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PENSOFT

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Descriptions of two new species of *Culicoides* Latreille from Sundarbans, India with an adult key to the *ornatus* species group of the Oriental region (Diptera, Ceratopogonidae)

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Abstract

Two new species of biting midges, *Culicoides cornatus* **sp. nov.** and *Culicoides pileus* **sp. nov.** are described based on adults. The new species are compared to their congeners with close similarity. All specimens were collected from the Indian Sundarban Mangrove Forests, few specimens were mounted in glass slides and few were prepared for SEM study. Total 78 species under the genus *Culicoides* Latreille including the two new ones (6 species from *ornatus* species group) are described from India. An adult key of the *ornatus* species group from the Oriental Region is provided.

Key Words

Adult Key, India, New species, *ornatus* group, Sundarbans, Taxonomy

Introduction

Culicoides Latreille, 1809 is one of the most species rich genera of the family Ceratopogonidae with approximately 1368 valid species, 32 subgenera, 38 species groups, and 176 unplaced species described worldwide (Borkent and Dominiak 2020); so far 76 species have been reported from India (Chatterjee et al. 2020). Most female members of this genus are haematophagous and many species act as important vectors of pathogenic viruses, protozoans and filarial nematodes (Mellor et al. 2000; Borkent 2005). These midges are of great concern because they transmit bluetongue (BT), Akabane and other viruses that cause disease in sheep, cattle and wild ruminants (Kettle 1977; Linley et al. 1983). The outbreak of the BT disease in Tamil Nadu (India) and its occurrence in many parts of India over the last few decades has affected millions of sheep and goats and other livestock (Ilango 2006). Immature stages of this genus can be found in a variety of aquatic or semi aquatic habitats, including tree holes, ponds, marshes, streams, various muddy and saturated organic materials, damp or rotting vegetation, and manure (Kettle and Lawson 1952; Jamnback 1965; Borkent 2014; Shults and Borkent 2018).

The *ornatus* species group of this genus comprises of 33 species worldwide (Nandi et al. 2013; Borkent and Dominiak 2020) including 27 reported from the Oriental region (Table 1). Before this study, four species of the *ornatus* group have been reported from India: *C. peliliouensis* Tokunaga in Tokunaga and Esaki 1936, *C. aequalispinus* Nandi, Mazumdar & Das Gupta, 2013, *C. fuscitibialis* Nandi, Mazumdar & Das Gupta, 2013, and *C. pateli* Nandi, Mazumdar & Das Gupta, 2013. Members of the *ornatus* group can be recognised by the following characteristics: Eyes usually bare, seldom hairy; contiguous to moderately separated; hind tibial comb with 4 (rarely 5) tibial spines, the one nearest the spur longest; wing with second radial cell usually dark to tip but pale distally in some species; presence of two large sclerotised spermathecae with a vestigial one, sclerotised ring present or absent; male genitalia with well developed apicolateral processes, aedeagus usually with low basal arch and long, tapering, rather blunt distal process; parameres usually fused at bases, the

Table 1. Distribution of the species of *ornatus* group of the genus *Culicoides* Latreille reported from the Oriental region.

Sl. No.	Name of the species	Distribution
1.	*C. aequalispinus* Nandi, Mazumdar & Das Gupta, 2013	India
2.	*C. circumbasalis* Tokunaga, 1959	Indonesia, Malaysia, Papua New Guinea, Philippines, Thailand
3.	*C. cordiger* Macfie, 1934	Australia, Papua New Guinea, Malaysia, Philippines
4.	*C. corti* Causey, 1938	Malaysia, Thailand, Vietnam
5.	*C. damnosus* Delfinado, 1961	Indonesia, Malaysia, Philippines
6.	*C. flumineus* Macfie, 1937	Indonesia, Malaysia, Philippines
7.	*C. fuscitibialis* Nandi, Mazumdar & Das Gupta, 2013	India
8.	*C. garciai* Wirth & Hubert, 1989	Malaysia
9.	*C. griffithi* Wirth & Hubert, 1989	Laos, Thailand
10.	*C. hewitti* Causey, 1938	Malaysia, Philippines, Thailand, Vietnam
11.	*C. hollandiensis* Tokunaga, 1959	Indonesia
12.	*C. infulatus* Delfinado, 1916	Indonesia, Philippines
13.	*C. cornatus* sp. nov.	India
14.	*C. maai* Wirth & Hubert, 1989	Malaysia
15.	*C. mcdowelli* Delfinado, 1961	Indonesia, Philippines
16.	*C. niphanae* Wirth & Hubert, 1989	Thailand
17.	*C. okinawensis* Arnaud, 1956	Indonesia, Japan, Laos, Taiwan, Thailand, Vietnam
18.	*C. palawanensis* Delfinado, 1961	Indonesia, Malaysia, Philippines
19.	*C. pampangensis* Delfinado, 1961	Indonesia, Malaysia, Philippines, Sri Lanka, Thailand
20.	*C. pangkorensis* Wirth & Hubert, 1989	Indonesia, Malaysia
21.	*C. papuensis* Tokunaga, 1962	Brunei, Indonesia, Papua New Guinea, Philippines
22.	*C. pateli* Nandi, Mazumdar & Das Gupta, 2013	India
23.	*C. peliliouensis* Tokunaga, in Tokunaga and Esaki 1936	Kiribati, Indonesia, Malaysia, Philippines, Thailand, Vietnam, India
24.	*C. pileus* sp. nov.	India
25.	*C. pongsomiensis* Chu, 1986	Cambodia
26.	*C. ornatus* Taylor, 1913	Australia, Papua New Guinea, Indonesia, Malaysia, Singapore
27.	*C. quatei* Wirth & Hubert, 1989	Indonesia, Malaysia

basal portion of each directed laterad with well developed anterior process, the distal portion usually straight, simple and slender with simple pointed tip.

In this paper we describe two new species of the genus *Culicoides* Latreille belonging to the *ornatus* species group from the Indian Sundarban Deltaic region and provide a key to the adults of the species of the *ornatus* group of the Oriental Region.

Materials and methods

Adults of both sexes of *Culicoides pileus* sp. nov. and *C. cornatus* sp. nov. were caught using ultraviolet light trap with an 8W UV light operated besides the cow shed adjoining to mangrove forest area in Sundarbans (Fig. 1A–C). The adults were preserved in 70% ethanol. The insects were mounted on glass slides following Wirth and Marston (1968).

Morphology and terminology of adults follow Brown et al. (2009). The wing venation is after Szadziewski (1996). Measurements are in micrometres (µm), except length and width of wing, which are in millimetres (mm). All measurements are presented as ranges when sample size was more than one, with the mean value in parentheses. The illustrations were made using a compound microscope (Wild Leitz GMBH, Portugal) in combination with an attached camera lucida. The photographs were taken both with a trinocular compound microscope (Wild Leitz GMBH) and a Stereo zoom trinocular microscope (Olympus, model SZX16, Japan). For Scanning Electron Microscopy a Carl Zeiss Sigma 300 FESEM instrument was used.

Type specimens are now in the Entomological collections of the Department of Zoology, University of Burdwan (India) and will be deposited to the National Zoological Collections (NZCI), Kolkata (India) in due course.

Abbreviations of morphological terms used in the text and/or figures: **Adult. AR** – antennal ratio; **SCh** – sensilla chaetica; **SCo** – sensilla coeloconica; **P/H** – proboscis to head ratio; **PR** – palpal ratio; **CR** – costal ratio; **WL** – wing length; **WW** – wing width; **TRn** – tarsal ratio; **BUENTD** – Burdwan University Entomology Division; **NZCI** – National Zoological Collections of India.

Taxonomy

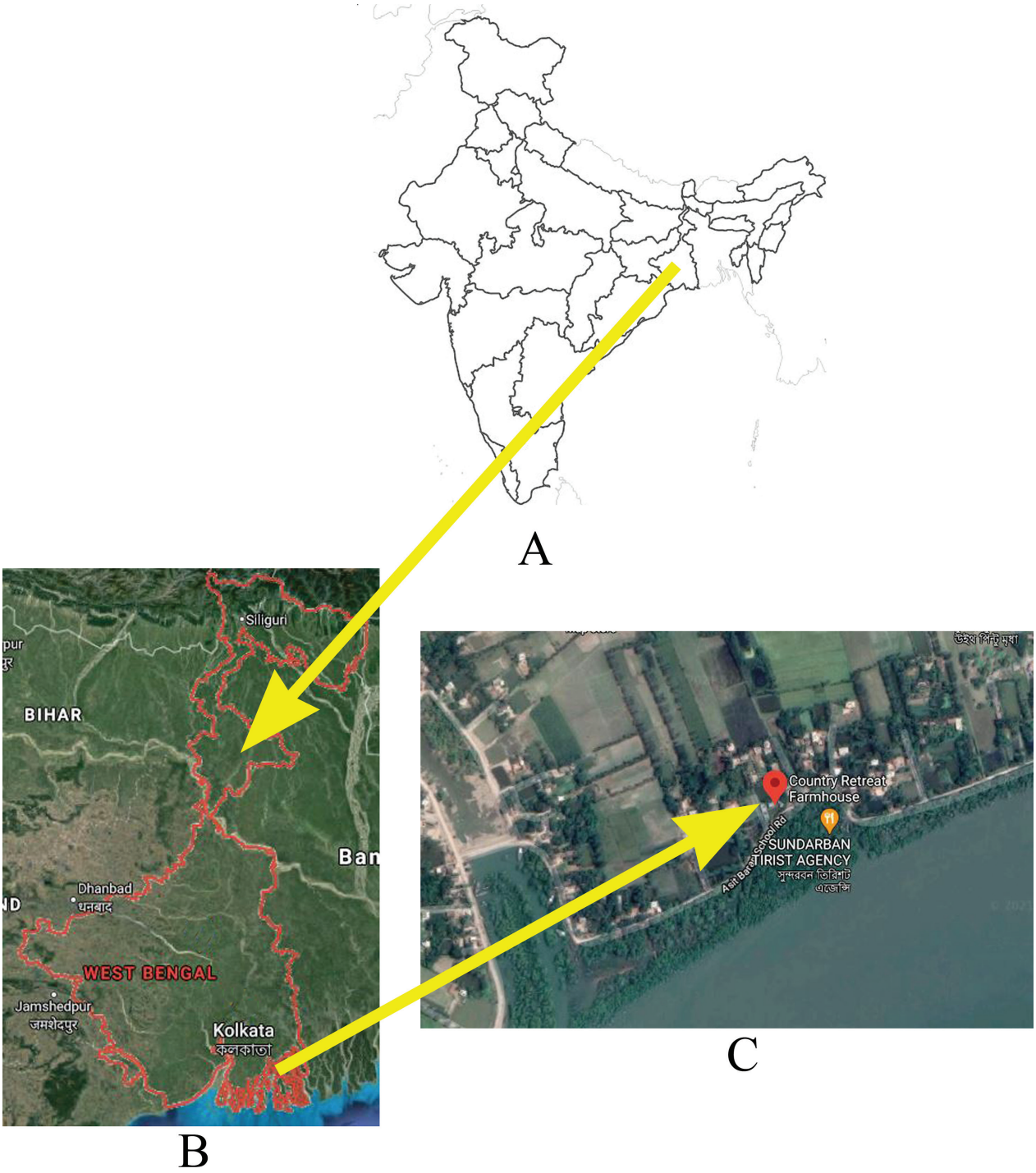
Genus *Culicoides* Latreille, 1809
Subgenus unplaced, *ornatus* species group

Culicoides cornatus sp. nov.

https://zoobank.org/80804421-42DA-46AB-A5BE-F047EF11BFB6

Figs 2A–H, 3A–E

Type material. *Holotype*: male, labelled as 'Holotype *Culicoides cornatus* Chatterjee, Pal and Hazra, India, West Bengal, South 24 Parganas, Balibazar [22°08'88"N,

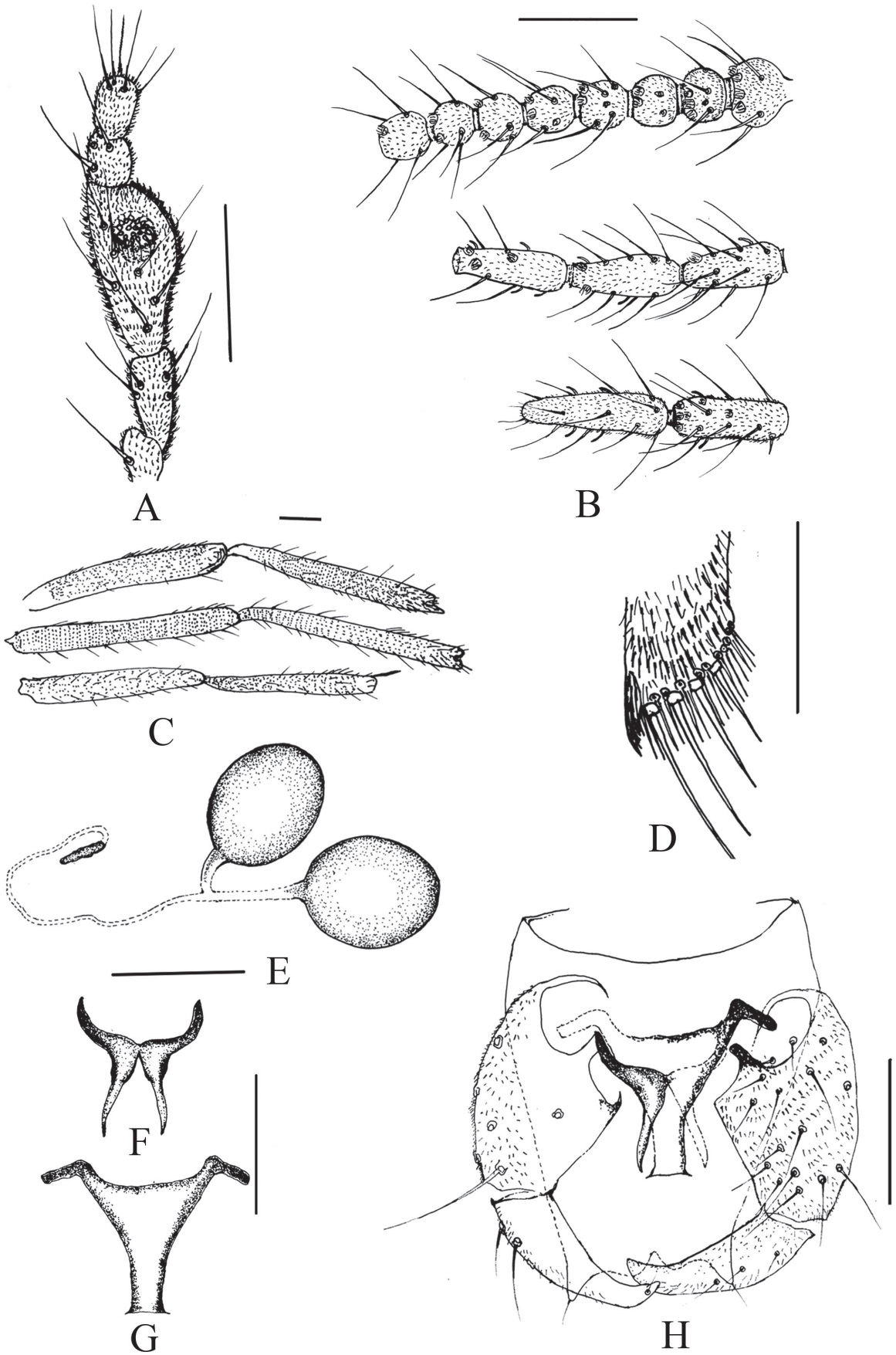


Figures 1. A–C. Collection site. **A**. Outline map of India; **B.** Google map of West Bengal (Source: maps.google.com); **C.** Collection site of *Culicoides cornatus* sp. nov. and *C. pileus* sp. nov.

88°75'72"E], 16.04.2019, Coll. S. Chatterjee' (NZCI). ***Paratypes*:** 1 male and 3 females, data as holotype (BUENTD).

Diagnosis. Eyes with interfacetal hair, wing with inconspicuous pale marking, pale spot on cell r_3 occupying greater than half of the entire cell, tips of veins pale; horn shaped appearance of anterior portion of parameres.

Description. Female (n = 3). ***Head.*** Brown, eyes with interfacetal hair (Fig. 3C), separated by distance of 1–2 ommatidia; frontovertex with 29–31 SCh; antenna pale; length ratio of antennal segments (I–XIII): 21–22 (21.5): 10: 10–11 (10.5): 9–10 (9.5): 10: 9–10 (9.5): 9: 10: 20: 24–25 (24.5): 24–25 (24.5): 25: 31–33 (32); AR 1.40–1.39 (1.395); SCo (Fig. 2B) present on antennal segments I–XII; only absent in segment XIII; maxillary palpus (Figs 2A, 3D) pale, hairy; length ratio of palpal segments (I–V): 10: 19: 28: 9: 10; PR 2.15. Palpal segment III moderately swollen with subapically round, shallow sensory pit with numerous capitate sensilla restricted in sensory pit; SCh numbers in palpal segments (I–V): 1: 4: 6: 3: 6. Mandible with 17 teeth. P/H 0.58.



Figures 2. A–H. Adult male and female of *Culicoides cornatus* sp. nov. **A.** Female maxillary palp; **B.** Female antenna; **C.** Female legs (femur and tibia); **D,** Female hind tibial comb; **E.** Female spermatheca; **F.** Paramere of male genitalia; **G.** Aedeagus of male genitalia; **H.** Male genitalia. Scale bar: 0.05 mm.

Thorax (Fig. 3B). Brown in colour.

Wing (Fig. 3A). Wing with inconspicuous pale marking; costa moderately long; cell r_2 moderately broad with distinct lumen; macrotrichia sparse; wing length 0.90–0.92 (0.91) mm, width 0.44–0.46 (0.45) mm; CR 0.68–0.69 (0.685); second radial cell entirely in dark region; pale spot over r-m cross vein moderately large, extending from vein M_1 to costal margin; post stigmatic pale spot obliquely placed with slight medial constriction; cell r_3 with distal large pale spot occupying greater than half of cell r_3 and broadly touching wing margin; cell M_1 with two pale spots, distal one touching wing margin; anal cell with one medially constricted distal pale spot, proximal one extended to pale spot at arculus, ends of veins pale at wing margin.

Leg (Fig. 2C). Brown in colour. Fore femora and tibia dark throughout with proximal small pale region, mid tibia and femora dark throughout; hind femora moderately dark all over and hind tibia with distal pale region; hind tibial comb (Figs 2D, 3E) with 4 spines, one nearest to spur longest, spur tip frayed.

***Abdomen*.** Brown; two large, subequal, roughly rounded functional spermathecae with sclerotised necks, measuring one 55.20–57.50 (55.35) µm by 46.00–48.30 (47.00) µm, another one 52.90–55.20 (54.05) µm by 41.40–43.70 (42.55) µm; both with slender, moderately long neck, rudimentary third one and faintly sclerotised ring present (Fig. 2E).

Male (n = 1). Same as female with the usual sexual differences.

***Head*.** Brown. Eyes with interfacetal hair, separated by distance of 2 ommatidia; frontovertex with 28 SCh; palpus pale, palpal segment III moderately swollen with apical shallow sensory pit; PR 2.5.

***Thorax*.** Dark brown.

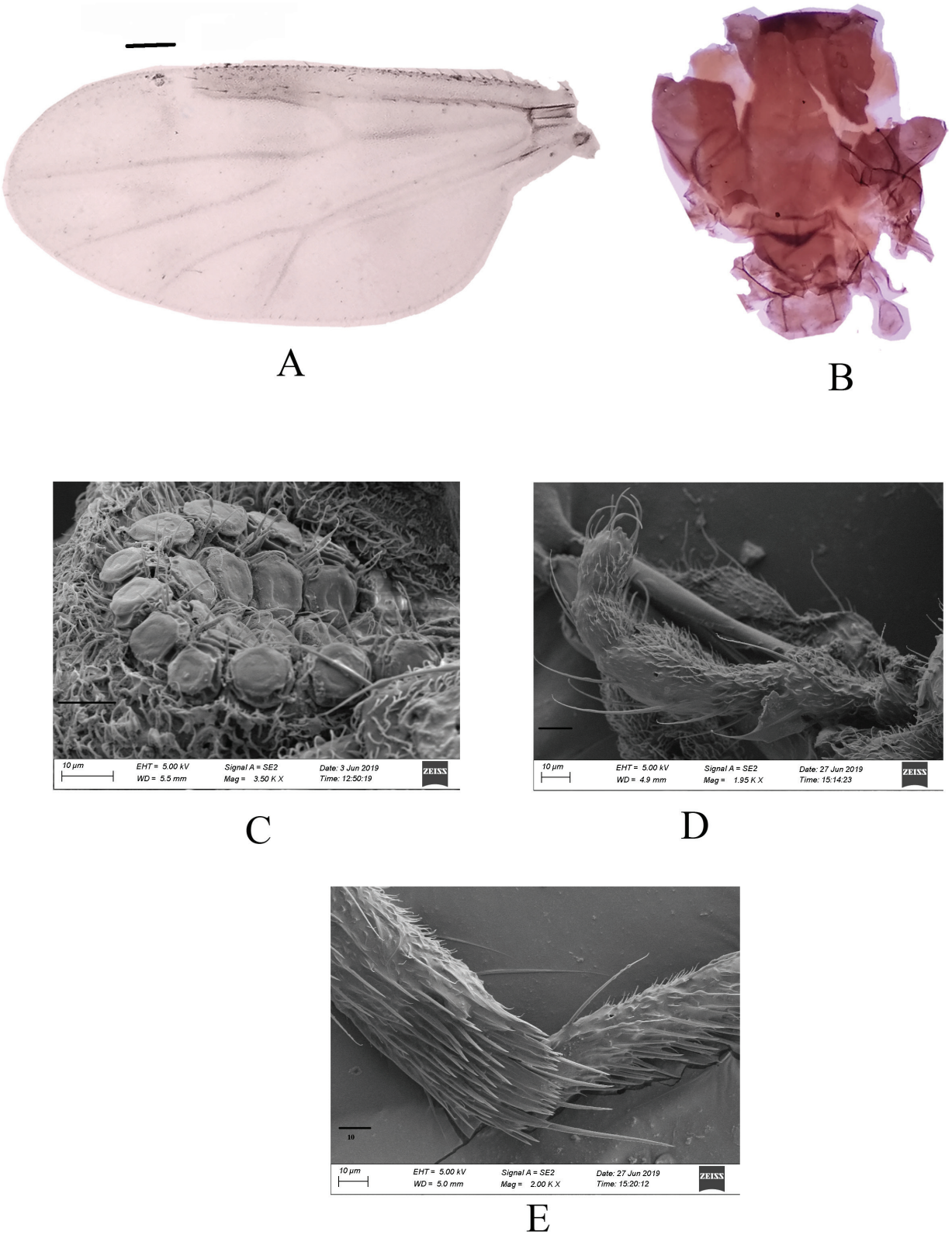
***Wing*.** Similar with female except morphometric characters. Distribution of macrotrichia in cells; wing length 0.89 mm, width 0.34 mm.

***Leg*.** Brown in colour, all legs uniformly dark without any pale region; hind tibial comb with 4 spines and nearest to spur longest, spur tip frayed.

***Abdomen*.** Ninth sternum with shallow caudomedial excavation; ventral membrane not speculated; ninth tergum with lateral margin more or less straight.

Genitalia (Fig. 2H). Apicolateral process well developed, moderately elongated, broadly separated caudal margin between them rounded with deep mesal notch; gonocoxite (Fig. 2H) 80.5 µm long, 52.9 µm wide at base, 27.6 µm wide at apex with ventral root poorly developed while dorsal root well developed. Gonostylus (Fig. 2H) 62.1 µm long; 18.4 µm wide at base, 4.6 µm wide at apex, slightly curved, narrowed distally. Aedeagus (Fig. 2G) 62.10 µm long with basal arch low; basal arm short and stout, directed posterolaterad; distal stem stout, tapering distally to blunt, truncated tip; parameres (Fig. 2F) 52.9 µm long, fused very short distance at base anteriorly, basal arm directed anterolaterad with well developed anterior process, anterolateral arm horn shaped, stem tapering near base, simple, filamentous, pointed distally.

Remarks. New species shows similarities with *C. aequalispinus* and *C. fuscitibialis* but differs from the former in wing pattern and spine structure of hind tibial comb (second nearest the spur longer in *C. aequalispinus*). *Culicoides fuscitibialis* differs from the new species in disposition of some pale spots of wing and structure of third palpal segment. New species shows similarities with *C. circumbasalis* Tokunaga, 1959 and *C. cordiger* Macfie, 1934 in wing pattern but differs in many attributes such as eyes with interfacetal hair and pale spots on wing inconspicuous in *Culicoides cornatus* sp. nov. *Culicoides cornatus* shows similarities with *C. cordiger* Macfie, 1934 in wing pattern but differs in attributes like eyes (eyes with interfacetal hair in new species but eyes are bare in *C. cordiger*), antennal ratio, mandibular teeth number and distribution of SCo on antennal segments. The new species shows similarities with *C. corti* Causey, 1938 in some characters like eyes with interfacetal hair, disposition of some pale spots on wing but differs in characters like palpal ratio, distribution of SCo, and on antennal segments (SCo are present on I–XII in *C. cornatus* but SCo on I and XI–XIII in *C. corti*), P/H ratio, shape of the aedeagus and paramere. Distribution of SCo on antennal segments of *Culicoides cornatus* are similar with *C. damnosus* Delfinado, 1961 and *C. flumineus* Macfie, 1937 but differs in characters like eyes with interfacetal hair, antennal ratio, mandibular teeth, and number and disposition of pale spots on wing. *Culicoides cornatus* shows similarities with *C. palawanensis* Delfinado, 1961 in SCo distribution and hairy eyes but differs in disposition of pale spots on wing, shape of the parameres and aedeagus, P/H ratio (much less in *C. cornatus*), mandibular teeth number (17 in *C. cornatus* but 11–13 in *C. palawanensis*), and antennal ratio. *Culicoides cornatus* also shares similarities with *C. papuensis* Tokunaga, 1962 in disposition of some pale spots on wing but differs in the presence of interfacetal hair on eyes in *Culicoides cornatus* (bare in *C. papuensis*), distribution of SCo on the antennal segments, mandibular teeth number, antennal ratio and the shape of parameres. *Culicoides cornatus* differs with *C. hollandiensis* Tokunaga, 1959 in pale marking of wing (inconspicuous pale marking in *C. cornatus* whereas prominent pale marking present in *C. hollandiensis*) and shape of the aedeagus (terminally rounded in *C. hollandiensis*). *Culicoides cornatus* differs from *C. pampangensis* Delfinado, 1961 in structure of paramere and pale marking of wing. *Culicoides cornatus* is different from *C. paragarciai* Dyce, 1996 in pale marking on wing (pale marking absent in *C. paragarciai*) and structure of hind tibial comb (hind tibial comb with 5 spines and 2nd from the spur is longest in *C. paragarciai* whereas 4 spines and 1st from the spur longest in *C. cornatus*). *Culicoides quaterifasciatus* Tokunaga, 1959 differs in presence of densely spread macrotrichia on wing and also some pale marking is different from *C. cornatus*.



Figures 3. A–E. Adult male and female of *Culicoides cornatus* sp. nov. **A.** Female wing (Photograph); **B.** Female thorax (Photograph); **C.** Female Eye (SEM Photograph); **D.** Female maxillary palp (SEM Photograph); **E.** Female hind tibial comb. (SEM Photograph).

Etymology. The name '*cornatus*' refers to Latinised version of cow horn shaped appearance of anterior portion of parameres.

Distribution and bionomics. The species was collected in adjacent to Indian Sundarbans Deltaic region, a world heritage site (West Bengal state). Adult midges were collected from a cowshed using an ultraviolet light trap in the type locality, situated in the vicinity of Datta River. The type locality is at an altitude of 7.50 m above sea level.

***Culicoides pileus* sp. nov.**

https://zoobank.org/CC15E87B-BDBB-404C-ADE5-60AD9063F068

Figs 4A–H, 5A–E

Type material. ***Holotype*:** male, labelled as 'Holotype *Culicoides pileus* Chatterjee, Pal and Hazra, India, West Bengal, South 24 Parganas, Balibazar [22°08'88"N, 88°75'72"E], 16.04.2019, Coll. S. Chatterjee' (NZCI). ***Paratypes*** 2 males and 5 females, data as holotype (BUENTD).

Diagnosis. Eyes bare; wing with one distal pale spot in cell r_3 separated from wing margin; cell m_1 with two pale spots, distal one away from wing margin; anal cell with one distal pale spot with slight medial constriction; SCo present on flagellomeres I–VII and IX–XII; parameres basally fused, cap shaped basal knob, mid portion wide, distally slender, abruptly bent laterad with pointed end.

Description. Female (n = 5). ***Head*.** Brown. Eyes bare (Fig. 5C), separated by distance of 1–2 ommatidia; frontovertex with 33–37 SCh; antenna pale; length ratio of antennal segments (I–XIII): 12–15 (13.50): 9–10 (9.50): 10–11 (10.5): 10–11 (10.50): 10–11 (10.5): 10: 11: 10–11 (10.50): 17–19 (18): 17–19 (18): 19–21 (20): 21–22 (21.5): 29–30 (29.50); AR 1.20–1.23 (1.21); SCo (Fig. 4B) present on antennal segments I–VII, IX–XII; maxillary palpus (Fig. 4A) pale, hairy; length ratio of palpal segments (I–V): 8–9 (8.50): 20–25 (22.5): 25–28 (26.5): 7–9 (8): 9–10 (9.50); PR 2.15–2.27 (2.21); palpal segment III moderately swollen with subapical round shallow sensory pit with 22–26 (24) capitate sensilla restricted in sensory pit; SCh numbers in palpal segments (I–V): 0: 3: 8: 2: 6. Mandible (Fig. 5E) with 16–17 teeth. P/H 0.85–0.89 (0.87).

Thorax (Fig. 5B). Brown in colour.

***Wing*.** Wing pattern as in figure 5A, costa moderately long; cell r_2 moderately broad with distinct lumen, macrotrichia sparse, arranged from middle to distal most portion of wing; wing length 0.77–0.80 (0.78) mm; width 0.38–0.42 (0.40) mm; CR 0.64–0.65 (0.645). wing spots moderately distinct, second radial cell completely in dark region; pale spot over r-m cross vein moderately large, extending from vein M_1 to costal margin; post stigmatic pale spot obliquely placed with slight medial constriction; cell r_3 with distal large pale spot away from wing margin; cell M_1 with two pale spots, distal one separated from wing margin; cell m_2 with narrow pale streak connecting pale spot at basal arculus, pale spot behind medial fork and distal pale spot; distal pale spot touching wing margin; cell cua_1 with moderately large, roughly round pale spot touching CuA_1 vein and broadly touching wing margin; anal cell with one medially constricted distal pale spot, proximal one extended to pale spot at arculus.

Leg (Fig. 4C). Brown in colour. Fore and mid femora pale throughout, fore and mid tibia with proximal pale region; hind femora moderately dark throughout and hind tibia also with proximal pale region; hind tibial comb with 4 spines, one nearest to spur longest, spur tip frayed (Figs 4D, 5D).

***Abdomen*.** Brown; two large subequal roughly rounded functional spermathecae with sclerotised necks, measuring one 46.00–50.60 (48) µm by 41.40–43.70 (42.55) µm, another one 43.70–48.30 (46.00) µm by 39.10–41.40 (40.25) µm; both with slender, moderately long neck, rudimentary third one, and faintly sclerotised ring present (Fig. 4E).

Male (n = 3). Same as female with the usual sexual differences.

***Head*.** Brown. Eyes bare, separated by distance of 1–2 ommatidia, frontovertex with 18–21 SCh. Palpus pale; palpal segment III moderately swollen with apical shallow sensory pit; PR 2.00.

***Thorax*.** Dark brown.

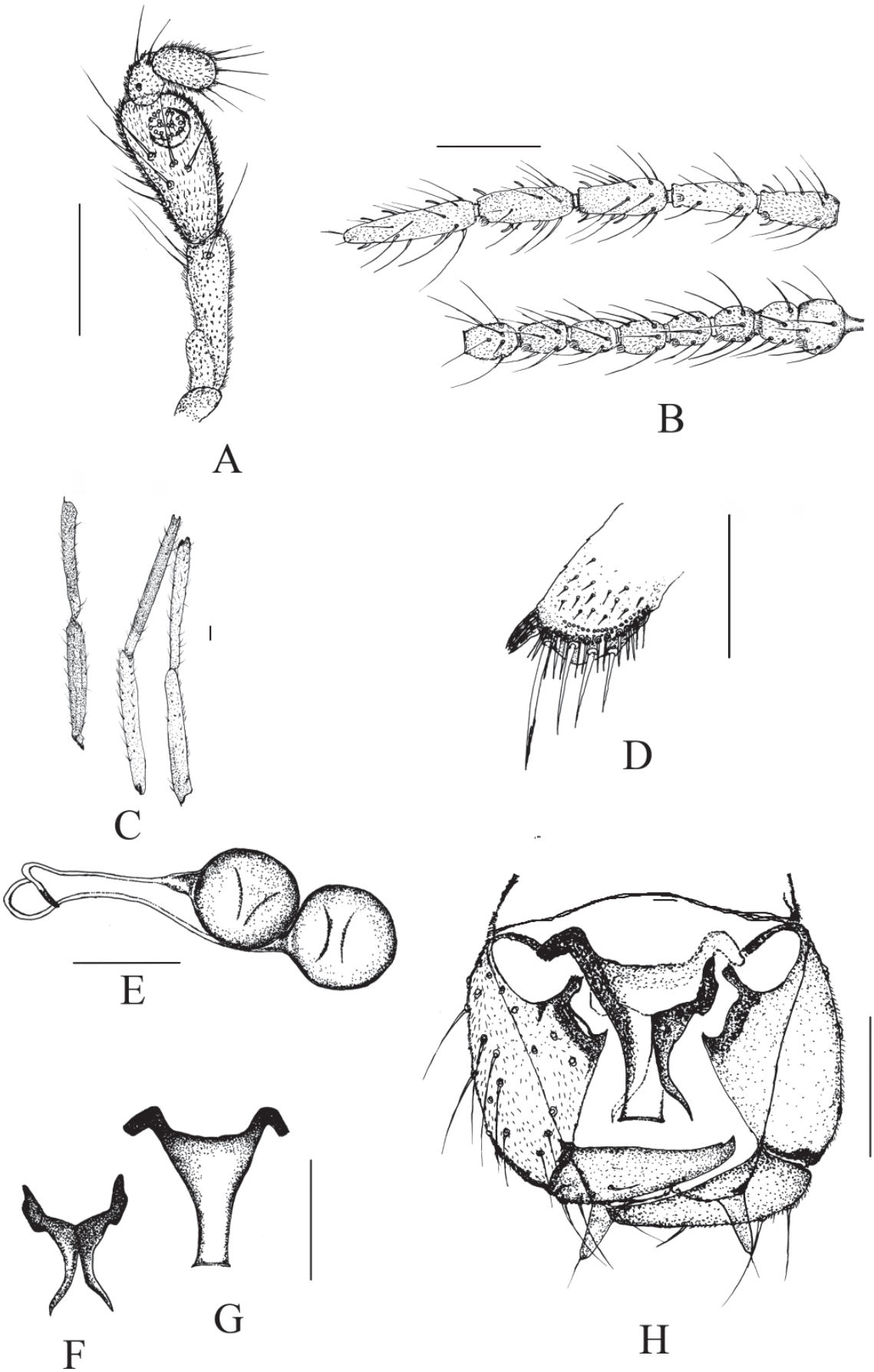
***Wing*.** Similar with female except distribution of macrotrichia in cells; macrotrichia sparse, mostly arranged on distal one third portion of wing; wing length 0.81–0.83 (0.82) mm, width 0.36–0.38 (0.37) mm.

***Leg*.** Light brown in colour, hind tibial comb with 4 spines and nearest to spur longest, spur tip frayed.

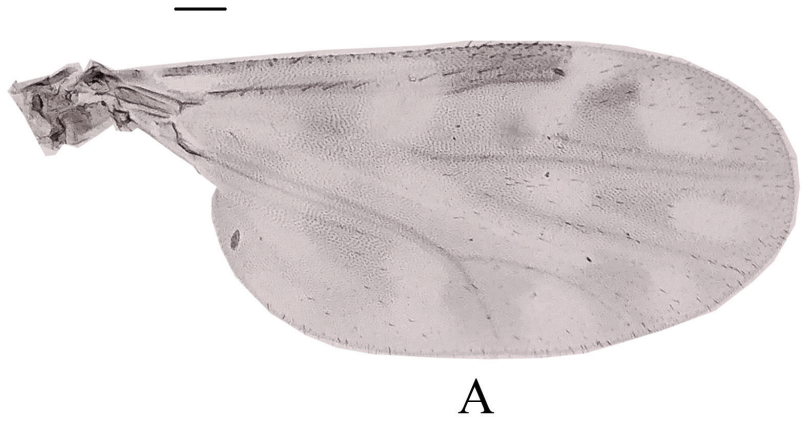
***Abdomen*.** Ninth sternum with shallow caudomedial excavation; ventral membrane not speculated; ninth tergum with lateral margin more or less straight.

Genitalia (Fig. 4H). Apicolateral process well developed, elongated, broadly separated caudal margin between them rounded with slight mesal notch; gonocoxite (Fig. 4H) 69.00–71.3 (70.15) µm long, 46.00–48.30 (47.15) µm wide at base, 25.30–27.60 (26.45) µm wide at apex with ventral root poorly developed and dorsal root well developed. Gonostylus 59.80–64.4(62.1) µm long; 16.10–18.40 (17.25) wide at base, 6.9 µm wide at apex slightly curved, narrowed distally with blunt mesally toothed tip. Aedeagus (Fig. 4G) 62.10–64.40 (63.25) µm long with basal arch low, less than one sixth of total length; basal arm short and stout, directed posterolaterad; mid portion slender to moderately broad with bluntly rounded tip. Parameres (Fig. 4F) 48.30–50.6 (49.45) µm long, fused short distance at base anteriorly, basal arm directed anterolaterad with well developed cap shaped anterior process, mid portion wide, distally slender, abruptly bent laterad with pointed end.

Remarks. New species shows similarities with *C. aequalispinus* in bare eyes and mandibular teeth number but differs in attributes like distribution of SCo on antennal segments, and presence of two equal length spines nearest to the spur in *C. aequalispinus*. The new species shares a few similarities with *C. peliliouensis* Tokunaga in Tokunaga and Esaki 1936 like bare eyes, disposition of some pale spots on wing but differs in characters like distribution of SCo on antennal segments (SCo present on I, V–VII and IX–XII in *C. peliliouensis* but in *C. pileus* sp. nov. these are on I–VII and IX–XII), pale spot on cell r_3 broadly touching the wing margin but in new species it is separated by dark region; pale spot over r-m cross vein is different in shape, post stigmatic pale spot medially constricted in *C. pileus* but not in *C. peliliouensis*. *Culicoides pileus* shows some similarities with *C. circumbasalis* Tokunaga, 1959 and *C. ornatus* Taylor, 1913



Figures 4. A–H. Adult male and female of *Culicoides pileus* sp. nov. **A.** Female maxillary palp; **B.** Female antenna; **C.** Female legs (femur and tibia); **D.** Female hind tibial comb; **E.** Female spermatheca; **F.** Paramere of male genitalia; **G.** Aedeagus of male genitalia; **H.** Male genitalia. Scale bar: 0.05 mm.



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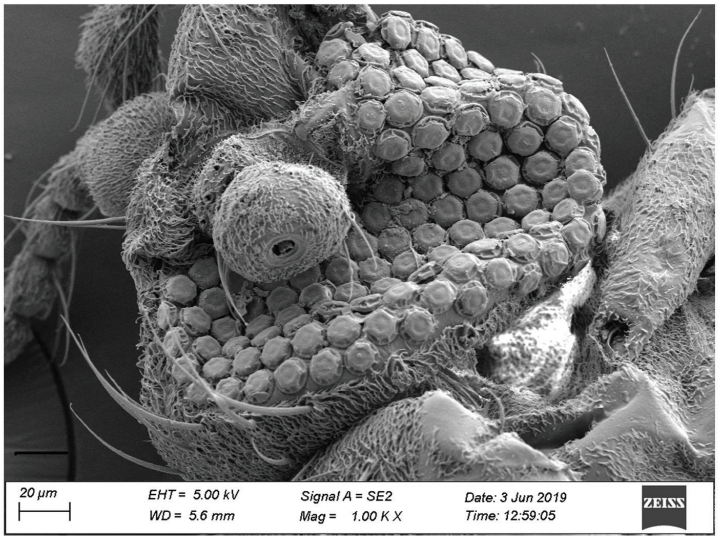
B



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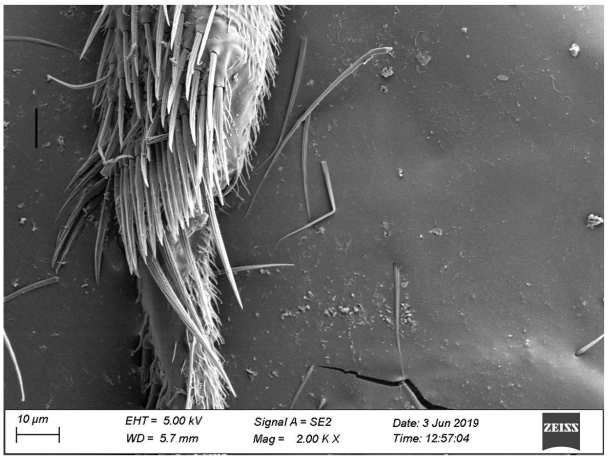

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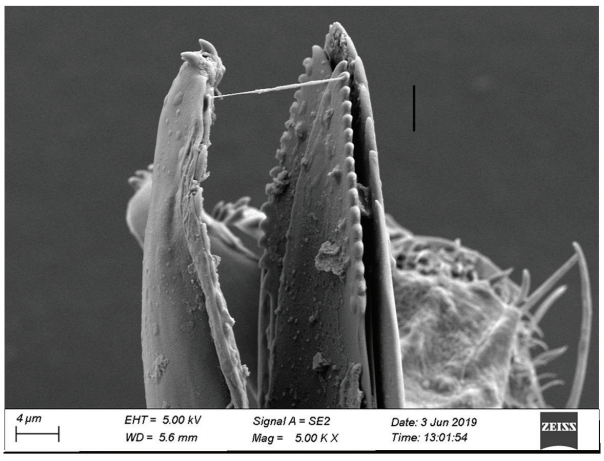


E

Figures 5. A–E. Adult male and female of *Culicoides pileus* sp. nov. **A.** Female wing (Photograph); **B.** Female thorax (Photograph); **C.** Female Eye (SEM Photograph); **D.** Female hind tibial comb (SEM Photograph); **E.** Female mandible (SEM Photograph).

but differs in characters like distal pale spot in anal cell of wing (two separate distal pale spots present in both *C. circumbasalis* and *C. ornatus* but in *C. pileus* a single pale spot present with little medially constricted), cell r_3 with three pale spots and most distal one touching the wing margin in *C. circumbasalis* but two in *C. pileus* sp. nov. and most distal one away from the wing margin. It is quite similar in some attributes with *C. cordiger* Macfie,

1934 but differs in distribution of SCo on antennal segments (SCo are present on antennal segments I–XIII in *C. cordiger*) and mandibular teeth number (7–12 in *C. cordiger* but 16–17 in *C. pileus*). *Culicoides pileus* differs from *C. damnosus* Delfinado, 1961 and *C. quatei* Wirth & Hubert, 1989 in the shape of pale spot over r-m cross vein and distribution of SCo on antennal segments. It shares similarities with *C. mcdowelli* Delfinado, 1961 but differs in the shape of pale spot over r-m cross vein, distal pale spot on cell r_3 (touching the wing margin in *C. mcdowelli*) and mandibular teeth number (11–13 in *C. mcdowelli*). It also shows some similarities with *C. hollandiensis* Tokunaga, 1959 in wing pattern but pale spot is absent at the base of CuA_1 in *C. pileus* and anal cell with two separated distal pale spots in *C. hollandiensis*. *Culicoides pileus* differs from *C. hollandiensis* in pale marking of wing (anal cell with two separate distal pale spots in *C. hollandiensis*) and shape of the aedeagus. *Culicoides pileus* differs from *C. pampangensis* Delfinado, 1961 in structure of paramere and pale marking of wing (cell r_3 with distal pale spot not prominent in *C. pampangensis* Delfinado). *Culicoides paragarciai* Dyce, 1996 differs from *C. pileus* in pale marking on wing (pale marking absent in *C. paragarciai*) and structure of hind tibial comb (hind tibial comb with 5 spines and 2nd from the spur is longest in *C. paragarciai* whereas 4 spines and 1st from the spur longest in *C. cornatus*).

Etymology. The name '*pileus*' refers to Latinised version of cap shaped basal knob of parameres.

Distribution and bionomics. The species was collected from Sundarbans Mangrove Forest in India (West Bengal state). Adult midges were collected from a cowshed using an ultraviolet light trap in the type locality situated in the vicinity of Datta River. The type locality is at an altitude of 7.50 m above sea level.

An inventory of *ornatus* group of the genus *Culicoides* Latreille from the Oriental region

Distribution of Oriental species of ornatus group has been presented in Table 1 and Fig. 6.

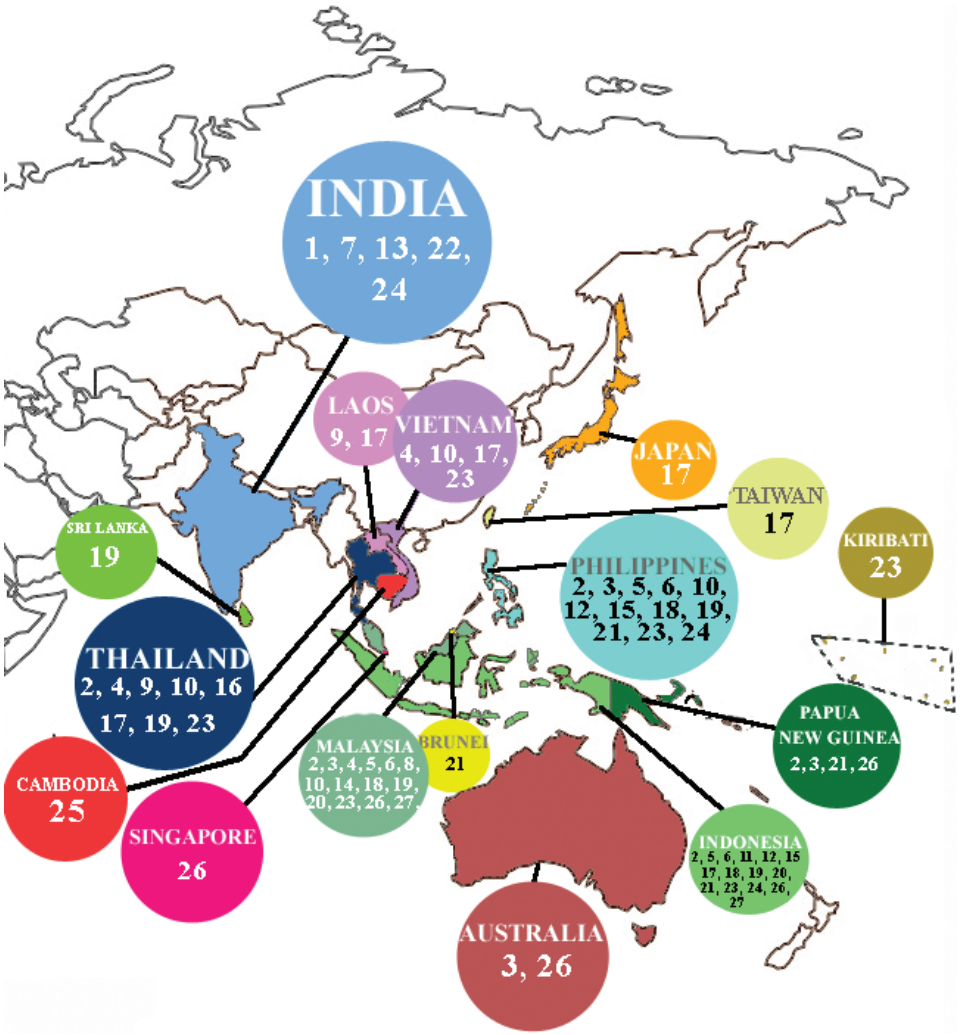
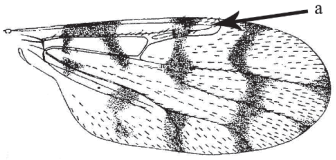


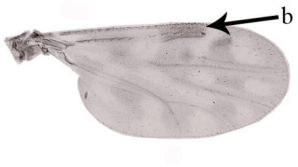
Figure 6. Distribution of the Oriental species of *ornatus* group of the genus *Culicoides* Latreille. The number(s) in the bubbles of the respective countries depicts the species (Sl. nos.) presented in Table 1.

A key to the *ornatus* group of the genus *Culicoides* Latreille from the Oriental region

1 Wing with second radial cell partially included in pale spot distally (a) ..... *C. quaterifasciatus* Tokunaga, 1959
– Wing with second radial cell almost fully included in dark spot (b) 2

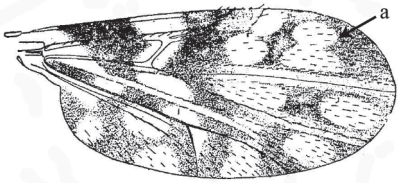


C. quaterifasciatus Source: Tokunaga, 1959



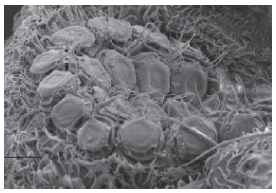
C. pileus sp. nov.

1 Distal pale spot in cell r_3 with medial constriction in wing (a) ..... *C. hollandiensis* Tokunaga, 1959
– Distal pale spot in cell r_3 without medial constriction in wing 3

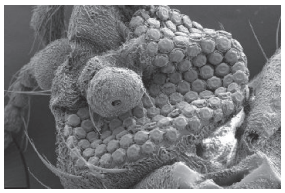


C. hollandiensis Source: Tokunaga, 1959

2 Eyes with interfacetal hair 4
– Eyes bare 7

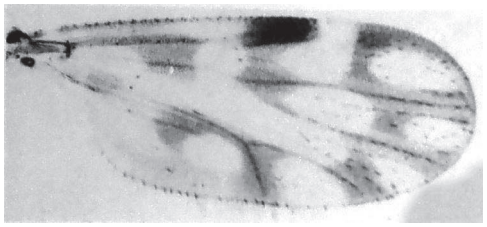


C. cornatus sp. nov.



C. pileus sp. nov.

3 Mandible with 5–6 vestigial teeth ..... *C. corti* Causey, 1938
– Mandible with 10–17 teeth 5
4 Pale spots on wing conspicuous ..... *C. griffithi* Wirth & Hubert, 1989
– Pale spots on wing inconspicuous 6



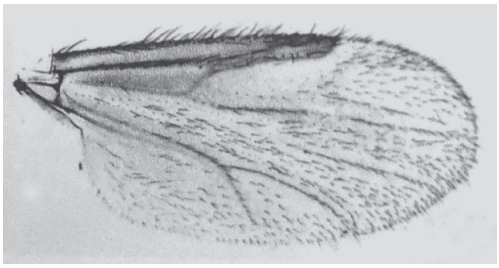
C. griffithi Source: Wirth and Hubert 1989, (American Entomological Institute (AEI))

5 Mandible with 12 teeth ..... *C. palawanensis* Delfinado, 1961
– Mandible with 17 teeth ..... *C. cornatus* sp. nov.
6 Hind tibial comb with 5 spines 8
– Hind tibial comb with 4 spines 11
7 Wing without pale marking 9
– Wing with pale and dark spots 10
8 Nearest spine from spur longest in hind tibial comb ..... *C. flumineus* Macfie, 1937
– Second nearest spine from spur longest in hind tibial comb ..... *C. paragarciai* Dyce, 1996

C. flumineus Source: Wirth and Hubert 1989, (AEI)

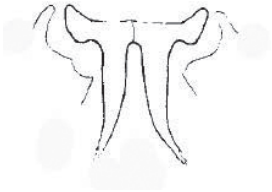
C. paragarciai Source: Dyce, 1996

9 Smaller sized species; darker legs; spermathecae smaller ..... *C. pangkorensis* Wirth & Hubert, 1989
– Large sized species; paler legs; spermathecae comparatively larger ..... *C. papuensis* Tokunaga, 1962
10 Second spine from spur of hind tibial comb longest 12
– First spine from spur of hind tibial comb longest or both first and second spines with same length..... 14
11 Wing without any pale spot.....*C. garciai* Wirth & Hubert, 1989
– Two pale spots present on wing 13



C. garciai Source: Wirth and Hubert 1989, (AEI)

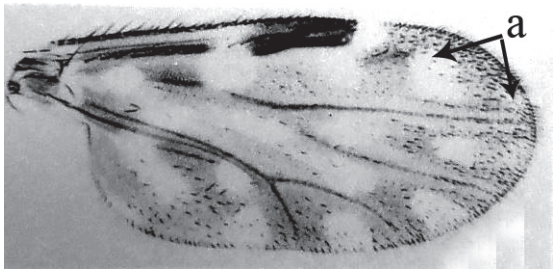
12 Parameres distally becoming hyaline and curving ventrolaterad with blunt tip ..... *C. okinawensis* Arnaud, 1956
– Parameres with filamentous distal end ..... *C. pateli* Nandi, Mazumdar & Das Gupta, 2013



C. okinawensis Source: Wirth and Hubert 1989, (AEI)

C. pateli Source: Nandi, Mazumdar & Das Gupta, 2013

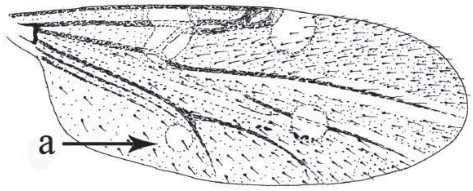
13 First and second spines from spur of hind tibial comb same in length .....
C. aequalispinus Nandi, Mazumdar & Das Gupta, 2013
– First spine from spur of hind tibial comb longest..... 15
14 SCo present on terminal antennal segment..... 16
– SCo absent on terminal antennal segment..... 17
15 Distal stem of aedeagus short and slender with a little expanded tip .....*C. cordiger* Macfie, 1934
– Distal stem comparatively long with tapering to slender tip..... *C. maai* Wirth & Hubert, 1989
16 Anal cell of wing with two separate distal pale spots..... 18
– Anal cell of wing with one distal pale spot 23
17 Distal most pale spot of cell r_3 touching wing margin..... 19
– Distal most pale spot of cell r_3 separated from wing margin..... 22
18 Cell r_3 with two distal pale spots ..... *C. circumbasalis* Tokunaga, 1959
– Cell r_3 with one distal pale spot 20



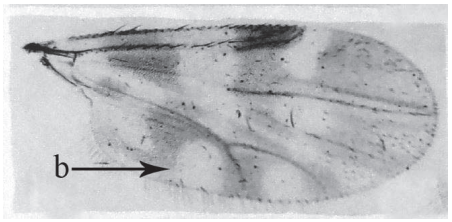
C. circumbasalis Source: Wirth and Hubert 1989, (AEI)

19 Third palpal segment with a moderately broad, shallow and round sensory pit..... *C. niphanae* Wirth & Hubert, 1989
– Third palpal segment with irregular sensory area, sometimes subdivided into one or several irregular pits 21
20 Haltere pale ..... *C. pelilioensis* Tokunaga in Tokunaga and Esaki 1936
– Haltere comparatively dark..... *C. pongsomiensis* Chu, 1986
21 SCo present on antennal segments I, IX–XII, sometimes also on II, III, IV and VI..... *C. ornatus* Taylor, 1913
– SCo present on antennal segments I–XII ..... *C. quatei* Wirth & Hubert, 1989
22 Anal cell of wing with one round distal pale spot..... 24
– Anal cell of wing with one medially constricted distal pale spot..... 25

23 Anal cell of wing with round distal pale spot away from wing margin (a)..... *C. fuscitibialis* Nandi, Mazumdar & Das Gupta, 2013
– Anal cell of wing with round distal pale spot touching wing margin (b)..... *C. pampangensis* Delfinado, 1961

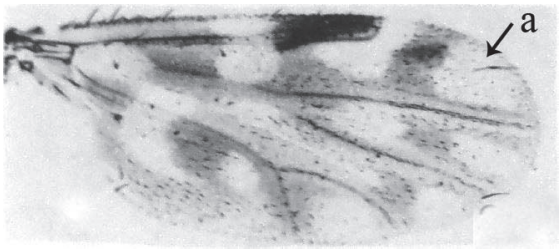


C. fuscitibialis Source: Nandi, Mazumdar & Das Gupta, 2013



C. pampangensis Source: Wirth and Hubert 1989, (AEI)

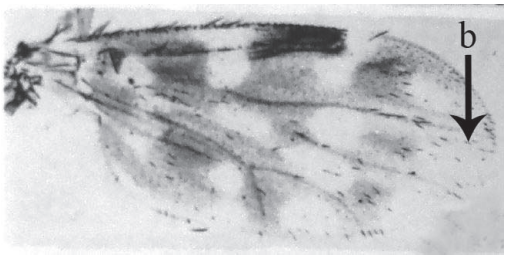
24 Distal most pale spot of cell r_3 touching wing margin (a) ..... *C. mcdowelli* Delfinado, 1961
– Distal most pale spot of cell r_3 separated from wing margin..... 26



C. mcdowelli Source: Wirth and Hubert 1989, (AEI)

25 SCo present on antennal segments I–XII 27
– SCo absent on one or more antennal segments in between I–XII 28
26 Vestigial third spermatheca and sclerotised ring present..... *C. hewitti* Causey, 1938
– Vestigial third spermatheca and sclerotised ring absent..... *C. damnosus* Delfinado, 1961
27 Distal pale spot on cell m_1 separated from wing margin .....*C. pileus* sp. nov.
– Distal pale spot on cell m_1 touching wing margin..... *C. infulatus* Delfinado, 1916

C. pileus sp. nov.



C. infulatus Source: Wirth and Hubert 1989, (AEI)

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