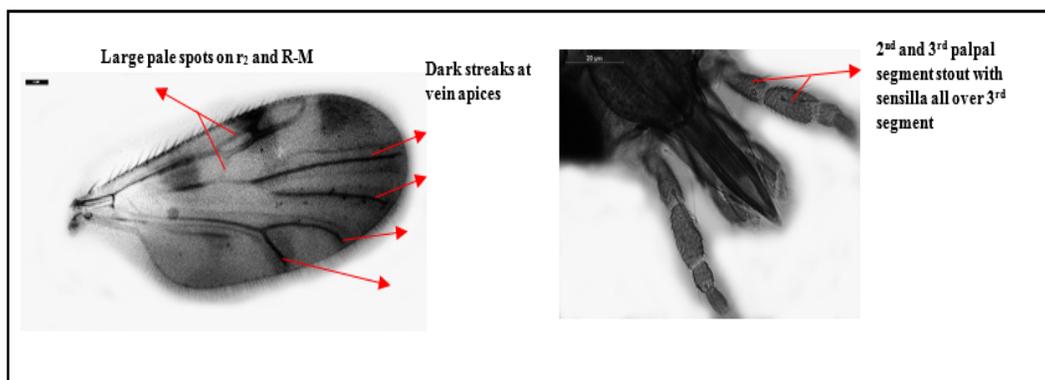


Plate 8: *Culicoides anophelis* Edwards, 1922

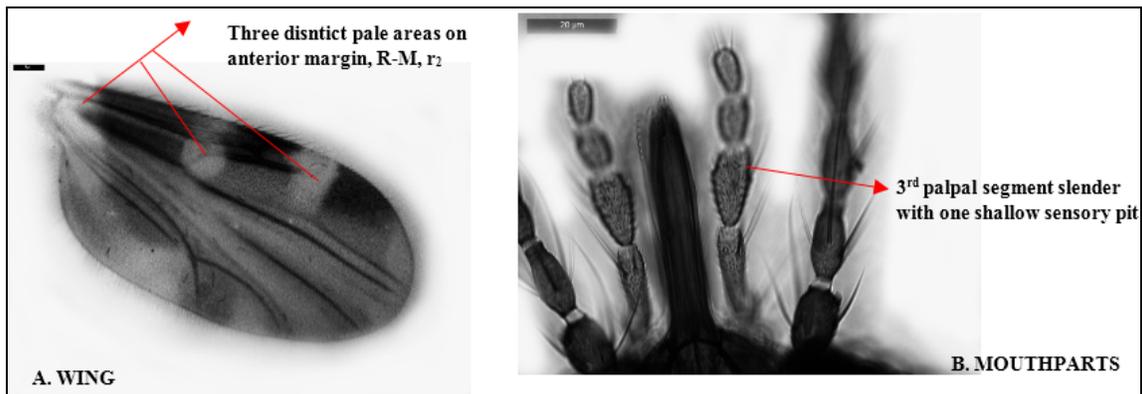


Plate 9: *Culicoides palpifer* Das Gupta and Ghosh, 1956

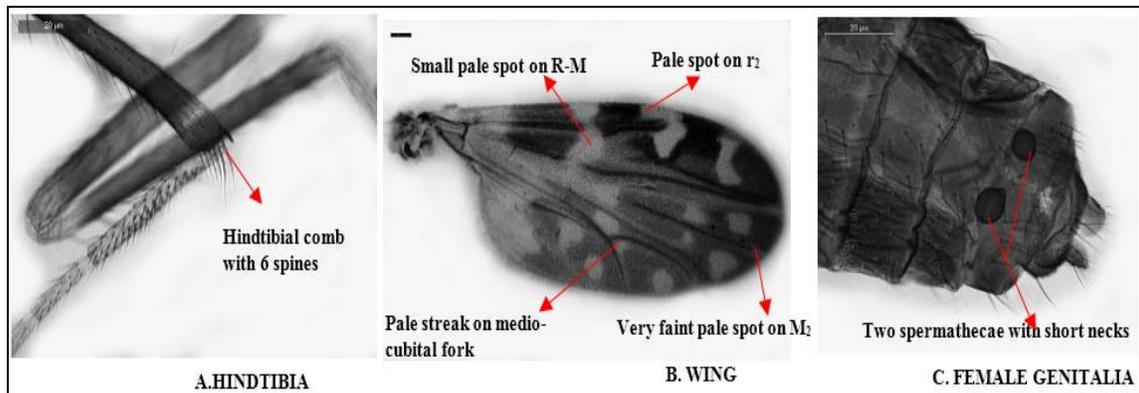


Plate 10: Subgenus *Hoffmania* Fox, 1948

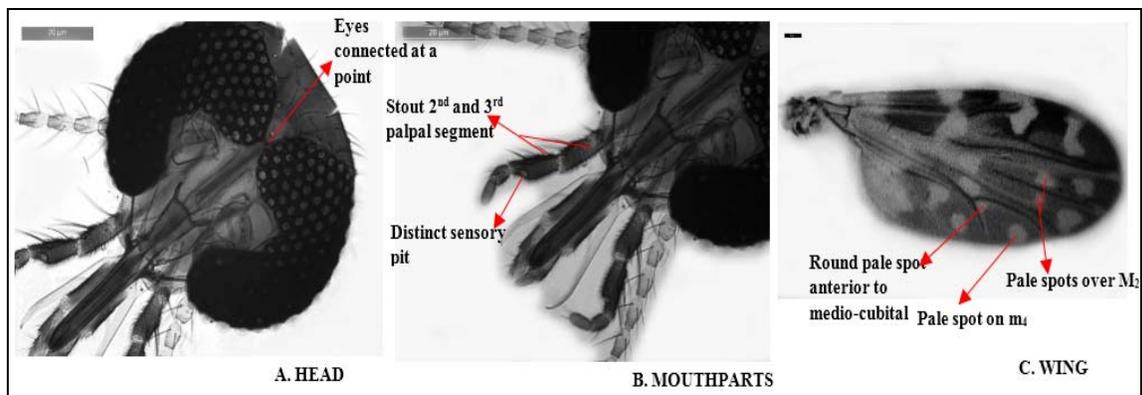


Plate 11: *Culicoides peregrinus* Kieffer, 1910

### 5. Conclusion

The current study provides a short illustration on the taxonomic importance of *C. imicola*, *C. fulvus*, *C. dumudmi*, *C. huffi*, *C. anophelis*, *C. palpifer* and *C. peregrinus* from the coastal saline districts of Haora, South 24 Parganas and North 24 Parganas in West Bengal. After analyzing the trend of distribution pattern, it is found that cattle sheds in areas with moderate temperature and rainfall, muddy landscapes rich in organic matter near coastal river basins favor dispersal of *Culicoides* midges. However, a high percentage of the area being pastoral with large number of cattle farms having poor sanitization, lack of literacy on livestock management and much more which still needs to be explored. In future, the study can be expanded to other unexplored districts which cover coastal saline areas of West Bengal and also in similar regions of other Indian states, which would help to develop a

comparative account on taxonomy, ecology and development of this insect. Further, these kind of studies would provide proper identification manuals, report on recent disease occurrences vectored by biting midges, spread alerts and training of farmers and villagers on cattle management and undergo preventive measures to conserve livestock in various rural and urban areas of West Bengal and India.

### 6. Acknowledgement

The authors are thankful to Dr. Kailash Chandra, Director, Zoological Survey of India, Kolkata and Mr. K.C. Gopi, Additional Director and Divisional-in-charge, Entomology for their supervision and providing necessary facilities for this study. Further, we express our deepest thanks to all the companions of the Diptera Section for sharing their knowledge and constant support.

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