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DOI:

<https://doi.org/10.1007/s11230-025-10215-1>

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Revision of the genus *Canalirogas* van Achterberg & Chen (Hymenoptera: Braconidae) from India with description of four new species and a key to the Indian species

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Received: 23 October 2024 / Accepted: 6 January 2025
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Abstract The Indian species of the genus *Canalirogas* van Achterberg & Chen, 1996 are revised. Four new species, *Canalirogas multinigratus* Gupta & van Achterberg **sp. nov.** and *C. subtransversus* Gupta & van Achterberg **sp. nov.** from Meghalaya (north-eastern India); *C. oblongus* Gupta & van Achterberg **sp. nov.** from Assam (north-eastern India) and *Canalirogas omninopallidus* Gupta & van Achterberg **sp. nov.** from Karnataka (southern India) are illustrated and described. An illustrated key to the Indian species of *Canalirogas* is provided.

Introduction

The species of the Indo-Australian genus *Canalirogas* van Achterberg & Chen, 1996 (Braconidae: Rogadinae) are known as parasitoids of Lymantriidae (Lepidoptera) (Quicke & Shaw, 2005). The genus is represented by twenty species described from the Oriental and Australasian regions, namely Burma, China, India, Indonesia, Malaysia, Nepal, Sri Lanka and Vietnam (Long & van Achterberg, 2015). Only one species occurs in India, *Canalirogas spilonotus* (Cameron, 1905), which was originally described from Sri Lanka and its synonym *C. balgooyi* van Achterberg & Chen, 1996, from Burma, China, India, Indonesia, Malaysia, Nepal, Vietnam (Long & van Achterberg, 2015).

In the present study, an attempt has been made to revise this genus for India by describing and illustrating four new species and providing a key to all known species from India.

Materials and methods

The specimens of present study were manually collected using a sweep net in the north-eastern and southern regions of India between 2016 and 2023. The following abbreviations are used in the descriptions: POL—Posterior Ocellar Line; OOL—Ocular Ocellar Line; OD—Ocellar Diameter; T1, T2, T3, T4, T5, T6 – first, second, third, fourth, fifth and

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sixth metasomal tergites, respectively; F1, F2 – first and second flagellomere (=third and fourth antennal segment/antennomere), respectively. Morphological terminology in general follows van Achterberg (1993a, 1993b). Photos were taken with a Leica M 205 A stereo-zoom microscope with Leica DC 420 inbuilt camera using automontage software (version 3.8). The specimens are deposited in the National Insect Museum (NIM) of ICAR-National Bureau of Agricultural Insect Resources (ICAR-NBAIR), Bengaluru, India. The species distribution map (Fig. 1) was prepared using Google Earth Pro ver. 7.3.6.9796 and QGIS software ver.3.26.0.

Results

Order Hymenoptera Linnaeus, 1758

Family Braconidae Latreille, 1829

Genus *Canalirogas* van Achterberg & Chen, 1996

Canalirogas van Achterberg & Chen, 1996: 63–64. Type-species (by original designation): *Canalirogas balgooyi* van Achterberg & Chen, 1996 (= *C. spilonotus* (Cameron, 1905) (Long & van Achterberg, 2015)).

Diagnosis. *Canalirogas* (Figs. 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21) can be identified mainly by the following combination of characters mentioned in Long & van Achterberg, 2015- female hypopygium strongly enlarged and distinctly convex ventrally (Figs. 4D, 10D, 19D); ovipositor distinctly curved downwards (Figs. 2, 3E, 4D, 8, 9E, 10D, 11, 12E, 13D, 17, 18E, 19D); ovipositor sheath widened (Figs. 19D); second metasomal tergite without distinct medio-basal area (Figs. 4F, 10F, 13F, 19F); anterior half of fourth-fifth tergites usually (partly) obliquely striate (Figs. 10G, 13G, 19G), mid and hind tibial spurs straight (Fig. 7) and tarsal claws simple.

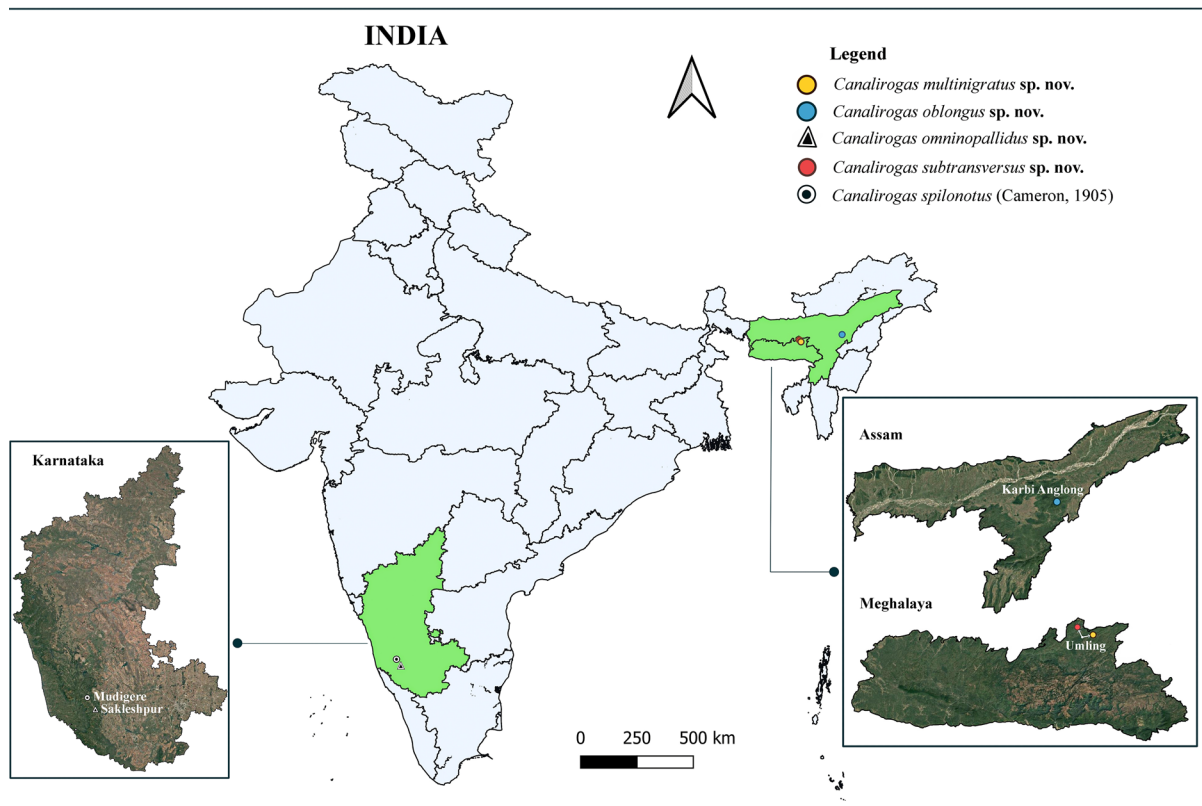


Fig. 1 Distribution map of Indian species of the genus *Canalirogas*



Fig. 2 *Canalirogas multinigratus* sp. nov. A. Female, holotype, habitus, lateral view

Five species are recorded from India, four of them are described as new followed by details of *C. spilonotus*, which was known to occur in India. An illustrated key to all the Indian species of *Canalirogas* is provided. The species distribution map of Indian species of *Canalirogas* is provided in Fig. 1.

Key to the Indian species of *Canalirogas* van Achterberg & Chen (based on females)

1. Propodeum entirely black to dark brown, without yellow area medially (Fig. 4C); side of pronotum conspicuously dark brown dorso-laterally (Fig. 3C) [India: Meghalaya].....
C. multinigratus sp. nov.
- Propodeum mostly black or dark brown basally with pale yellow longitudinal area medially, apically and laterally yellow (Figs. 10C, 13C, 19C); side of pronotum pale yellow (Figs. 12C, 13A) or with faint brown infuscation dorso-laterally (Figs. 8, 9D, 10A, 18D).....2
2. Third and fourth metasomal tergites without subtransverse striations posteriorly (Fig. 10F–G).....
.....3
- Third and fourth metasomal tergites with subtransverse striations posteriorly (Fig. 19F–G).....
.....4
3. Face yellowish brown with prominent sublateral black patches (Fig. 9A); diameter of posterior

ocellus $1.3 \times$ as long as OOL (Fig. 9B); eye in dorsal view $3.3 \times$ as long as temple (Fig. 9B), width of eye in lateral view $4.8 \times$ as long as temple (Fig. 10A); hypopygium largely dark brown medially, ivory basally and apically (Fig. 10D); ovipositor sheath uniformly dark brown and comparatively slender (Fig. 10D) [India: Assam].....

.....*C. oblongus* sp. nov.

- Face completely ivory to pale yellow; diameter of posterior ocellus $2.8 \times$ as long as OOL; eyes in dorsal view $6\text{--}8 \times$ longer than temple, width of eye in lateral view $5.6 \times$ as long as temple; hypopygium largely ivory, light brown at ventral edge; ovipositor sheath narrowly dark brown apically and stout [Burma, China, India, Indonesia, Malaysia, Nepal, Vietnam].....*C. spilonotus* (Cameron, 1905).
- 4. Diameter of posterior ocellus about $2.1 \times$ as long as OOL (Fig. 12B); first tergite $1.2 \times$ as long as its apical width (Fig. 13E); medial length of second tergite $1.4 \times$ as long as third (Fig. 13F); hypopygium completely pale yellow and slightly less convex baso-ventrally (Fig. 13D) [India: Karnataka].....*C. omninopallidus* sp. nov.
- Diameter of posterior ocellus $1.4\text{--}1.5 \times$ as long as OOL (Fig. 18B); first tergite $1.7 \times$ as long as its apical width (Fig. 19E); medial length of second tergite $1.8 \times$ as long as third (Fig. 19F); hypopygium light brown medially (Fig. 19D) and more

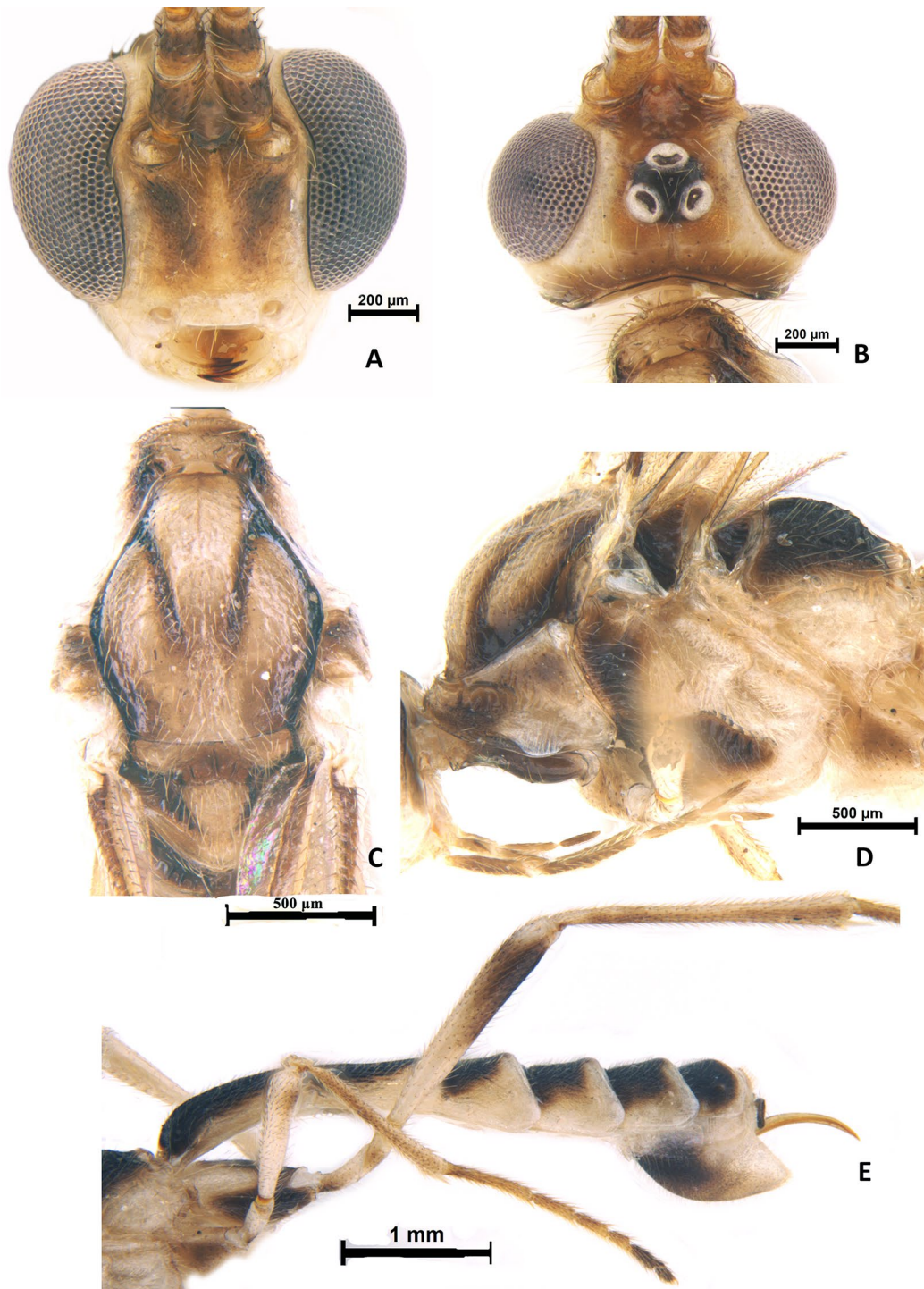


Fig. 3 *Canalirogas multinigratus* sp. nov. Female, holotype. **A.** Head in frontal view; **B.** Vertex; **C.** Mesosoma in dorsal view; **D.** Mesosoma in lateral view; **E.** Metasoma in lateral view

convex baso-ventrally (Fig. 19D) [India: Meghalaya].....*C. subtransversus* sp. nov.

I. *Canalirogas multinigratus* Gupta & van Achterberg sp. nov. (Figs. 2–7)

Type-examined: “Holotype”; female on card; “18.xii.2023”; “sweep net”; “coll. R. Pattar”; “Code-NIM/NBAIR/Brac/Cana/181223A-H”. “Paratype”: one male on card; same data as holotype; “coll. R. Pattar”; “Code- NIM/NBAIR/Brac/Cana/181223A-P1”. (NIM).

Type-locality: “India: Meghalaya, Umling, 25.967045, 91.872364”.

Etymology. The specific name ‘*multinigratus*’ is derived from combination of two words in Latin (‘multi’ means ‘many’ and ‘nigrum’ means ‘black’ in english), referring to black or blackish brown colouration of many body parts mainly propodeum (largely), face, stemmaticum, lateral edges of mesoscutum and notauli, most of first tergite, outer hind femur subapically and anterior hypopygium.

Description. Holotype, female (Fig. 2), body length 8.3 mm, fore wing length 5.4 mm.

Head. Head width $1.8 \times$ its median length (dorsal view). Eye glabrous, weakly emarginated opposite antennal sockets. Antenna incomplete (with 34 segments remaining); third antennal segment (F1) subequal to fourth segment (F2); middle segments (F24–F26) $2.8\text{--}3.4 \times$ longer than wide, width of face as long as length of face and clypeus combined; clypeus medially flat in lateral view; malar space $2.3 \times$ as long as mandible width, mandible width about as long as hypoclypeal depression; malar suture present; distance between tentorial pits $2.2 \times$ distance between pits and eyes; in dorsal view height of eye $3.3 \times$ as long as temple; in lateral view width of eye $2.9 \times$ as long as temple; ocelli large, POL:OD:OOL (relative) = 0.5: 1.3: 1.1; diameter of posterior ocellus about $1.2 \times$ as long as OOL and $2.6 \times$ as long as POL; distance between front and hind ocelli $0.48 \times$ OOL; face shallowly rugose with rough appearance, vertex and temple smooth; occipital carina concave.

Mesosoma. Length of mesosoma $1.4 \times$ as long as high; pronotum smooth medio-dorsally, rugose laterally, crenulate anteriorly (Fig. 3B, 3C); mesopleuron with prominent rugae or crenulae in antero-lateral region, smooth medially and posteriorly (Fig. 3D); metapleuron rugose; notauli wide and crenulate

anteriorly, flat and smooth posteriorly; mesoscutum rough and shallowly punctate (Fig. 3C); propodeum coarsely rugose (Fig. 4C), with transverse crenulae in mid-longitudinal areolar region (except in apical one-third). Margins of mid-longitudinal areolar region irregular.

Wings (Fig. 4B). Fore wing: pterostigma $4.7 \times$ as long as wide; r: 2-SR: 3-SR: SR1 (relative) = 2.2: 3.3: 7.5: 12.2; vein r arising before middle of pterostigma; vein 1-CU1 rather short, 1-CU1: cu-a: 2-CU1: 3-CU1 (relative) = 0.7: 1.4: 7.9: 1.5; posterior length of second submarginal cell $3.6 \times$ its apical width. Hind wing: vein M+CU: 1-M: 1r-m = 8.8: 7.8: 2.8; basal third of vein SR of hind wing not sclerotized and slightly curved; 2-SC+R longitudinal.

Legs. Hind coxa with fine punctures; length of hind femur: tibia: basitarsus: tarsus = 18.2: 18.4: 10.1: 24.8; length of hind femur, tibia and basitarsus 6.6, 8.5 and $9.5 \times$ as long as their maximum width, respectively (Fig. 3E); inner hind tibial spur $0.2 \times$ as long as basitarsus.

Metasoma. First tergite $1.3 \times$ as long as apical width (Fig. 4E); apical width of first tergite $3.1 \times$ its minimum subbasal width; medial length of second tergite $1.8 \times$ as long as third; third metasomal tergite obliquely striate, striations diverging posteriorly (Fig. 4F); third-fifth metasomal tergites without sub-transverse striations posteriorly; fourth tergite areolate-rugose medially and with oblique striations laterally (Fig. 4G); fifth tergite areolate-rugose medially and with comparatively less demarcated oblique striations laterally; sixth tergite finely strigate medially; ovipositor sheath $0.52 \times$ as long as hind basitarsus. Hypopygium convex baso-ventrally, ovipositor less slender, distinctly curved (Fig. 4D).

Colour. Body ivory to pale yellow with black markings; palpi brown; antenna brown; eyes greyish black; face with black infuscation as two sublateral patches; clypeus and malar region ivory; mandibles ivory, but tips dark brown to black; stemmaticum black; occipital region brown; oculo-ocellar region ivory; pronotum yellow to ivory with brown colouration dorsally and sub-laterally, mesoscutum ivory to light brown except dark brown to black notauli and lateral margins; scutellum ivory, sides of scutellum dark brown; propleuron with dark brown colouration anteriorly and ivory posteriorly; mesopleuron anteriorly dark brown to black and ivory posteriorly, medially pale yellow or ivory; metapleuron ivory;

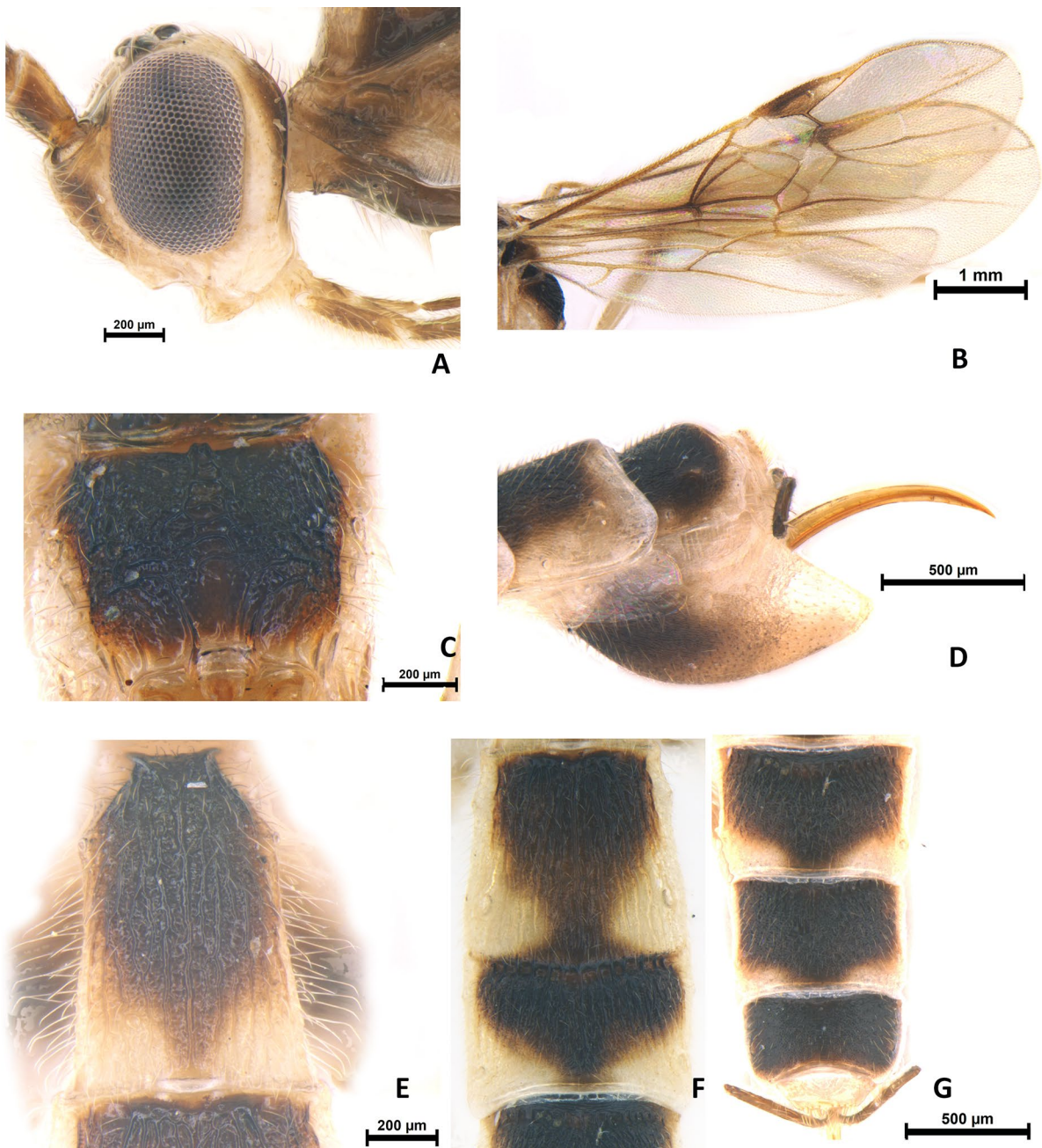


Fig. 4 *Canalirogas multinigratus* sp. nov. Female, holotype. **A.** Head in lateral view; **B.** Wings; **C.** Propodeum; **D.** Hypopygium; **E.** First tergite; **F.** Second and third tergite; **G.** Fourth–sixth tergites

outer side of hind coxa dark brown to black; outer side of hind femur more or less dark brown subapically; propodeum black to brownish black without yellow median longitudinal area, posterior or apical margin ivory; first metasomal tergite largely black to

dark brown except ivory to pale yellow latero-apical corners, second–fifth metasomal tergites black basally to medio-posteriorly, sixth tergite entirely dorsally blackish brown; second–sixth tergites lateral edges pale yellow to ivory; fore wing with faint infuscation

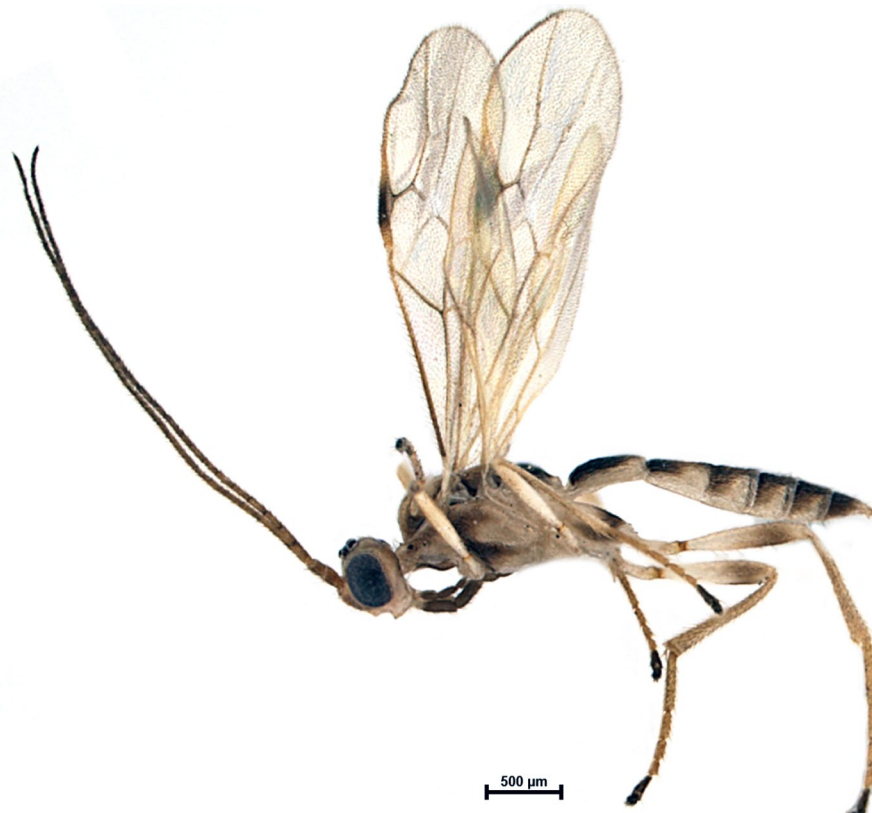


Fig. 5 *Canalirogas multinigratus* **sp. nov.** A. Male, paratype, habitus, lateral view

with veins brown except 2-SR+M, basal end of 2-M and r-m interstitial; pterostigma brown, pale yellow in apical one-third; tarsi light brown except dark brown telotarsus; ovipositor yellow, sheaths dark brown and hypopygium dark brown basally, ivory apically.

Comments. This species is morphologically similar to *C. hoabinhicus* Long & Achterberg, 2015 from Vietnam in having first tergite $1.3\text{--}1.4\times$ as long as apical width and a slender vein r of fore wing; however, differs in having diameter of posterior ocellus $2.6\times$ as long as POL (vs $1.2\text{--}1.3\times$ in *C. hoabinhicus*); distance between tentorial pits $2.2\times$ as long as distance between pits and eyes (vs $3.4\times$ in *C. hoabinhicus*); hind femur with back infuscation on outer side (vs without infuscation in *C. hoabinhicus*); all metasomal tergites mixed with ivory and black colouration (vs all tergites yellow, but first-second tergites basally and sixth tergite brown in *C. hoabinhicus*).

This species is similar to *C. parallelus* Long & Achterberg, 2015 in having propodeum entirely

black, without pale area medially; however, it differs in having first metasomal tergite $1.3\times$ as long as its apical width (vs $1.7\times$ in *C. parallelus*); hind femur and hind coxa with black infuscation on outer side (vs yellow in *C. parallelus*).

It can be separated from *Canalirogas oblongus* **sp. nov.** (from Assam) in having propodeum with black coloured mid-longitudinal area (vs yellow in *C. oblongus*); propodeum coarsely areolate-rugose, with mid-longitudinal areolar margins irregular, margins not reaching posterior edge (vs strigate-rugose, with well-defined mid-longitudinal areolar margins reaching posterior edge in *C. oblongus*); fourth tergite areolate-rugose medially and with oblique striations laterally (vs with distinct oblique striations throughout in *C. oblongus* **sp. nov.**).

Male

Description. Paratype, male (Fig. 5), body length 3.6 mm; antenna 3.6 mm.

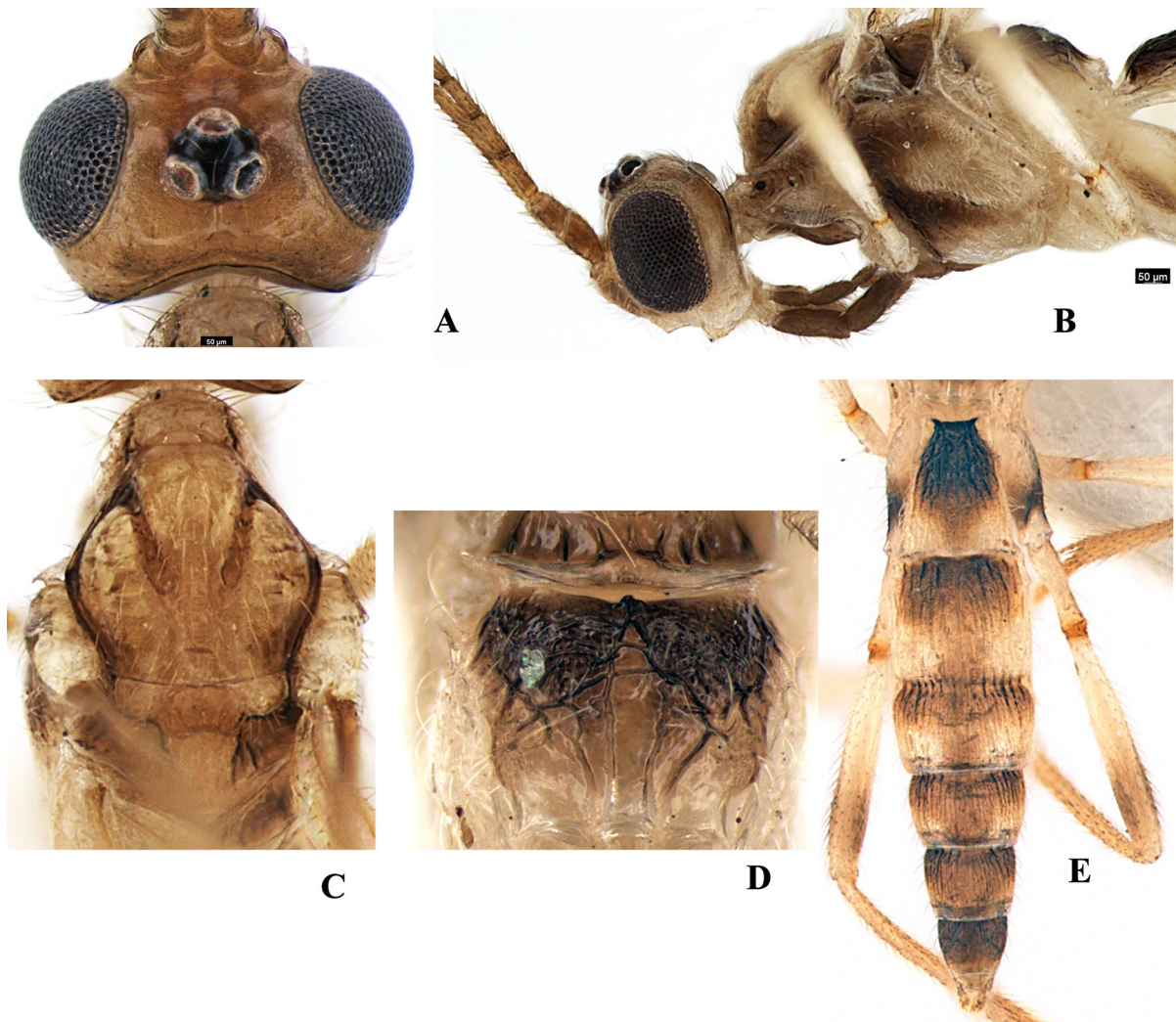


Fig. 6 *Canalirogas multinigratus* sp. nov. Male, paratype. **A** Vertex; **B** Head and mesosoma in lateral view; **C**. Mesosoma in dorsal view; **D**. Propodeum; **E**. Metasoma in dorsal view

Head. Head width $1.6 \times$ its median length (frontal view). Eye glabrous, weakly emarginated opposite antennal sockets. Maxillary and labial palpi dark brown and widened, especially second and third maxillary palp segments strongly enlarged (Fig. 6B). Antenna 29 segmented; third antennal segment (F1) $1.1 \times$ as long as fourth segment (F2). Malar space $2.2 \times$ as long as mandible width, malar suture present; distance between tentorial pits $2.0 \times$ distance between pits and eyes. Vertex smooth, ocelli large; POL:OD:OOL (relative) = 1: 3: 2.6; diameter of posterior ocellus about $1.2 \times$ as long as OOL and $3 \times$ as long as POL; distance between front and hind ocelli

$0.6 \times$ OOL; in dorsal view height of eye $3.3 \times$ as long as temple; occipital carina arched.

Mesosoma. Notauli wide and crenulate anteriorly, reduced and smooth posteriorly. Lateral lobes with transverse prominent rugae. Propodeum with rugae in anterior half and reticulations in between rugae, prominent mid-longitudinal areola present.

Metasoma. First tergite $1.2 \times$ as long as its apical width; apical width of first tergite $2.9 \times$ its minimum subbasal width; medial length of second tergite $1.5 \times$ as long as third. T1–T5 coarsely longitudinally striate to rugose in between; third-fifth metasomal tergites



Fig. 7 *Canalirogas multinigratus* sp. nov. **A.** Female mid leg spur; **B.** Female hind leg spur; **C.** Male mid leg spur; **D.** Male hind leg spur



Fig. 8 *Canalirogas oblongus* sp. nov. Female, holotype, habitus, lateral view

without sub-transverse striations posteriorly; sixth tergite finely striate.

Colour. Body colouration ivory to pale yellow with black markings. Face with black infuscation as two sublateral patches, mandibles ivory, but tips dark brown to black. Stemmaticum black. Palpi dark

brown. Mesoscutum ivory to light brown except dark brown notauli in anterior half, anterior end of notauli and lateral margins of mesoscutum black. Propodeum black to brownish black without yellow medio-longitudinal area (median area light brown). First metasomal tergite largely black to dark brown except ivory to pale yellow latero-apical corners. Basal half to one third of second to fourth tergites dark brown, fifth and sixth tergites brown.

II. *Canalirogas oblongus* Gupta & van Achterberg sp. nov. (Figs. 8, 9, 10)

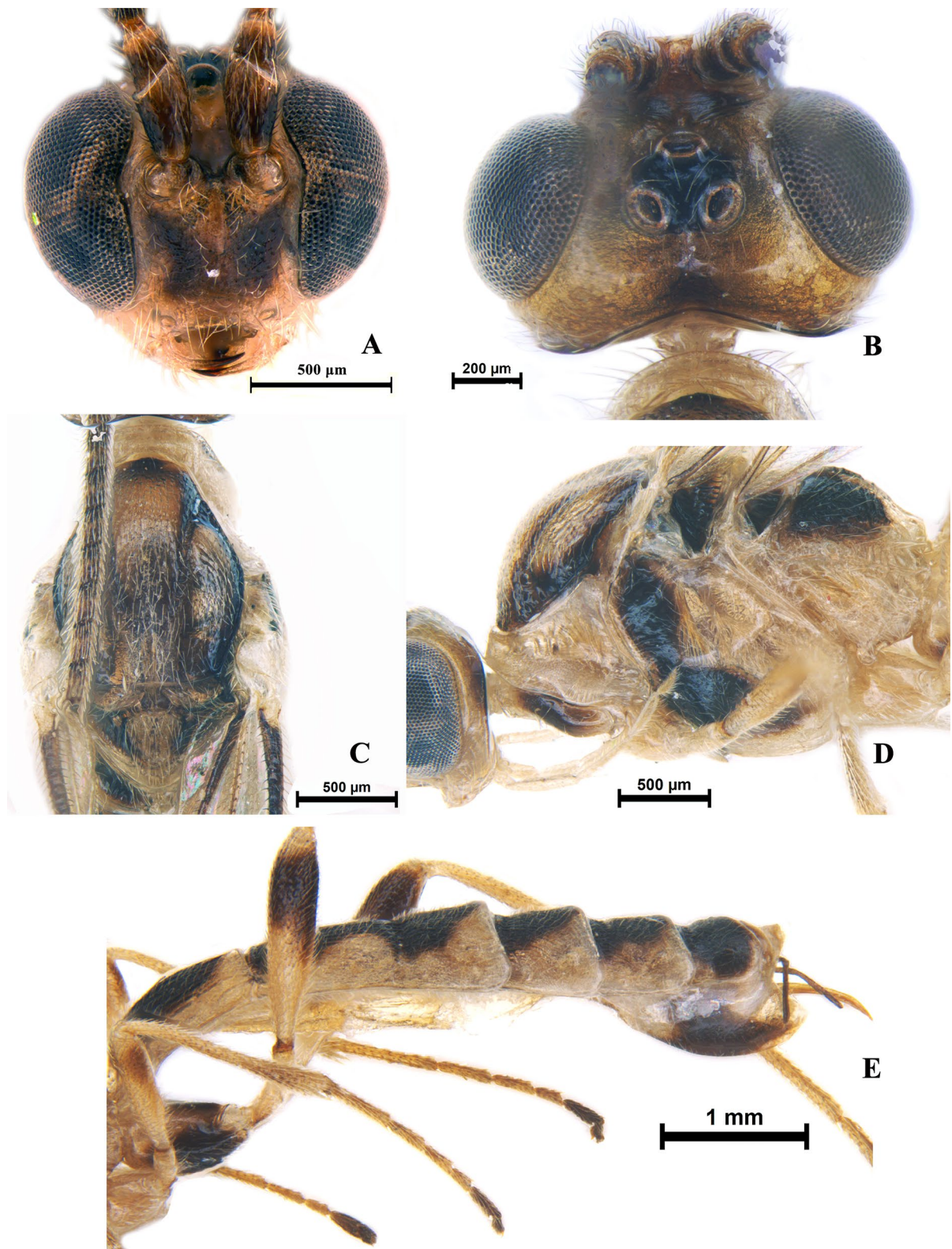
Type-examined: “Holotype”, female on card; “27. ii.2016”; “sweep net”; “coll. Ankita Gupta”; “Code-NIM/NBAIR/Brac/Cana/181223A-H”. NIM.

Type-locality: “India, Assam, Karbi Anglong, 26.092350, 93.110066”.

Etymology. The specific name ‘*oblongus*’ (in Latin) refers to the elongated areola.

Description. Holotype; female (Fig. 8), body length 8.0 mm, fore wing length 6.6 mm, antenna 10.2 mm.

Head. Antenna with 49 segments, $1.3 \times$ longer than body, $1.5 \times$ as long as fore wing; third antennal segment (F1) subequal to fourth segment (F2); middle segments (F24–F27) $2.6\text{--}2.9 \times$ longer than wide, penultimate antennal segment $0.8 \times$ as long as apical



◀**Fig. 9.** *Canalirogas oblongus* sp. nov. Female, holotype. **A.** Head in frontal view; **B.** Vertex; **C.** Mesosoma in dorsal view; **D.** Mesosoma in lateral view; **E.** Metasoma in lateral view

segment; apical segment with spine; width of face $1.1 \times$ length of face and clypeus combined; clypeus medially flat in lateral view; malar space $1.4 \times$ as long as mandible width, mandible width about $1.3 \times$ as long as hypoclypeal depression; malar suture present; distance between tentorial pits $2.5 \times$ distance between pits and eyes; in dorsal view height of eye $3.3 \times$ as long as temple (Fig. 9B); width of eye in lateral view $4.8 \times$ as long as temple (Fig. 10A); ocelli large, POL:OD:OOL (relative) = 0.6: 1.3: 1.0; diameter of posterior ocellus about $1.3 \times$ OOL; distance between front and hind ocelli $0.8 \times$ OOL (Fig. 9B); face shallowly rugose with rough appearance (Fig. 9A), vertex shallowly granulate to smooth and temple smooth; occipital carina concave.

Mesosoma. Length of mesosoma $1.5 \times$ as long as high (Fig. 9D); pronotum smooth posteriorly, crenulate at anterior edge, finely granulate dorsally and ventrally; precoxal sulcus sparsely crenulate; propleuron irregular strigate-rugose (Fig. 10A); mesopleuron finely punctate anteriorly and areolate-rugose posteriorly; metapleuron irregularly areolate-rugose (Fig. 9D); notauli distinct, wide and crenulate anteriorly and medially, flat and smooth posteriorly; scutellar sulcus $0.4 \times$ scutellum; mesoscutum punctate; propodeum prominently and irregularly strigate-rugose (Fig. 10C), areolate-rugose medially, with medial longitudinal crenulate areola. Areolar margins well-defined and clearly reaching posterior edge of propodeum.

Wings. Fore wing (Fig. 10B): pterostigma $4.4 \times$ as long as wide; r: 2-SR: 3-SR: SR1 (relative) = 3.5: 4.9: 9.8: 15; vein r arising before middle of pterostigma; 1-CU1: cu-a: 2-CU1: 3-CU1 (relative) = 1.0: 1.8: 8.7: 1.8; posterior length of second submarginal cell $4.0 \times$ its apical width. Hind wing: vein M+CU: 1-M: 1r-m = 9.95: 8.8: 3.75. Basal third of vein SR of hind wing curved and light brown.

Legs. Length of hind femur: tibia: basitarsus: tarsus (relative) = 19.5: 22.4: 10.4: 26.4; length of hind femur, tibia and basitarsus 5.6 , 9.1 and $8.6 \times$ as long as their maximum width, respectively; inner hind tibial spur $0.3 \times$ as long as basitarsus.

Metasoma. First tergite $1.4 \times$ as long as apical width (Fig. 10E); apical width of first tergite $2.8 \times$

its minimum subbasal width; medial length of second tergite $1.6 \times$ as long as third (Fig. 10F); third-fifth metasomal tergites with distinct oblique-divergent striations on both sides (Fig. 10G); sixth tergite finely strigate medially; ovipositor sheath $0.5 \times$ as long as hind basitarsus. Hypopygium distinctly convex baso-ventrally, ovipositor less slender, distinctly curved.

Colour. Body ivory to pale yellow with black markings; palpi pale yellow; antenna brown; eyes greyish black; tips of mandibles dark brown; ocelli pale or testaceous on outer edges, followed by brown and dark brown in the centre; stemmaticum black; face with sublateral black patches; propodeum blackish brown antero-submedially, yellowish longitudinal area medially, laterally and posteriorly pale yellow; first metasomal tergite blackish brown except pale yellow to ivory posteriorly, laterally ivory throughout; second-fifth metasomal tergites basally and medio-posteriorly, and sixth tergite entirely dorsally blackish brown; second-sixth lateral edges pale yellow to ivory; fore wing yellow with veins brown except 2-SR+M, basal end of 2-M and r-m interstitial; pterostigma brown; mesopleuron (except blackish to dark brown anteriorly) and metapleuron pale yellow or ivory; pronotum dorsally and medially ivory and dark brown antero-laterally, middle and lateral lobes of mesoscutum mixed with yellow brown to dark brown; scutellum pale yellow to ivory with dark brown lateral edges; anterior and lateral edges of mesoscutum dark brown to black; outer side of hind coxa apically and ventrally, and outer side of hind femur more or less dark brown subapically; tarsi mainly yellowish-brown (except dark brown or brown telotarsus); ovipositor yellow, sheaths dark brown and hypopygium largely dark brown medially, ivory basally and apically.

Comments. This species is similar to *C. spilonotus* in having oblique striations on third and fourth tergites, without sub-transverse striations posteriorly and in having an area in front of prepectal carina pale yellow. However, it differs from the latter in the following characters: width of eye in lateral view about $4.8 \times$ as wide as temple (vs $5.6 \times$ as long as temple in *C. spilonotus*); eyes in dorsal view $3.3 \times$ longer than temple (vs eyes in dorsal view $6\text{--}8 \times$ longer than temple in *C. spilonotus*); POL $0.6 \times$ OOL (vs subequal in *C. spilonotus*); diameter of posterior ocellus usually $1.3 \times$ OOL (vs $2.8 \times$ in *C. spilonotus*); face with

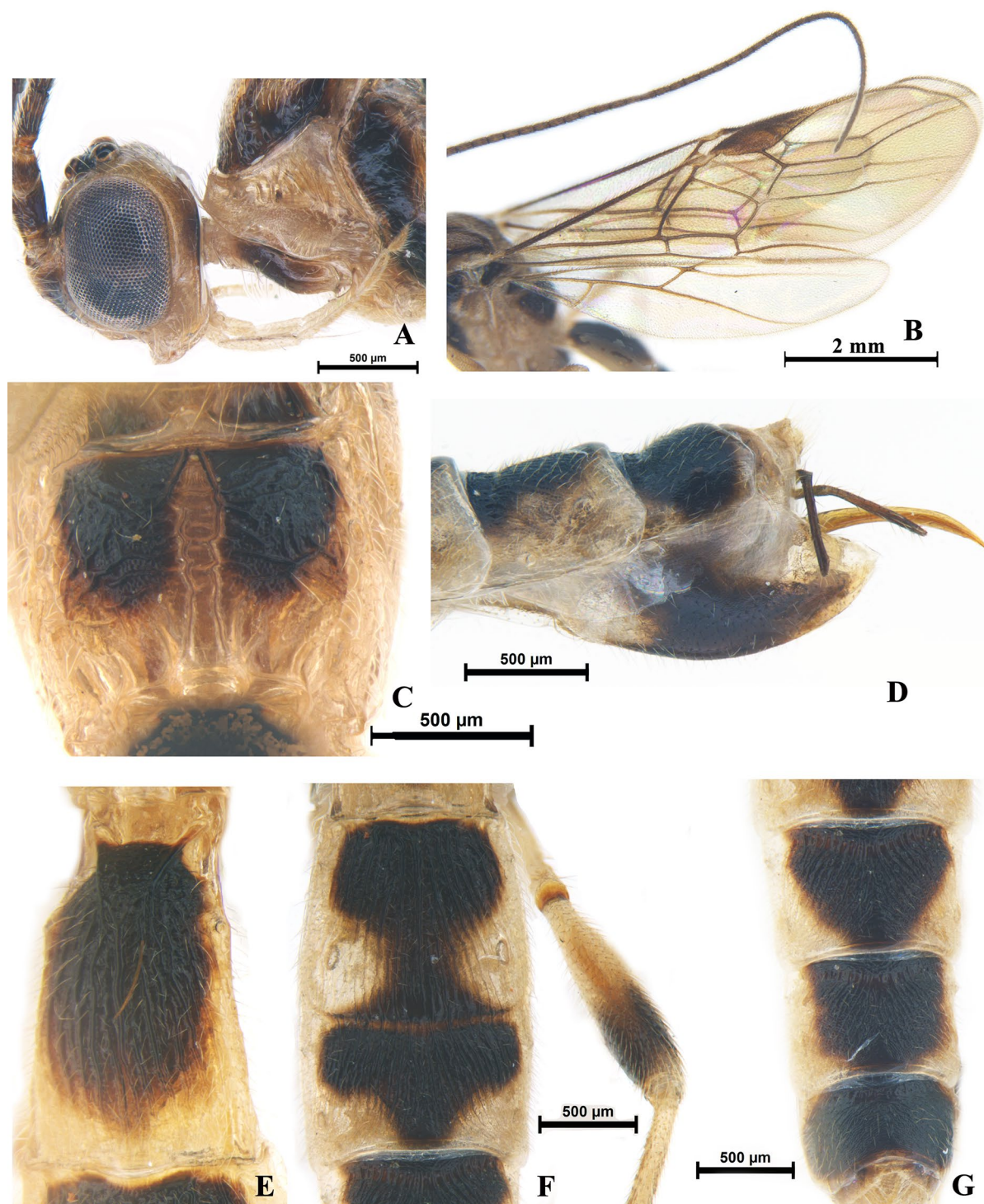


Fig. 10. *Canalirogas oblongus* sp. nov. Female, holotype. **A.** Head in lateral view; **B.** Wings; **C.** Propodeum; **D.** Hypopygium; **E.** First tergite; **F.** Second and third tergite; **G.** Fourth–sixth tergites

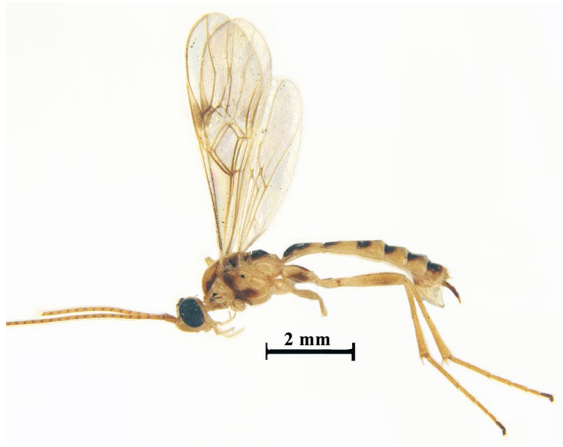


Fig. 11 *Canalirogas omninopallidus* sp. nov. Female, holotype, habitus, lateral view

sublateral black patches (vs ivory in *C. spilonotus*); ovipositor sheath uniformly dark brown and comparatively slender (vs ovipositor sheath mainly yellowish brown and only apically darkened and rather stout in *C. spilonotus*); hypopygium largely dark brown medially, ivory basally and apically (vs ivory to light brown at ventral edge in *C. spilonotus*) and pterostigma largely dark brown (vs medially dark brown in *C. spilonotus*).

III. *Canalirogas omninopallidus* Gupta & van Achterberg sp. nov. (Figs. 11, 12, 13, 14, 15, 16)

Type-examined: “Holotype”; female on card; “23.xi.2023”; “sweep net”; “coll. R. Pattar & Hemanth Kumar H. M”; “Code- NIM/NBAIR/Brac/Cana/231123-H”. “Paratype”: two males on card with same data as holotype; “Code- NIM/NBAIR/Brac/Cana/231123-P1” and “Code- NIM/NBAIR/Brac/Cana/231123-P2”.

Type-locality: “India: Karnataka, Sakleshpura, 12.953047, 75.834060”.

Etymology. The specific name ‘*omninopallidus*’ is derived from ‘omnino’ (Latin for ‘completely’) and ‘pallidus’ (Latin for ‘pale’) referring to completely pale to light yellowish hypopygium.

Description. Holotype, female (Fig. 11), body length 7.2 mm, fore wing length 5.5 mm.

Head. Antenna 30 segmented (but apical part missing), third antennal segment (F1) subequal to fourth segment (F2); middle segments (F25–F28) 2.7–2.9 × longer than wide; width of face 0.8 × length of face

and clypeus combined; clypeus medially flat in lateral view; malar space 1.4 × as long as mandible width, mandible width about 1.2 × as long as hypoclypeal depression; malar suture present; distance between tentorial pits 3.0 × distance between pits and eyes; in dorsal view height of eye 3.7 × as long as temple (Fig. 12B); in lateral view width of eye 5.6 × as long as temple; ocelli large, POL:OD:OOL (relative) = 0.9: 1.4: 0.7; diameter of posterior ocellus about 2.1 × as long as OOL; distance between front and hind ocelli 1.0 × OOL (Fig. 12B); face punctate, shallowly rugose with rough appearance, vertex and temple smooth. Occipital margin concave.

Mesosoma. Length of mesosoma 1.6 × as long as high; pronotum granulate; mesopleuron smooth (Fig. 12D); metapleuron smooth with sparse fine punctures; notauli wide and crenulate anteriorly, flat and smooth posteriorly; mesoscutum smooth; propodeum distinctly crenulate antero-laterally, with medial crenulate areola anteriorly, posteriorly smooth.

Wings. Fore wing (Fig. 13B): pterostigma 5.1 × as long as wide; r: 2-SR: 3-SR: SR1 (relative) = 2.4: 3.9: 7.4: 12.4; vein r arising before middle of pterostigma; vein 1-CU1 short, 1-CU1: cu-a: 2-CU1: 3-CU1 (relative) = 0.7: 1.7: 7.4: 1.6; posterior length of second submarginal cell 3.6 × its apical width. Hind wing: vein M+CU: 1-M: 1r-m = 6.9: 7.8: 2.9. Basal third of vein SR of hind wing not sclerotized and slightly curved.

Legs. Hind coxa with sparse fine punctures; length of hind femur: tibia: basitarsus: tarsus = 15.0: 21.7: 10.1: 25.2; length of hind femur, tibia and basitarsus 5.9, 9.6 and 13.5 × as long as their maximum width, respectively; inner hind tibial spur 0.25 × as long as basitarsus.

Metasoma. First tergite 1.2 × as long as apical width (Fig. 13E); apical width of first tergite 3.4 × its minimum subbasal width; medial length of second tergite 1.4 × as long as third (Fig. 13F); third-fifth metasomal tergites with sub-transverse striations posteriorly; sixth tergite strigulate in middle, smooth laterally; ovipositor sheath 0.5 × as long as hind basitarsus. Hypopygium slightly convex baso-ventrally, ovipositor stout and slightly curved.

Colour. Body ivory to pale yellow with black markings; palpi pale yellow; antenna yellowish, dark brown at joints; eyes black; tips of mandibles dark brown; ocelli pale testaceous; stemmaticum brownish black; propodeum blackish brown

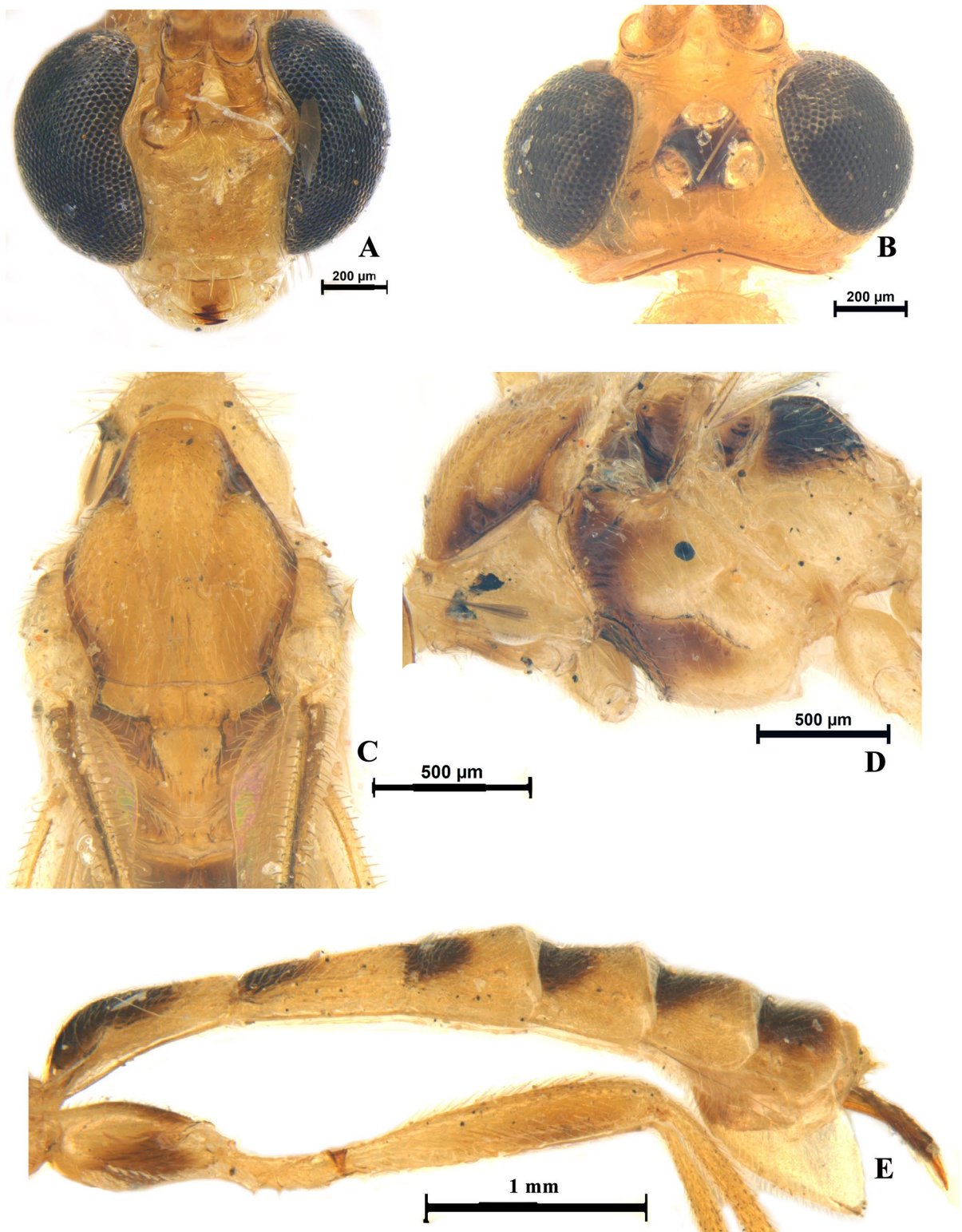


Fig. 12 *Canalirogas ominopallidus* sp. nov. Female, holotype. **A.** Head in frontal view; **B.** Vertex; **C.** Mesosoma in dorsal view; **D.** Mesosoma in lateral view; **E.** Metasoma in lateral view

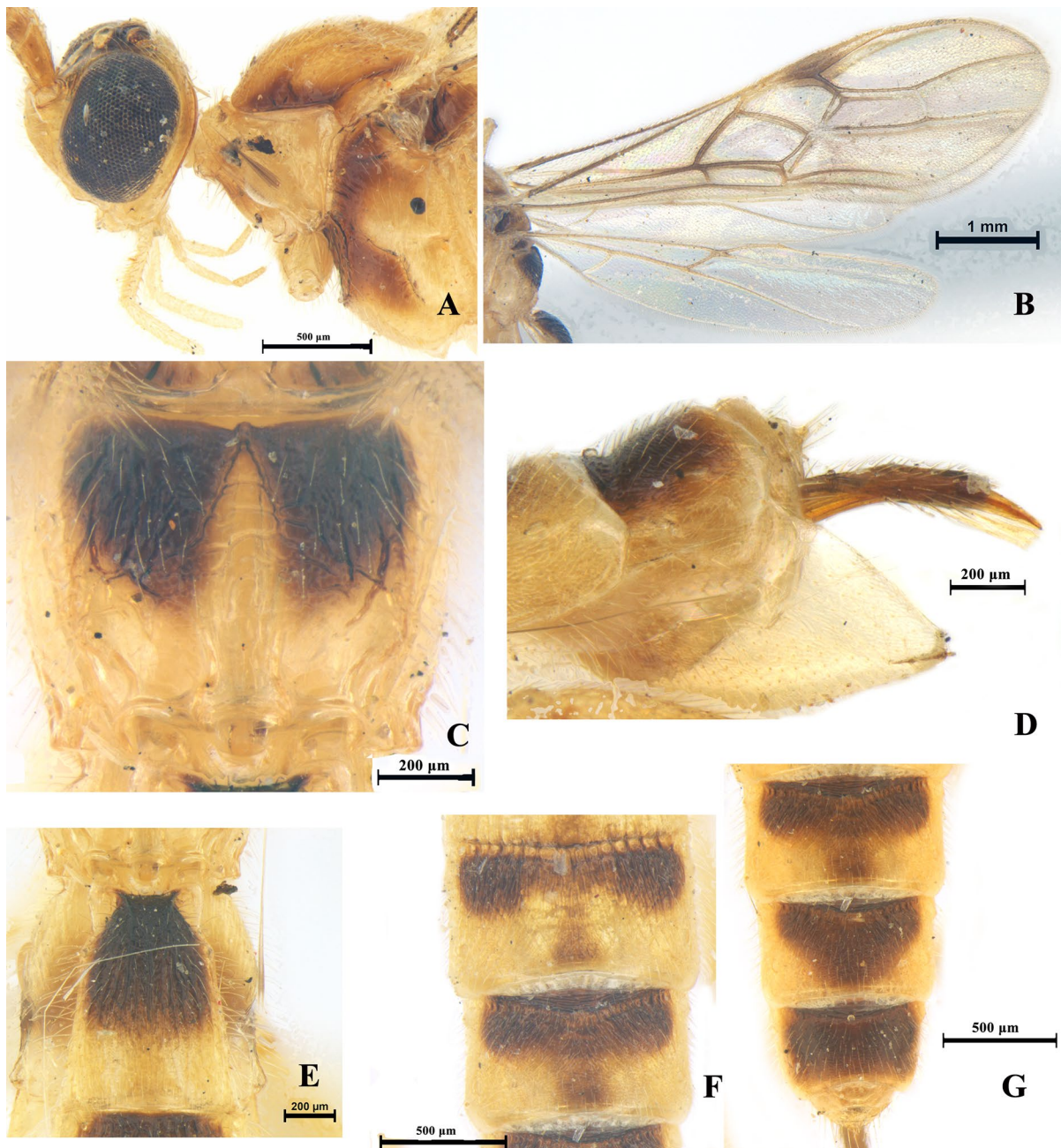


Fig. 13 *Canalirogas ominopallidus* sp. nov. Female, holotype. **A.** Head in lateral view; **B.** Wings; **C.** Propodeum; **D.** Hypopygium; **E.** First tergite; **F.** Second and third tergite; **G.** Fourth–sixth tergites

antero-laterally, with yellowish longitudinal area medially and posteriorly, lateral edges yellow; first metasomal tergite ivory to pale yellow in posterior half, blackish brown in anterior half, lateral anterior corners ivory; third–fifth metasomal tergites basally

and medio-posteriorly, and sixth tergite entirely dorsally dark brown; second–fourth tergites lateral edges pale yellow to ivory; fore wing yellow with veins brown, basal end of 2-M, 2-SR+M and r-m interstitial; pterostigma brown medially, yellow basally and



Fig. 14 *Canalirogas omninopallidus* sp. nov. Male, paratype, habitus, dorsal view

pale apically; pronotum testaceous, mesopleuron with brown colouration anteriorly, metapleuron pale yellow or ivory; pronotum ivory to pale yellow dorsally; middle and lateral lobes of mesoscutum and scutellum pale yellow to ivory; anterior edges of notaulic region dark brown; outer side of hind coxa and outer side of hind femur with brown infuscation apically; tarsi mainly yellowish-brown (except dark brown or brown telotarsus); ovipositor dark brown and hypopygium ivory apically, light yellowish basally.

Comments. This species is similar to *C. intermedius* Long & Achterberg, 2015 from Vietnam because of the sub-transverse striations present on third and fourth metasomal tergites. However, it differs in having the diameter of posterior ocellus about $1.6 \times$ as long as POL and $2.1 \times$ as long as OOL (vs diameter of posterior ocellus $3.0 \times$ as long as POL and $1.5 \times$ as long as OOL in *C. intermedius*); apical width of first tergite $3.4 \times$ its minimum subbasal width (vs $1.7\text{--}1.8 \times$ its minimum subbasal width in *C. intermedius*); mesopleuron with brown colouration anteriorly (vs pale yellow antero-dorsally in *C. intermedius*); medial length of second tergite $1.4 \times$ as long as third (vs $1.8 \times$ in *C. intermedius*).

Male

(Figs. 14, 15, 16)

Description. Paratype, male, body length 5.8 mm; antenna 5.5 mm.

Head. Antenna 34 segmented; third antennal segment (F1) subequal to fourth segment (F2). Malar space $1.7 \times$ as long as mandible width, mandible width about $0.8 \times$ as long as hypoclypeal depression; malar suture present; distance between tentorial pits $3.0 \times$ distance between pits and eyes (Fig. 16A); POL:OD:OOL (relative) = 0.7: 1.4: 0.9; diameter of posterior ocellus about $1.6 \times$ as long as OOL; distance between front and hind ocelli $0.8 \times$ OOL; in dorsal view height of eye $3.4 \times$ as long as temple.

Mesosoma. Notauli wide and crenulate anteriorly, flat and smooth posteriorly (Fig. 16B).

Metasoma. First tergite $1.4 \times$ as long as its apical width (Fig. 16D); apical width of first tergite $3.4 \times$ its minimum subbasal width; medial length of second tergite $1.6 \times$ as long as third. T1-T5 coarsely longitudinally striate to rugose in between, striations more prominent in first three tergites; third-fifth metasomal tergites without sub-transverse striations posteriorly; sixth tergite reticulate.

Colour. Body colouration ivory to pale yellow with black markings, black markings less prominent than in female. Propodeum blackish brown antero-laterally, with yellowish longitudinal area medially and posteriorly. Basal half of first and sixth tergite dark brown to black, basal margins of second to fifth tergite with brown infuscation.

IV. *Canalirogas subtransversus* Gupta & van Achterberg sp. nov.

(Figs. 17, 18, 19, 20, 21)

Type-examined: “Holotype”; female on card; “19. xii.2023”; “sweep net”; “coll. R. Pattar”; “Code-NIM/NBAIR/Brac/Cana/191223-H”. Paratype: One male on card; same data as holotype; “coll. Hemanth Kumar H. M.”; “Code- NIM/NBAIR/Brac/Cana/191223-P1”.

Type-locality: “India, Meghalaya, Umling, 25.967045, 91.872364”.

Etymology. The specific name ‘*subtransversus*’ refers to the presence of distinct sub-transverse striations in the third-fifth metasomal tergites.

Description. Holotype, female (Fig. 17), body length 7.9 mm, fore wing length 6.6 mm, antenna 10.1 mm.



Fig. 15 *Canalirogas ominopallidus* sp. nov. Male, paratype, habitus, lateral view

Head. Antenna with 45 segments, $1.3 \times$ longer than body (Fig. 17); third antennal segment subequal to fourth segment; middle segments $2.7\text{--}3.2 \times$ longer than wide, penultimate antennal segment $0.8 \times$ as long as apical segment; apical segment with spine; width of face $0.9 \times$ length of face and clypeus combined; clypeus medially flat in lateral view; malar space $1.5 \times$ as long as mandible width, mandible width about $0.8 \times$ as long as hypoclypeal depression; malar suture present; distance between tentorial pits $2.9 \times$ distance between pits and eyes; in dorsal view height of eye $4.5 \times$ as long as temple (Fig. 18B); in lateral view width of eye $4.3 \times$ as long as temple; ocelli large, POL:OD:OOL (relative) = 0.7: 1.4: 1.0; diameter of posterior ocellus about $1.4 \times$ as long as OOL; distance between front and hind ocelli $0.8 \times$ OOL and ocellar triangle rather acute (Fig. 18B); occipital margin concave; face shallowly rugose with rough appearance, vertex and temple smooth.

Mesosoma. Length of mesosoma $1.5 \times$ as long as high (Fig. 18D); pronotum smooth dorsally and posteriorly, crenulate medio-anteriorly, finely granulate ventrally; mesopleuron shiny and smooth (Fig. 18D); metapleuron smooth with sparse fine punctures; notauli wide and crenulate anteriorly, flat and smooth posteriorly (Fig. 18C); scutellar sulcus $0.4 \times$

scutellum; mesoscutum smooth; propodeum rugose laterally, with medial crenulate areola (Fig. 19C).

Wings. Fore wing (Fig. 19B): pterostigma $4.8 \times$ as long as wide; r: 2-SR: 3-SR: SR1 (relative) = 3.2: 5.0: 8.6: 13.6; vein r arising before middle of pterostigma; vein 1-CU1 rather short, 1-CU1: cu-a: 2-CU1: 3-CU1 (relative) = 0.7: 2.0: 9.0: 1.7; posterior length of second submarginal cell $4.5 \times$ its apical width. Hind wing: vein M+CU: 1-M: 1r-m = 10.4: 8.6: 3.6; basal third of vein SR of hind wing not sclerotized and slightly curved.

Legs. Hind coxa with sparse fine punctures; length of hind femur: tibia: basitarsus: tarsus = 18.4: 23.5: 11.9: 30.7; length of hind femur, tibia and basitarsus 7.1 , 11.7 and $12.3 \times$ as long as their maximum width, respectively; inner hind tibial spur $0.22 \times$ as long as basitarsus.

Metasoma. First tergite $1.7 \times$ as long as apical width (Fig. 19E); apical width of first tergite $3.2 \times$ its minimum subbasal width; medial length of second tergite $1.8 \times$ as long as third (Fig. 19F); third-fifth metasomal tergites with sub-transverse striations posteriorly; antero-lateral convexities of third and fourth tergites nearly absent; sixth tergite strigate-rugulose; ovipositor sheath $0.7 \times$ as long as hind basitarsus. Hypopygium distinctly convex baso-ventrally, ovipositor comparatively slender, distinctly curved.

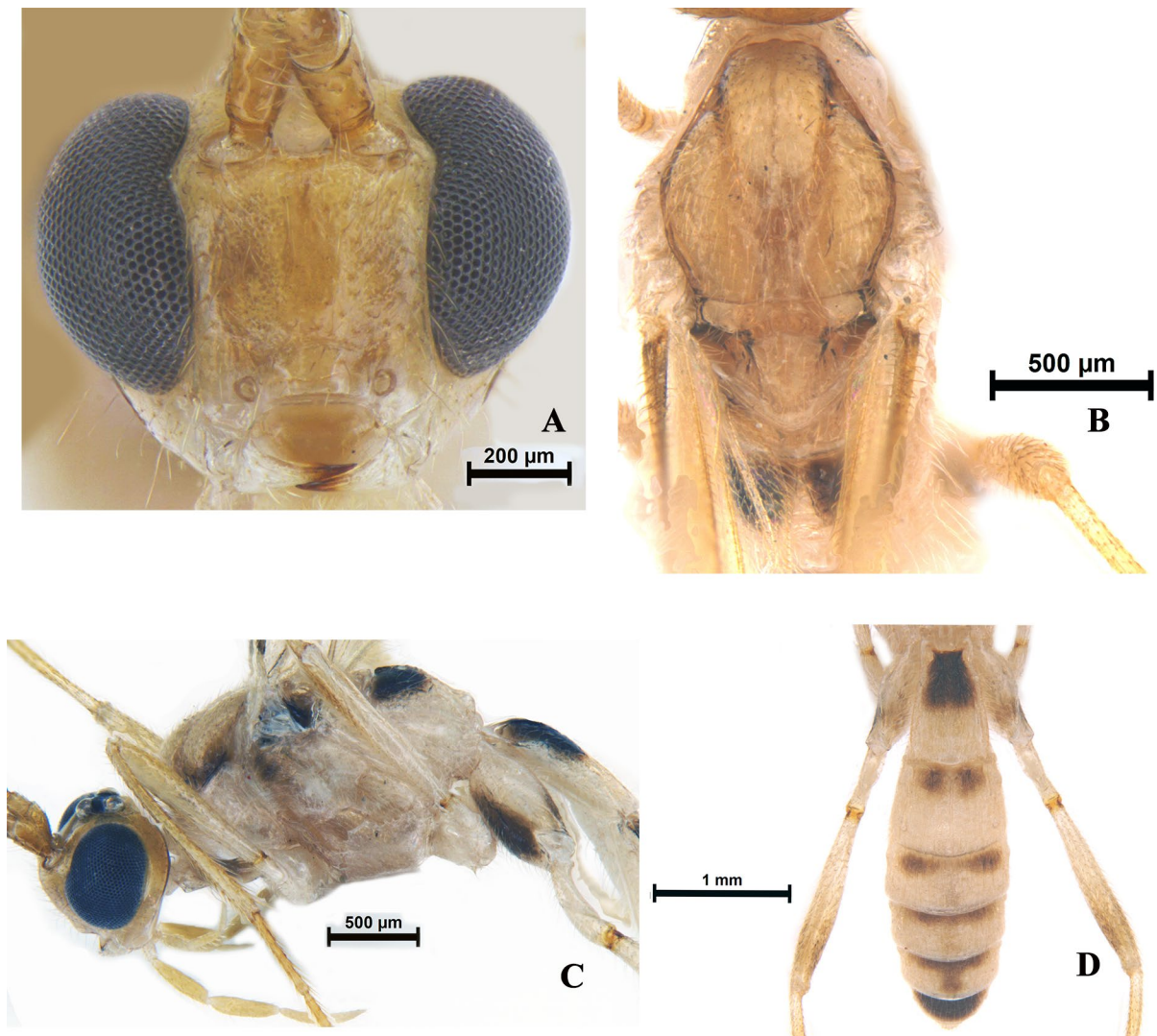


Fig. 16 *Canalirogas omninopallidus* sp. nov. Male, paratype. **A.** Head in frontal view; **B.** Mesosoma in dorsal view; **C.** Mesosoma in lateral view; **D.** Metasoma in dorsal view

Colour. Body ivory to pale yellow with black markings; palpi pale yellow; antenna yellowish brown, joints dark brown; eyes greyish black; mandibles ivory, tips of mandibles dark brown; stemmaticum black; propodeum blackish brown antero-laterally, yellowish longitudinal area medially and posteriorly; first metasomal tergite ivory to pale yellow except blackish brown antero-medially, antero-lateral corners ivory; second–fifth metasomal tergites anteriorly and medio-posteriorly, medially ivory without black longitudinal band, and sixth tergite entirely dorsally blackish brown; second–sixth lateral edges pale yellow to ivory; fore wing yellow with veins

brown except cu-a, 3-CU1, 2-SR+M, basal end of 2-M and r-m interstitial; pterostigma brown medially, yellow basally and apically; pronotum, mesopleuron (except small brown patch medio-anteriorly) and metapleuron pale yellow or ivory; side of pronotum ivory, pale yellow dorsally; middle and lateral lobes of mesoscutum and side of scutellum pale yellow to ivory; anterior edges of mesoscutum dark brown; outer side of hind coxa apically and outer side of hind femur more or less dark brown subapically; tarsi mainly yellowish brown (except dark brown or brown telotarsus); ovipositor yellow, sheaths dark brown and hypopygium dark brown basally, ivory apically.



Fig. 17 *Canalirogas subtransversus* sp. nov. A. Female, holotype, habitus, lateral view

Comments. This species is similar to *C. intermedius* in having the third and fourth metasomal tergites with sub-transverse striations posteriorly, the diameter of posterior ocellus about $1.4\text{--}1.5 \times$ OOL, and the occipital carina evenly concave. However, it differs by having the first tergite $1.7\text{--}1.8 \times$ as long as apical width (vs. $1.4 \times$ as long as apical width in *C. intermedius*), the apical width of first tergite $3.2 \times$ as long as its minimum subbasal width (vs. $1.7\text{--}1.8 \times$ as long as its minimum subbasal width in *C. intermedius*), and veins 1-M and m-cu of fore wing dark brown (vs. yellowish brown in *C. intermedius*).

Male

Description. Paratype, male (Fig. 20), body length 4.4 mm.

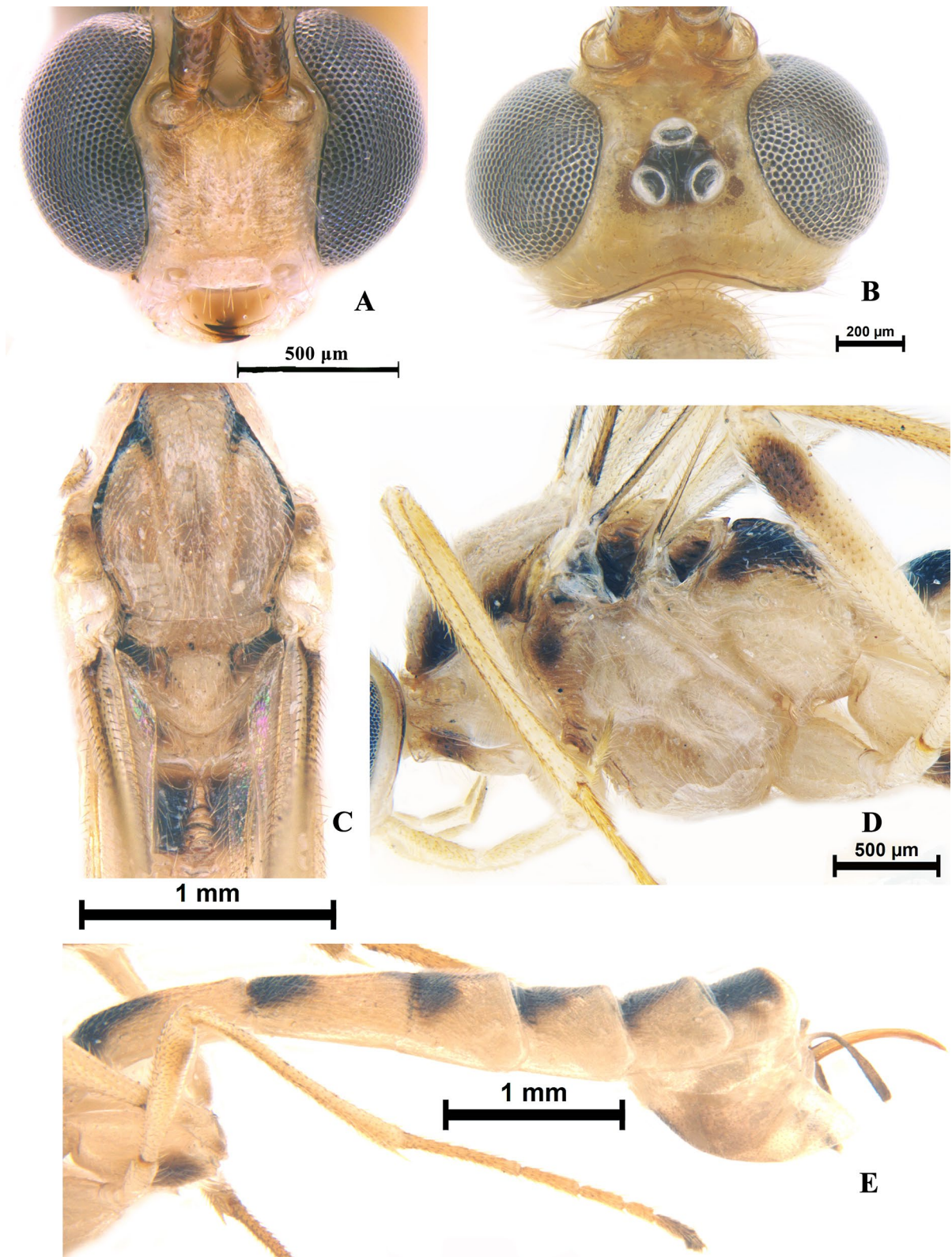
Head. Head width $1.6 \times$ its median length (frontal view). Eye glabrous, weakly emarginated opposite antennal sockets. Maxillary and labial palpi yellowish brown and moderately widened (Figs. 20, 21B). Third antennal segment (F1) $1.1 \times$ as long as fourth segment (F2). Malar space $1.6 \times$ as long as mandible width, malar suture present; distance between tentorial pits $2.9 \times$ distance between pits and eyes. Vertex smooth, ocelli large; POL:OD:OOL (relative) =

1: 2.8: 2.2; diameter of posterior ocellus about $1.3 \times$ as long as OOL and $2.8 \times$ as long as POL; distance between front and hind ocelli $0.6 \times$ OOL; in dorsal view height of eye $3.1 \times$ as long as temple (Fig. 21A); occipital carina arched.

Mesosoma. Notauli wide and crenulate anteriorly, reduced and smooth posteriorly (Fig. 21C). Lateral lobes with transverse prominent rugae.

Metasoma. First tergite $1.3 \times$ as long as its apical width (Fig. 21E); apical width of first tergite $3.1 \times$ its minimum subbasal width; medial length of second tergite $1.6 \times$ as long as third. T1-T5 coarsely longitudinally striate to rugose in between; third-fifth metasomal tergites without sub-transverse striations posteriorly; sixth tergite finely striate.

Colour. Body colouration ivory to pale yellow with black markings. Antenna yellowish brown. Face without black infuscation, mandibles ivory, but tips dark brown to black. Stemmaticum black. Mesoscutum ivory to light brown except dark brown colouration at notaular anterior extremities. Propodeum black to brownish black in anterior half, with yellow median longitudinal area and pale lateral and posterior half. First metasomal tergite largely ivory to pale yellow except black to dark brown medio-basal patch.



◀**Fig. 18** *Canalirogas subtransversus* sp. nov. Female, holotype. **A.** Head in frontal view; **B.** Vertex; **C.** Mesosoma in dorsal view; **D.** Mesosoma in lateral view; **E.** Metasoma in lateral view

Medio-basal margin of second, fourth and fifth tergites dark brown, sixth tergite brown.

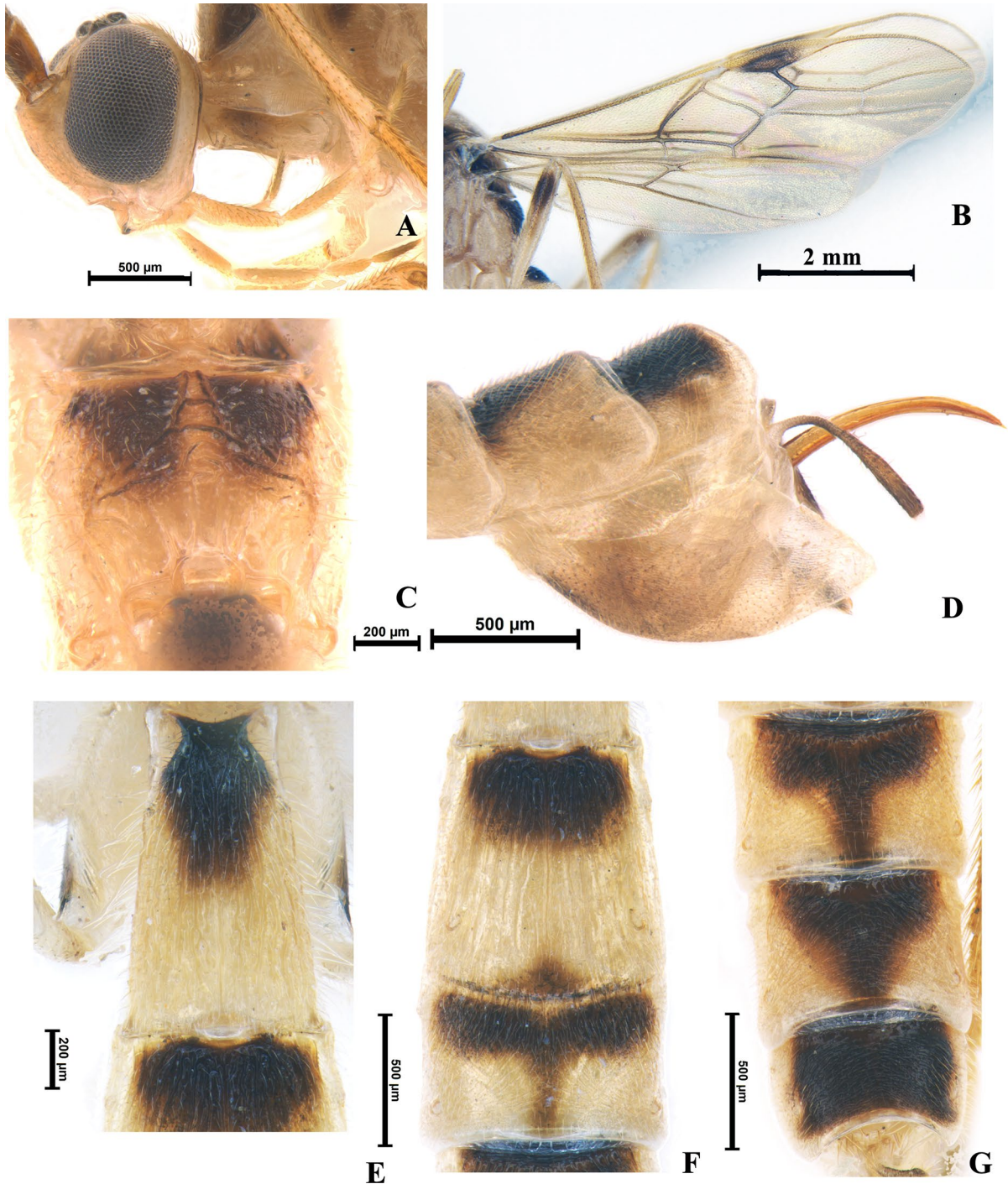


Fig. 19 *Canalirogas subtransversus* sp. nov. Female, holotype. **A.** Head in lateral view; **B.** Wings; **C.** Propodeum; **D.** Hypopygium; **E.** First tergite; **F.** Second and third tergites; **G.** Fourth–sixth tergites



Fig. 20 *Canalirogas subtransversus* sp. nov. Male, paratype, habitus, lateral view

V. *Canalirogas spilonotus* (Cameron, 1905)

Troporhogas spilonotus Cameron, 1905: 93. Lectotype female (BMNH: Hym. Type 3c.222 from Sri Lanka).

Canalirogas spilonotus Quicke & Shaw, 2005: 3531.

C. balgooyi van Achterberg & Chen, 1996: 70–73.

Brief diagnosis. Detailed description is given in Long & Achterberg, 2015. The range of variations include: antennal segments of female 44–51; eyes in dorsal view 6–8 × longer than temple and in lateral view width of eye about 3.8 × temple; first tergite 1.2–1.5 × as long as apical width; medial length of second tergite 1.5–1.6 × as long as third tergite medially and ovipositor stout.

Comment. This is a general diagnosis including all known variations from the literature. The types have not been physically examined in this study.

Discussion

Canalirogas van Achterberg & Chen, 1996 is a relatively small genus comprising altogether twenty-two known species from the Australasian and Oriental regions (van Achterberg & Chen, 1996; Yu et al. 2016; Long & van Achterberg, 2015). Prior to this study, the Indian fauna was poorly represented by barely one species, *C. spilonotus* (Long & van Achterberg, 2015).

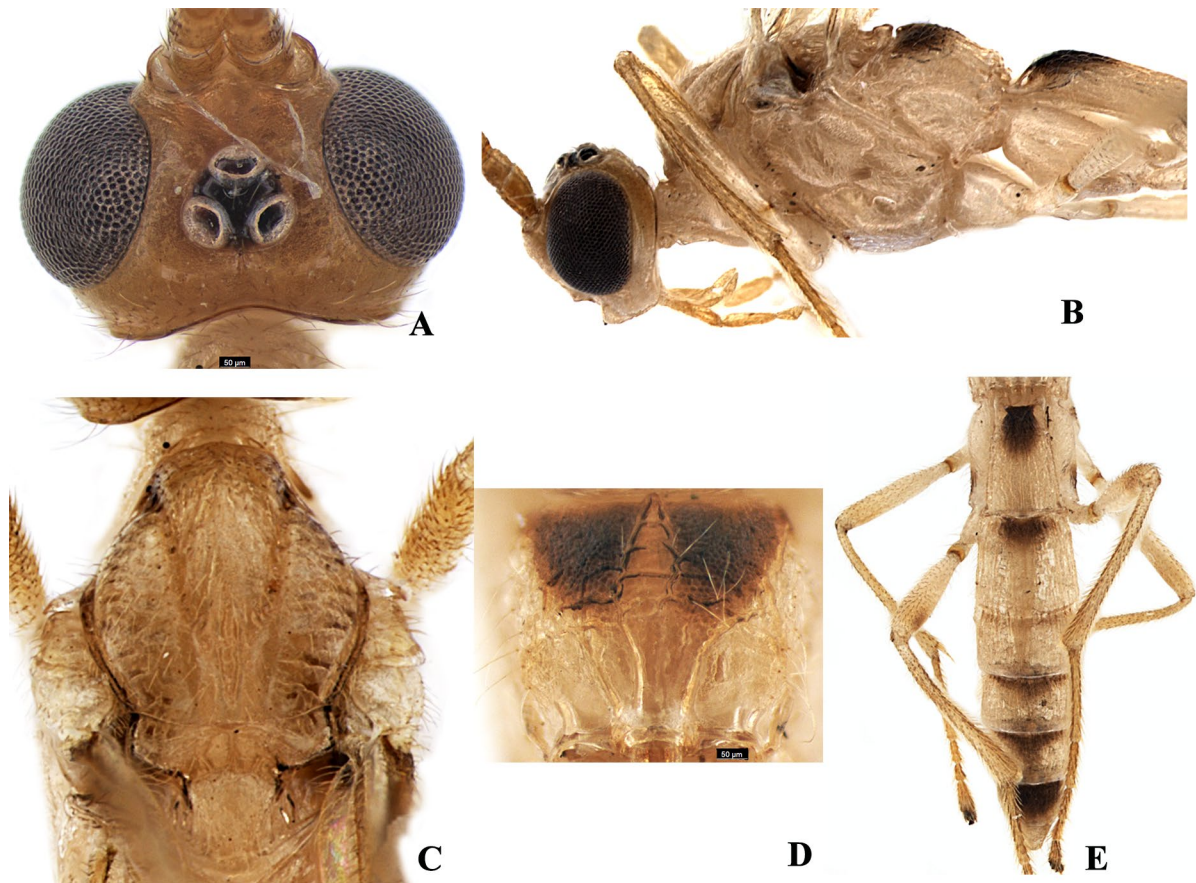


Fig. 21 *Canalirogas subtransversus* sp. nov. Male, paratype. **A.** Vertex; **B.** Head and mesosoma in lateral view; **C.** Mesosoma in dorsal view; **D.** Propodeum; **E.** Metasoma in dorsal view

Through this present study, the Indian fauna is enriched with four new species leading to a total of five species from the Indian mainland. All these five species have been documented from the biodiversity hot spots of India, with *C. multinigratus* sp. nov., *C. oblongus* sp. nov. and *C. subtransversus* sp. nov. from the north-eastern part of India, and *C. omnino-pallidus* sp. nov. and *C. spilonotus* from the Western Ghats in the southern part of India. The expeditions in the Himalayan range in northern India, which is one of the biodiversity hot spots, has not yielded any species of this genus so far. However, based on the present discoveries, expectations are high to encounter new species of this genus in future expeditions in the biodiversity hot spots.

Acknowledgements AG is grateful to the Indian Council of Agricultural Research, New Delhi and ICAR–NBAIR

for research facilities. AG gratefully acknowledges financial assistance from the Science and Engineering Research Board, Department of Science and Technology, New Delhi under the scheme: CRG/2021/001523 for undertaking Braconidae taxonomic studies. The authors are extremely thankful to the anonymous reviewers and the editor for critically reviewing this manuscript.

Author contributions AG conceptualization, investigation, project administration, supervision, surveys, specimen collection, writing species description, key preparation, imaging, figure plates preparation, comparing with other species and writing manuscript; CVA reviewing & editing manuscript, comparing with other known species; RP specimen collection, curation and preliminary identification; HKHM specimen collection and map preparation; SNS - facilitating expeditions and arranging funds. All authors reviewed the manuscript.

Funding Funding was provided by the Science and Engineering Research Board, New Delhi (CRG Grant No: CRG/2021/001523) and the Indian Council of Agricultural Research, New Delhi (ICAR–NBAIR MI funds).

Data Availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

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