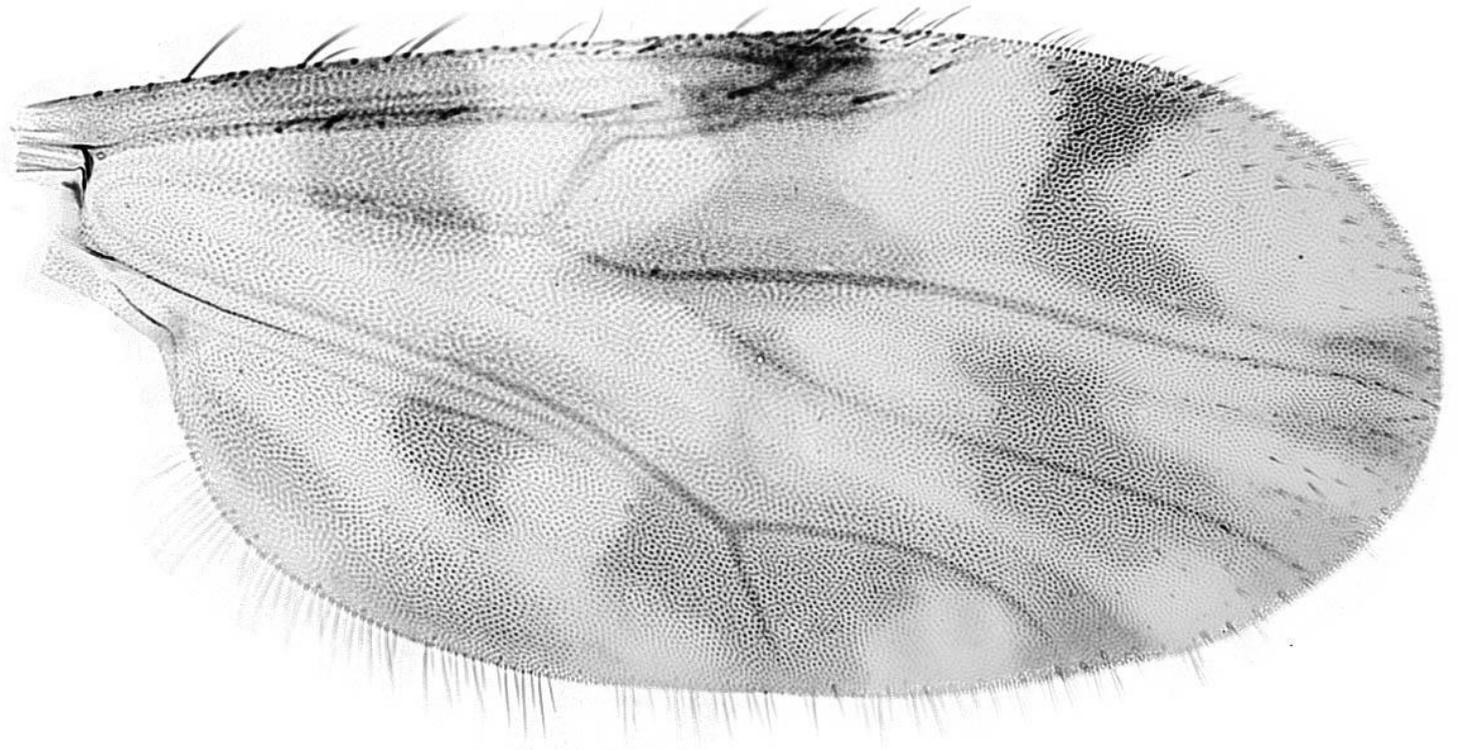
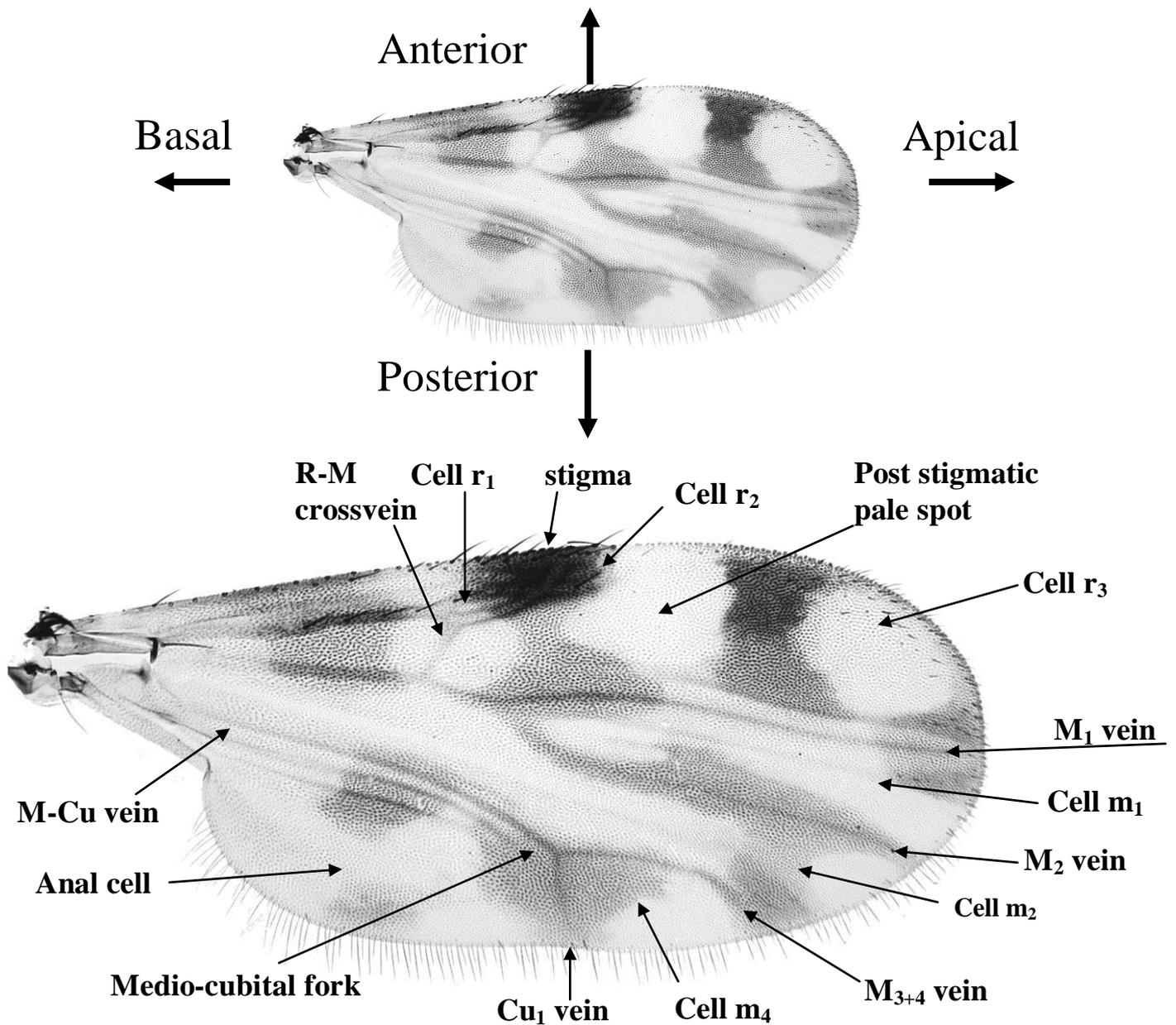


Key to females of economically important species of
Culicoides subgenus *Avaritia* from southern Asia and
Australasia using characters visible under a stereomicroscope



Glenn Bellis
Department of Agriculture
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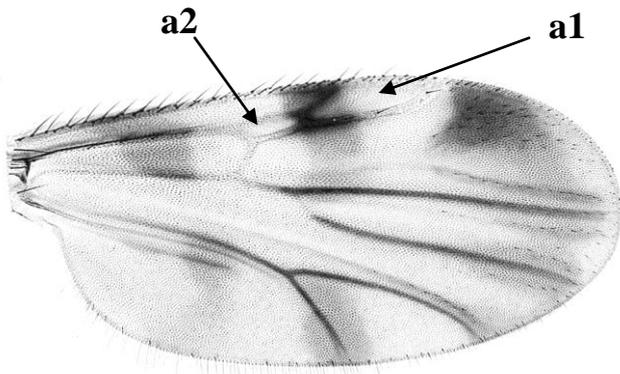
Orientation of a *Culicoides* wing



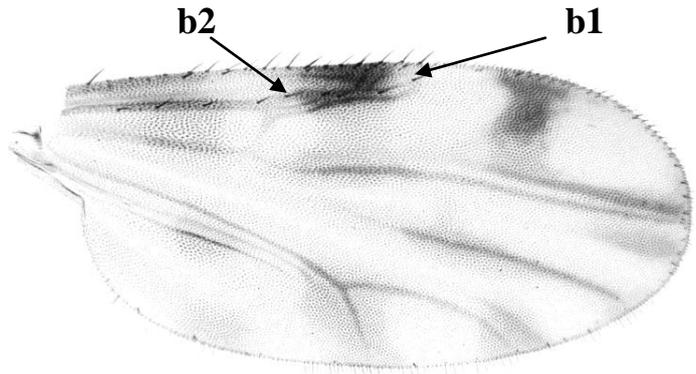
Note: This key aims to assist workers to separate the species belonging to *Culicoides* Subgenus *Avaritia* *sensu* Wirth & Hubert (1989) which have been reported to occur in southern Asia and Australasia. It has been extracted and expanded from Bellis G, Anderson S & Halling L (2015) A pictorial key to adult female *Culicoides* Latreille 1809 (Diptera: Ceratopogonidae) from the Northern Territory, Western Australia and South Australia. It is not a comprehensive treatment of the entire *Culicoides* fauna of the region as it does not include species belonging to other subgeneric groupings. Species included in this key conform to the diagnosis of *C. subg. Avaritia* provided by Wirth & Hubert (1989) which differs to the concept adopted by some other authors, for example Yu et al (2005), so does not include all species placed into *C. subg. Avaritia* by those authors.

The species included in the key are: *C. actoni* Smith, *C. albifascia*, *C. annandaliei* Majumdar & Das Gupta, *C. asiana* Bellis, *C. boophagus* Macfie, *C. brevipalpis* Delfinado, *C. brevitarsis* Kieffer, *C. dumdumi* Sen & DasGupta, *C. flavipunctatus* Kitaoka, *C. fulvus* Sen & DasGupta, *C. hui* Wirth & Hubert, *C. imicola* Kieffer, *C. jacobsoni* Macfie, *C. minimus* Wirth & Hubert, *C. nudipalpis* Delfinado, *C. obscurus* Tokunaga & Murachi, *C. orientalis* Macfie, *C. paraliui* DasGupta, *C. pastus* Kitaoka, *C. tainanus* Kieffer, *C. wadai* Kitaoka and an undescribed species related to *C. pastus*. The key is unable to distinguish between *C. annandaliei* and *C. hui* or between *C. brevipalpis* and *C. paraliui* as the status of these pairs of species requires taxonomic assessment. A further species reported from India, *C. autumnalis* Sen & DasGupta, is regarded as *nomen dubium* so has been omitted from the key.

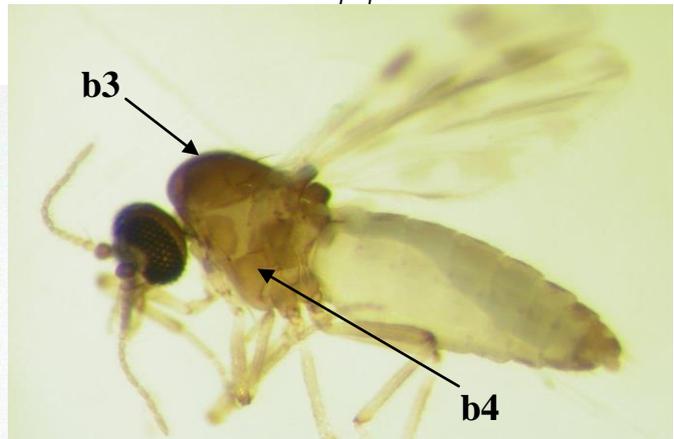
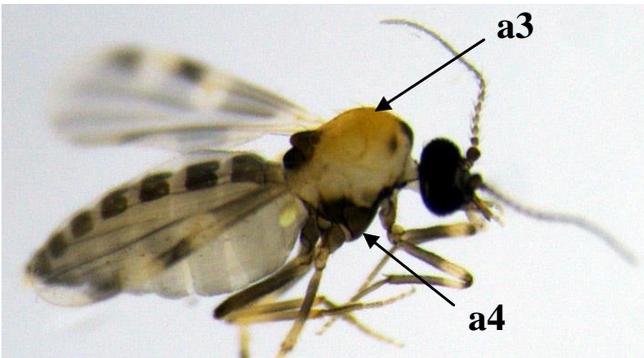
- Wing with cell r_2 (a1) long and broad, at least twice as long as cell r_1 (a2). Scutum and upper pleuron (a3) of most species yellow and distinctly paler than lower pleuron (a4)..... not subgenus *Avaritia*
 Wing with cell r_2 (b1) less than 1.5 times as long as cell r_1 (b2) but if larger then never twice as long,
 Scutum and upper pleuron (b3) predominately brown, similar in colour to lower pleuron (b4)..... 2



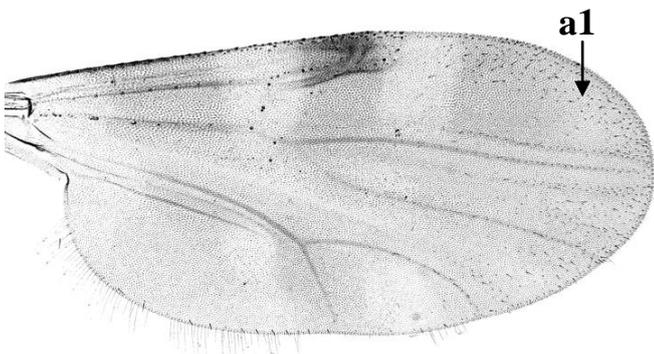
C. (Trithecoides) anophelis



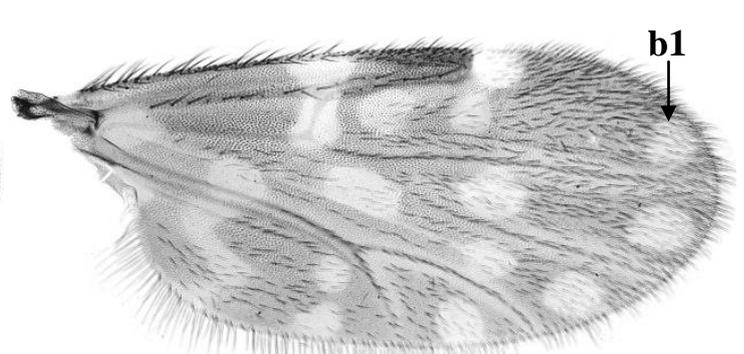
C. brevipalpis



- Wing with cell r_3 without distinct pale marking apical to post stigmatic pale spot (a1)..... 3
 Wing with cell r_3 with distinct pale marking apical to post stigmatic pale spot (b1)..... 5

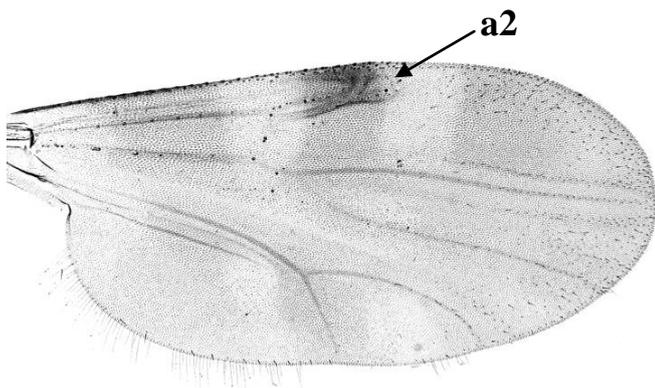


C. albifascia

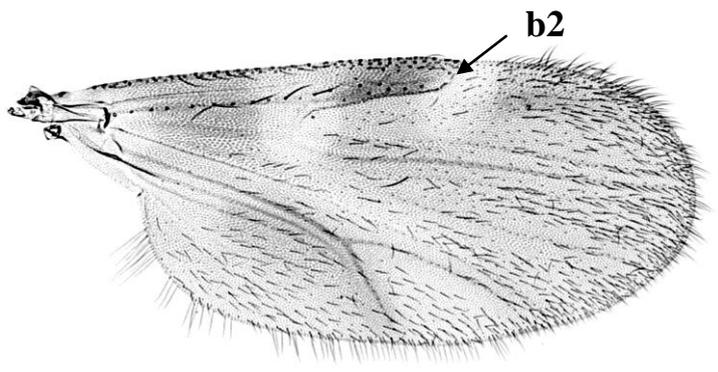


C. arakawai

3. Wing with part of lumen of cell r_2 included in post stigmatic pale spot (a1) ... Subgenus *Avaritia* (pt) 4
 Wing with cell r_2 dark to apex or at most, with only part of apical vein included in post stigmatic pale spot (b1) not Subgenus *Avaritia*



C. albifascia

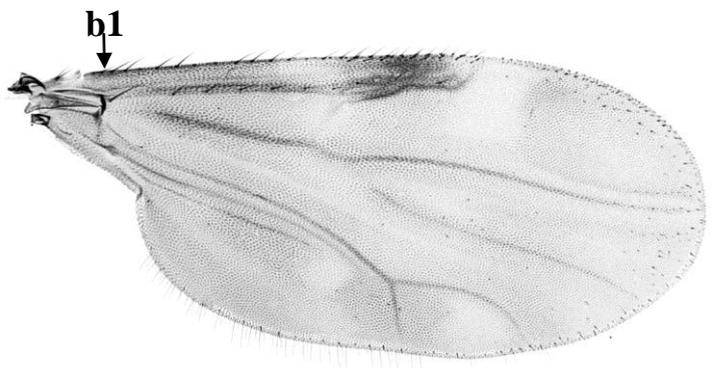


C. okinawaensis

4. Wing with pale marking at base of costa (a1) albifascia
 Wing with costa dark almost to base (b1) obscurus (pt)

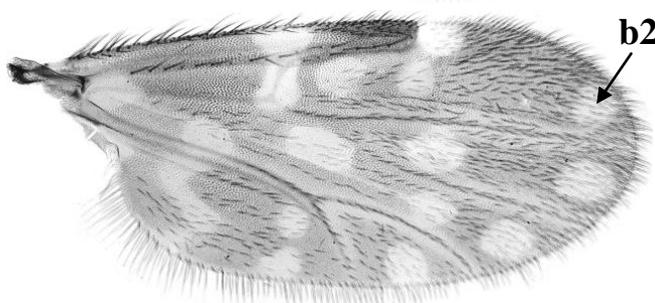
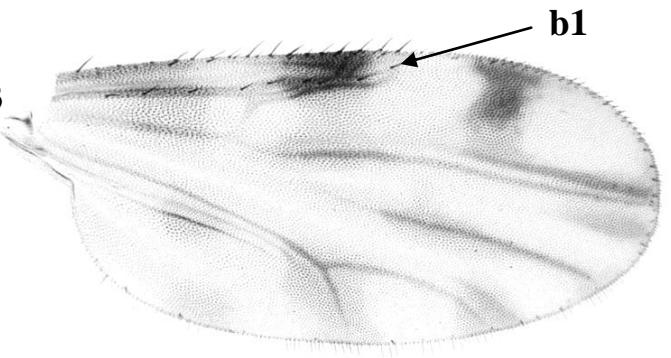
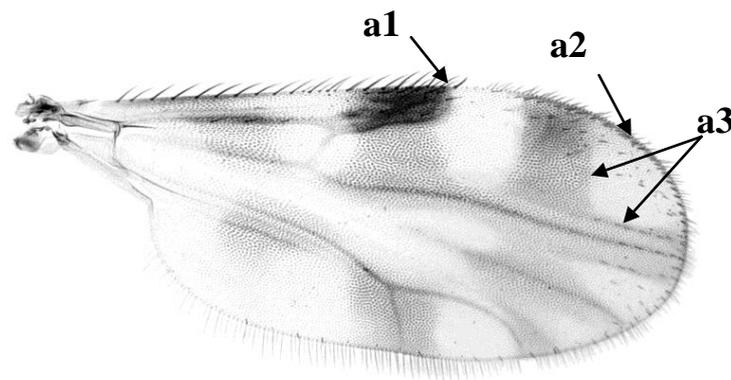


C. albifascia

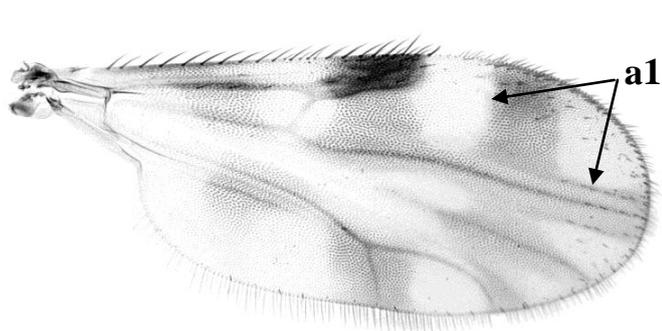


C. obscurus pale form

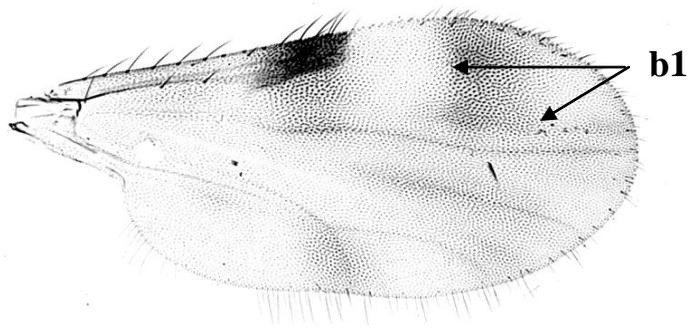
5. (2) Wing with both of the following characters: 1). Cell r_2 dark almost to apex (a1); and 2). apical pale marking in cell r_3 quadrant-shaped, i.e. reaching margin of wing (a2) and with straight basal and posterior margins (a3) Actoni Group of Subgenus *Avaritia* 6
 Wing with either of the following characters: 1). at least part of lumen of cell r_2 included in post stigmatic pale spot (b1) or 2). apical pale marking in cell r_3 ovoid, irregular or transverse and not quadrant-shaped i.e. either with basal and posterior margins not straight or not reaching the margin of the wing (b2) 7



6. Wing with pale markings relatively distinct with well defined edges (a1). Sensilla coeloconica present on flagellomere 10 *actoni*
 Wing with pale markings relatively indistinct and with poorly defined edges (b1). Sensilla coeloconica absent from flagellomere 10 *minimus*

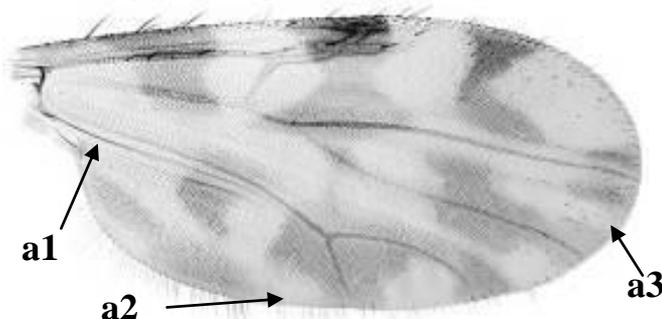


C. actoni



C. minimus

7. Wing with distinct pale marking continuous from base of M-Cu vein at base of anal cell (a1) to wing margin near apex of Cu₁ vein (a2) if unclear then apical pale spot in cell m₁ reaching margin of wing (a3)..... (subgenus *Avaritia*) 8
 Wing without distinct pale marking continuous from base of M-Cu vein at base of anal cell (b1) to wing margin near apex of Cu₁ vein (b2); if unclear then apical pale spot in cell m₁ not reaching margin of wing (b3)..... not *C. subg. Avaritia*



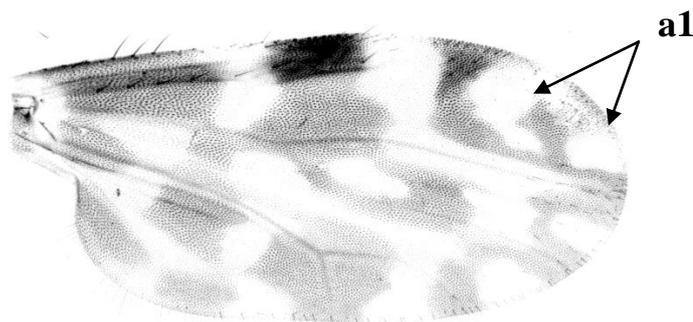
C. orientalis



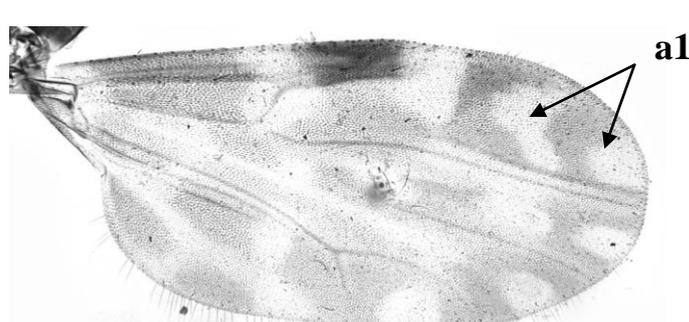
C. oxystoma

Subgenus *Avaritia*

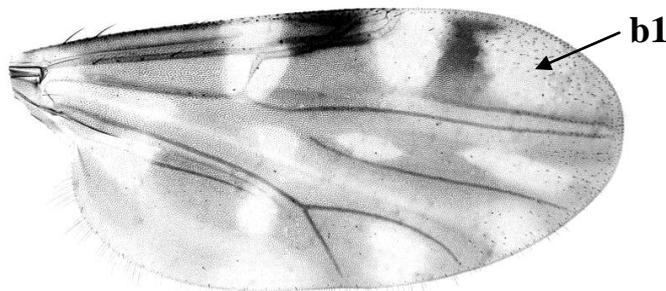
8. Cell r₃ with 2 pale spots distad of post stigmatic pale spot (a1) *annandalei/hui*
 Cell r₃ with 1 pale spot distad of post stigmatic pale spot (b1) or with apical pale markings indistinct (b2)..... 9



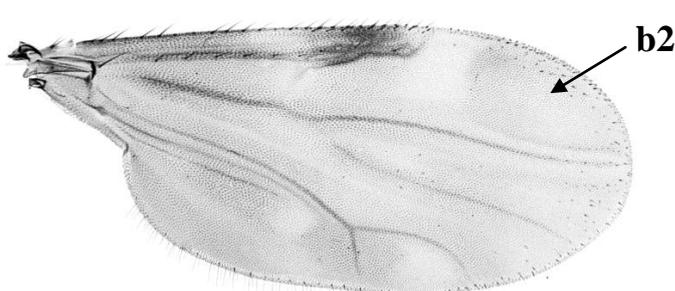
C. hui



C. annandalei

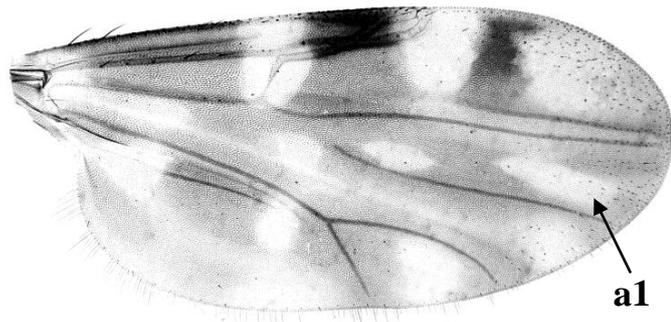


C. pastus

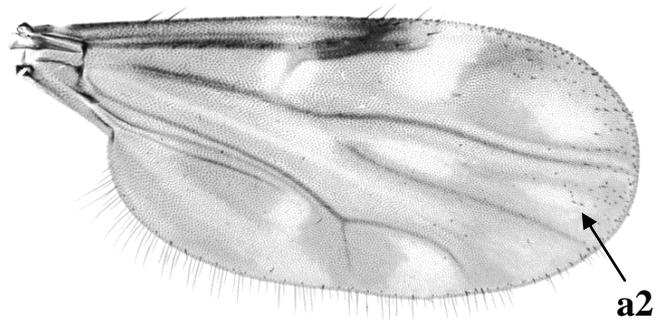


C. obscurus

9. Distal pale spot in cell m_1 not reaching wing margin (a1) or indistinct (a2)..... 10
 Distal pale spot in cell m_1 reaching wing margin (b1) 12



C. pastus

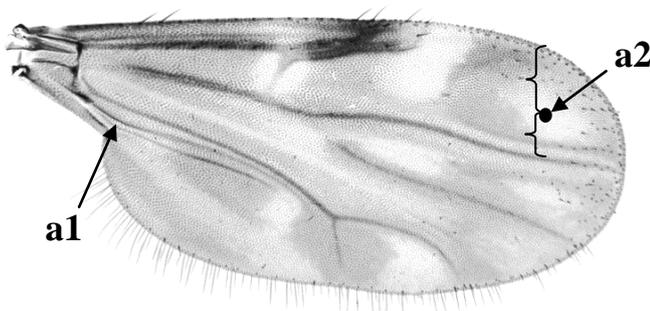


C. obscurus



C. brevipalpis

10. Base of M-Cu vein entirely enclosed in a large pale area (a1); centre of distal pale spot in cell r_3 closer to vein M_1 than to wing margin (a2), wing usually vaguely patterned, coastal species..... *obscurus*
 Base of M-Cu vein with distinct dark marking surrounded by paler area (b1); centre of distal pale spot in cell r_3 about midway between vein M_1 and wing margin (b1), wing always distinctly patterned..... 11

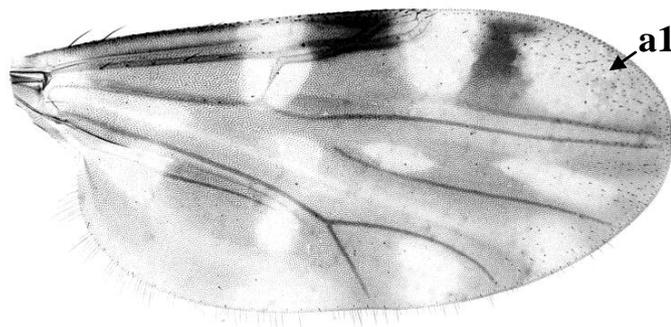


C. jacobsoni

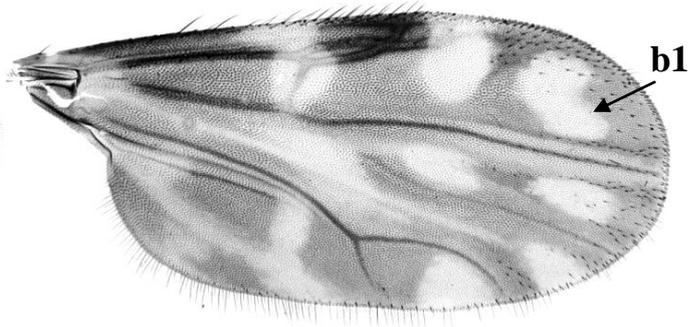


C. obscurus

11. Distal pale spot in cell r_3 with diffuse distal margin, often reaching wing margin (a1)..... *pastus*
 Distal pale spot in cell r_3 with distinct distal margin and usually crescent shaped, never reaching wing margin (b1)..... *jacobsoni*

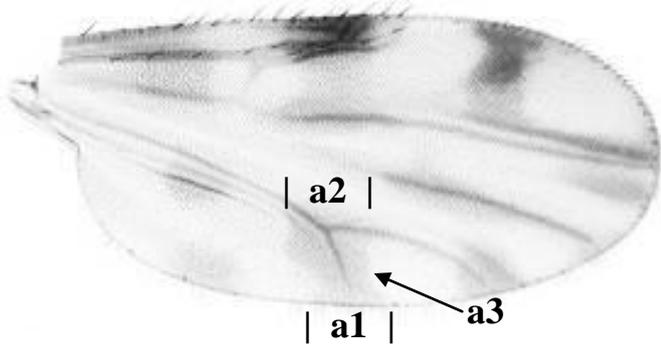


C. pastus

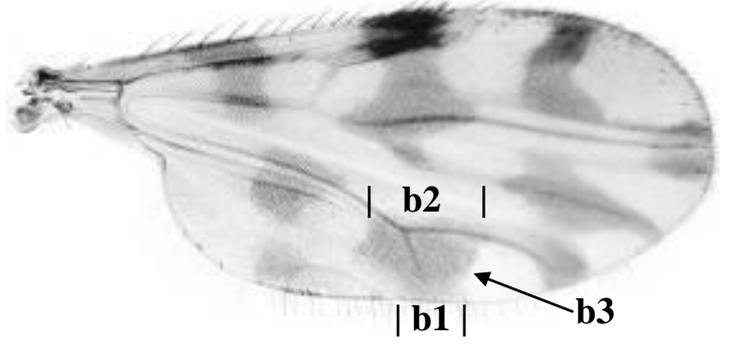


C. jacobsoni

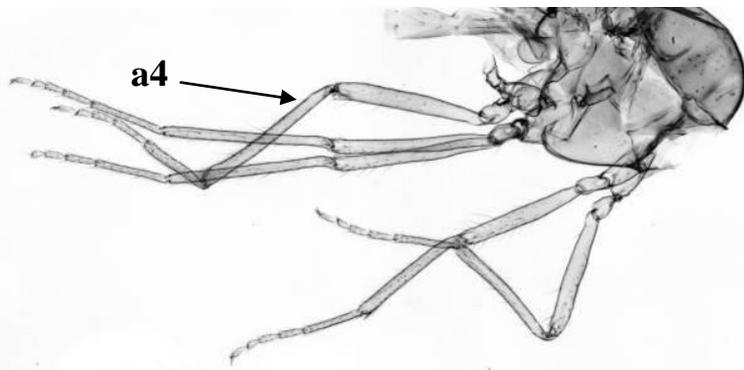
12. (9) Dark marking over Cu_1 vein rectangular with posterior width (a1) about the same as anterior width (a2) and with apical edge either more or less parallel to Cu_1 vein (a3); legs with indistinct markings and pale knees (a4) *brevipalpis*/ *C. paraliui*
 Dark marking over Cu_1 vein almost triangular with posterior width (b1) distinctly less than anterior width (b2) and with apical edge (b3) distinct and curved towards apex of wing, i.e. not parallel to vein Cu_1 ; legs with distinct pale banding at least on hind tibiae and all knees dark (b4) 13



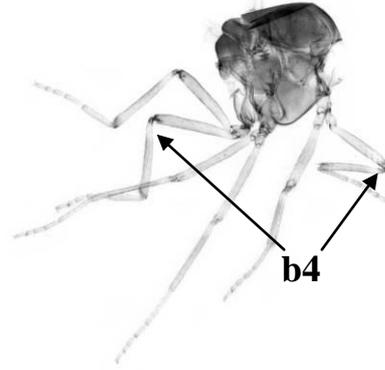
C. brevipalpis



C. fulvus



C. brevipalpis

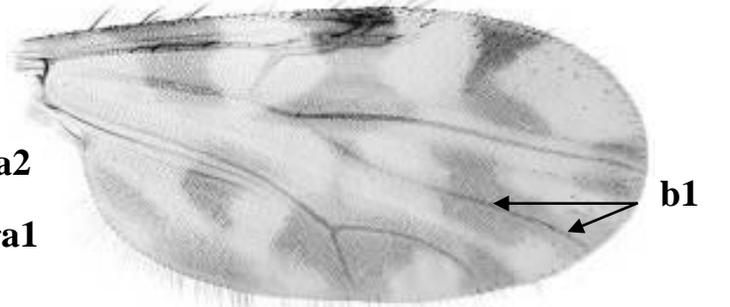


C. brevitarsis

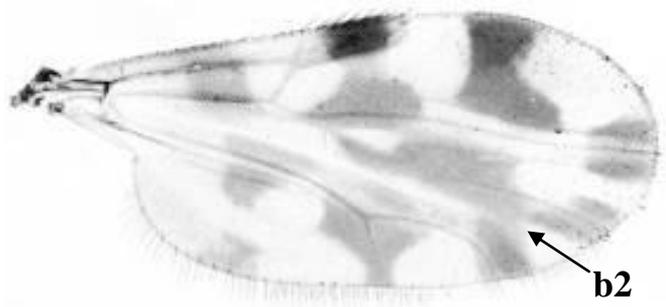
13. Dark marking at apex of vein M_2 quadrate (a1) and not joined to dark areas at midpoint of vein M_2 (a2) or apex of vein M_{3+4} (a3); anal cell with dark longitudinal stripe basally (a4) Boophagus group 14
 Dark marking at apex of vein M_2 not quadrate and either continuous to apex (b1) and/or joined to dark marking at apex of vein M_{3+4} (b2), if apparently separate (b3) then not quadrate and distinctly narrower than quadrate dark marking at end of vein M_1 (b4) and anal cell without dark longitudinal stripe basally (b5) 15



C. wadai



C. orientalis

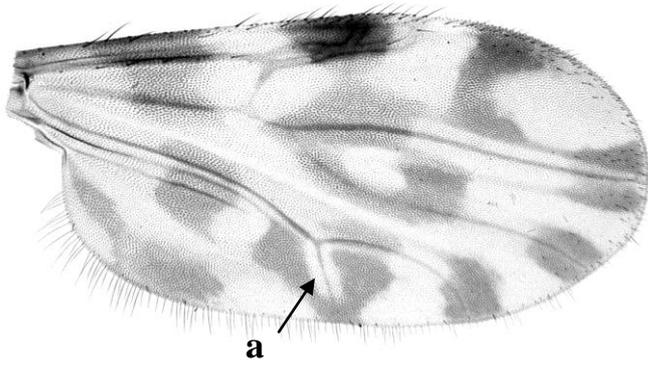


C. imicola

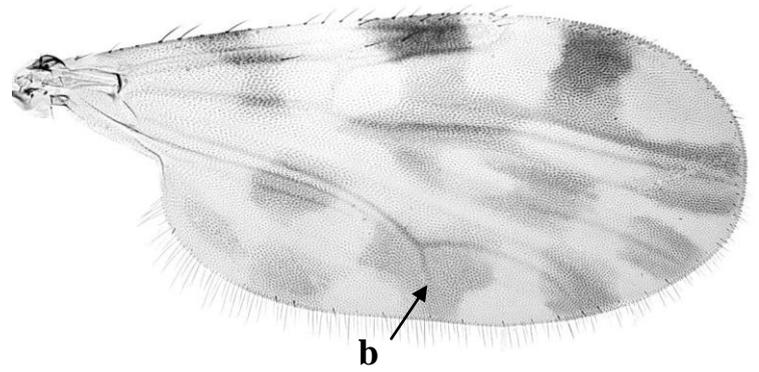


C. nudipalpis

14. Part of Cu_1 vein included in pale marking (a) *boophagus*
 Cu_1 vein entirely included in dark marking (b) *wadai*



C. boophagus



C. wadai

15. Apical pale marking in cell m_1 reaching or crossing vein M_2 subapically (a1) then narrowing apically (a2)..... *imicola/nudipalpis* (inseparable unless mounted onto slides to check proboscis length)
 Apical pale marking in cell m_1 not reaching or crossing vein M_2 subapically or if reaching vein M_2 then not narrowing apically (b1) 16

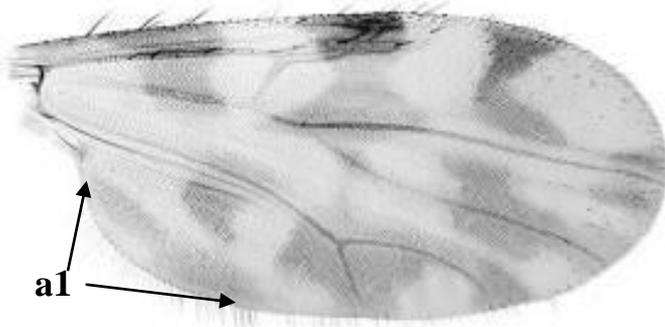


C. imicola

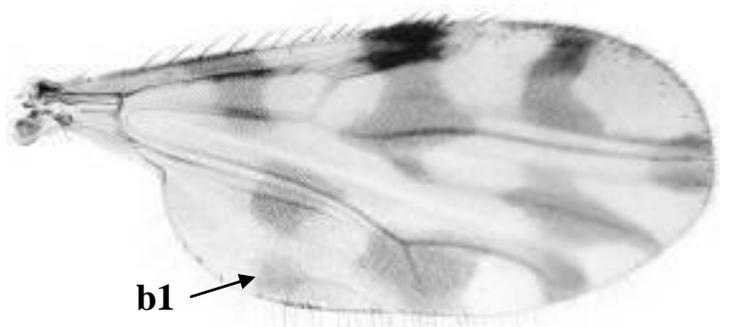


C. orientalis

16. Posterior dark marking in anal cell elongate and extending to base of the cell (a1)..... 17
 Posterior dark marking in anal cell quadrate or rounded, never extending to base of the cell (b1)..... 20

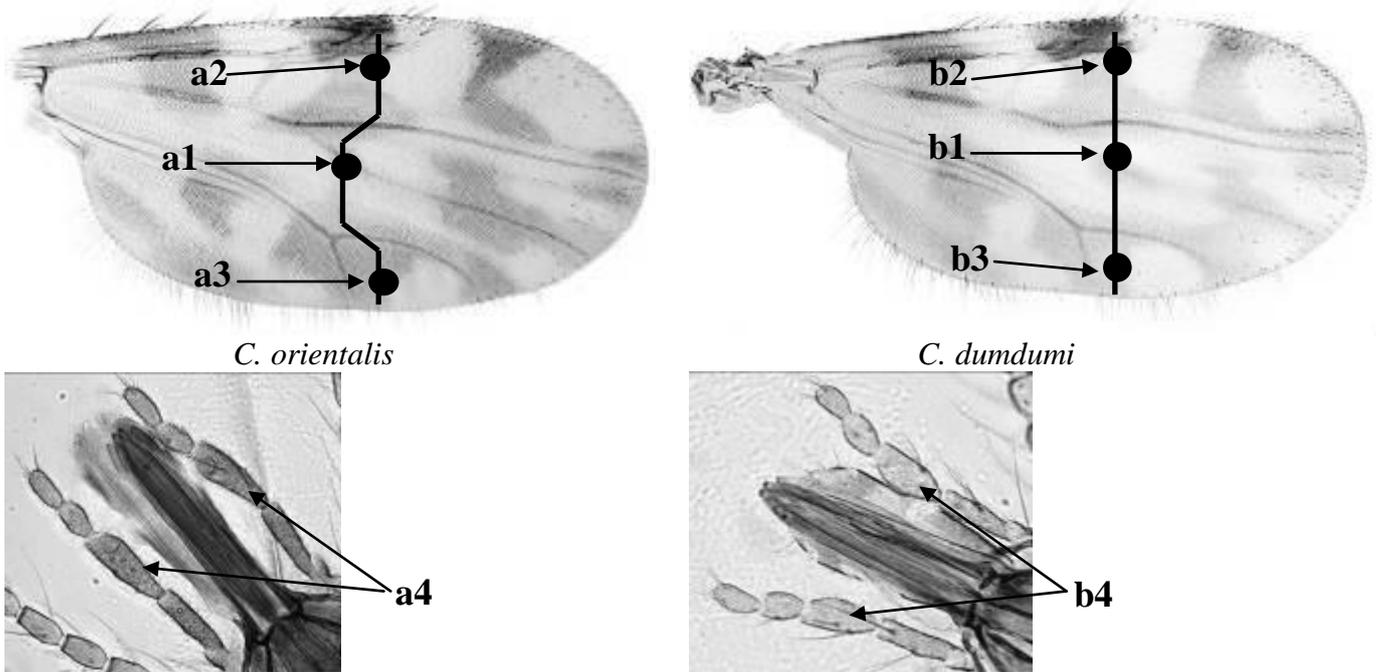


C. orientalis

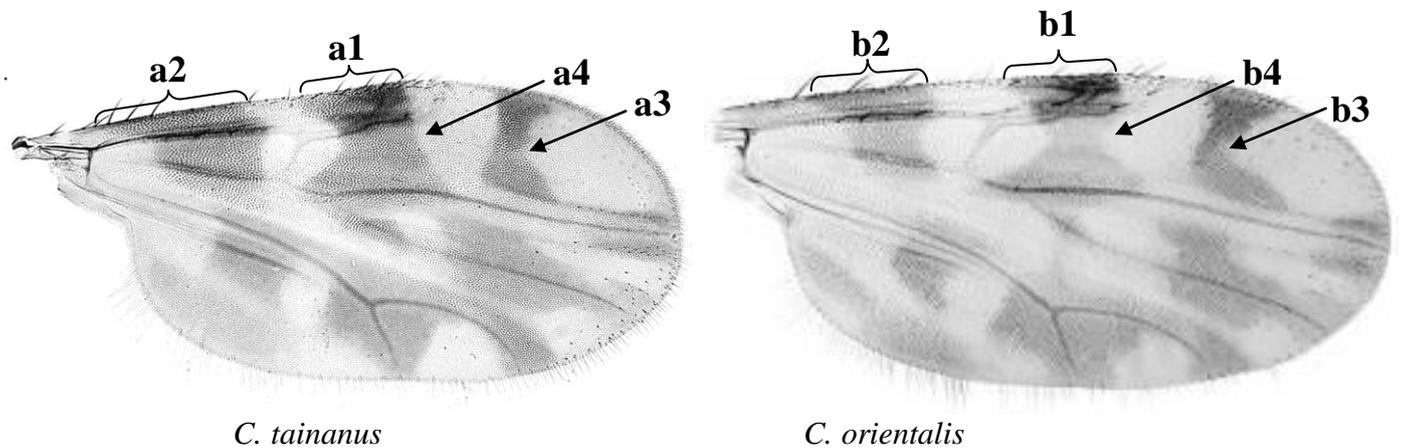


C. fulvus

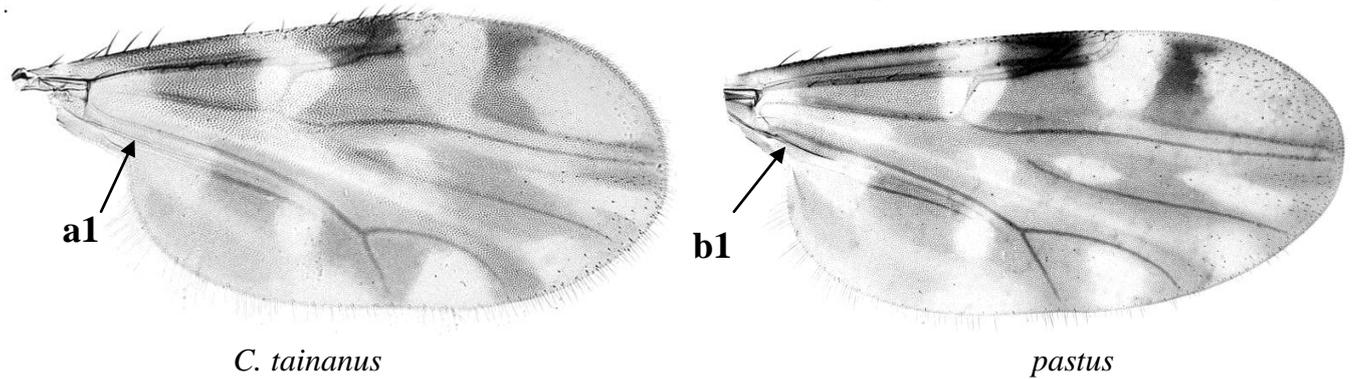
17. Proximal edge of basal pale spot in cell m_1 (a1) basal to distal edge of both post stigmatic spot (a2) and pale spot in cell m_4 (a3), 3rd palpal segment relatively long and dark (a4) 18
 Proximal edges of basal pale spot in cell m_1 (b1), post stigmatic spot (b2) and pale spot in cell m_4 (b3) roughly in a straight line, 3rd palpal segment relatively short and pale (b4)..... *dumdami*



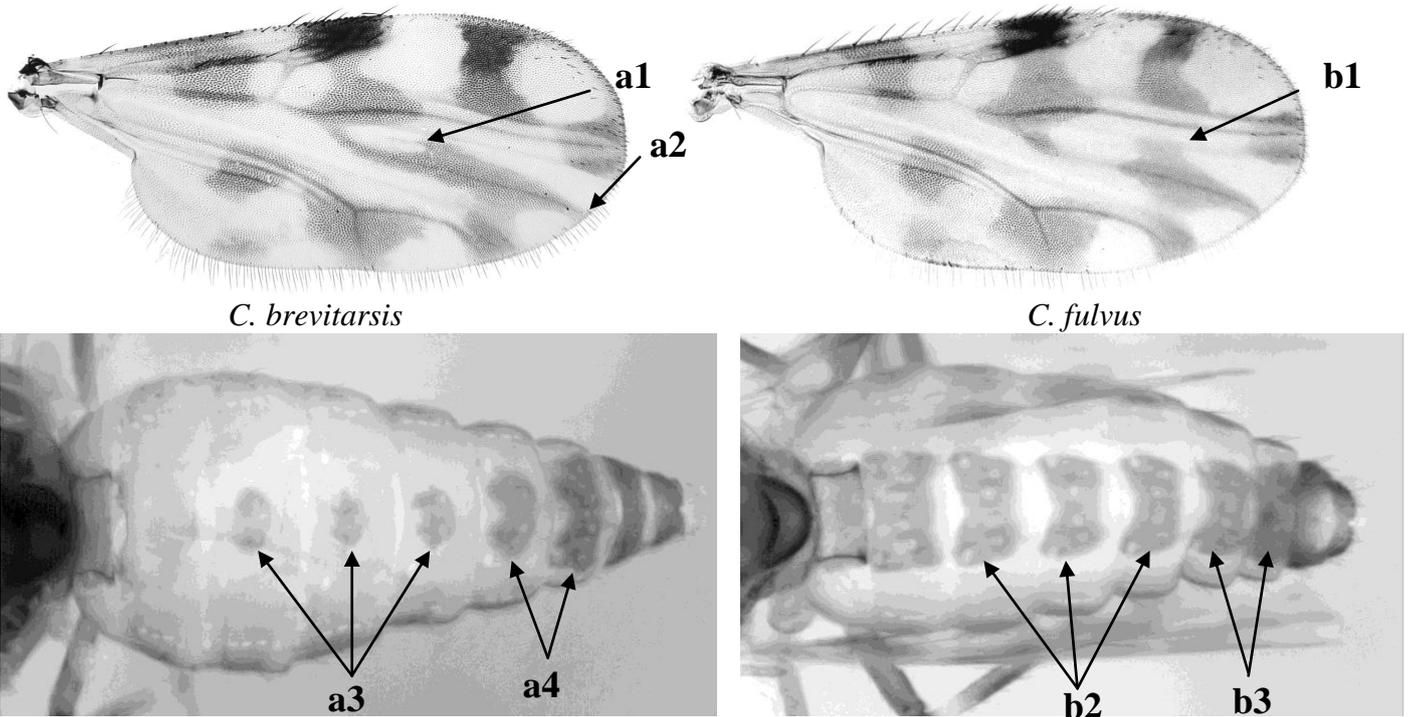
18. Stigma (a1) distinctly shorter than basal dark mark on costa (a2), dark mark in cell r_3 not so narrowed medially (a3), post stigmatic pale spot with basal edge evenly convex (a4) 19
 Stigma (b1) of similar length to basal dark mark on costa (b2), dark mark in cell r_3 distinctly narrowed medially (b3), post stigmatic pale spot with basal edge sinuate in most specimens (b4) *orientalis*



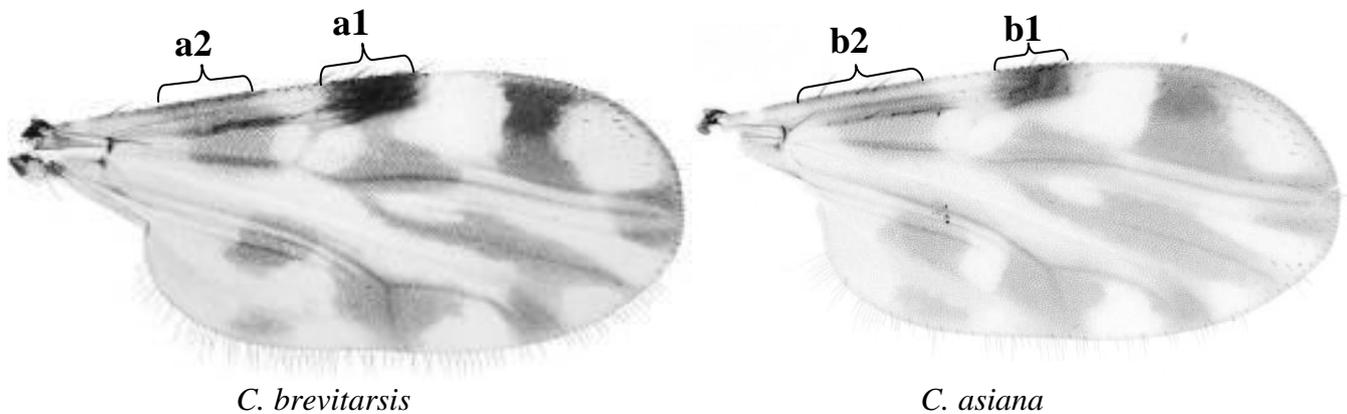
19. Base of M-Cu vein entirely enclosed in a large pale area (a1) *tainanus*
 Base of M-Cu vein with distinct dark marking surrounded by pale area (b1)..... *pastus* (pt)



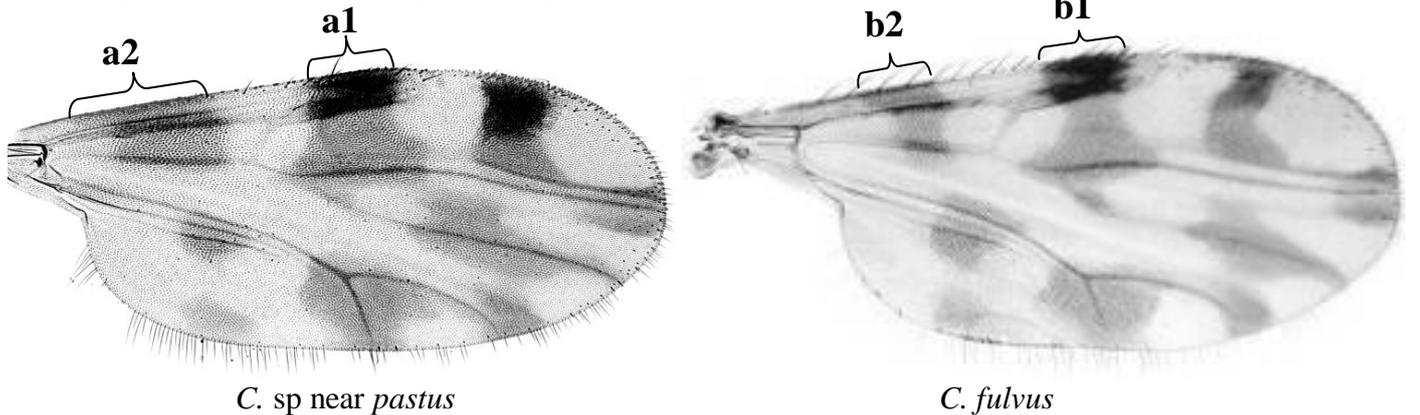
20. (16) Anterior edge of dark marking over vein M_2 more or less straight from apical margin of basal pale spot in cell m_1 (a1) to wing margin (a2); abdominal tergites III-V small, ovoid, no more than 1.5 times as wide as long (a3) and narrower than tergites VI and VII (a4) 21
 Anterior edge of dark marking on vein M_2 with 90° bend apicad of basal pale spot (b1); abdominal tergites III-V (b2) rectangular or crescent-shaped, about twice as wide as long and of similar size to tergites VI and VII (b3) 22



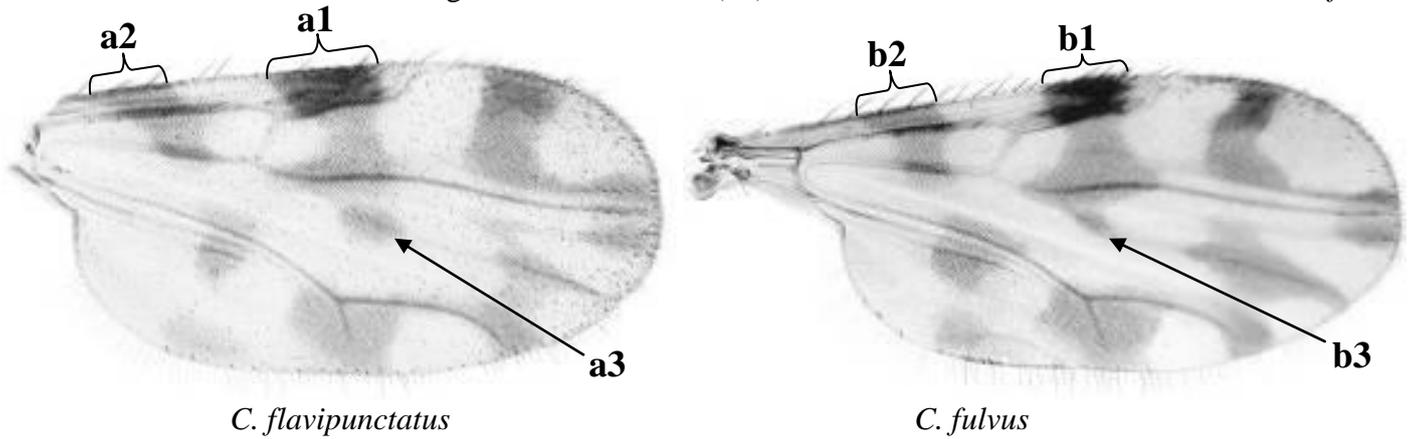
21. Wing with stigma (a1) of similar length to proximal dark marking on costa (a2)..... *brevitarsis*
 Wing with stigma (b1) distinctly shorter than proximal dark marking on costa (b2)..... *asiana*



22. Stigma (a1) distinctly shorter than basal dark mark on costa (a2).....near *pastus*
 Stigma (b1) of similar length or longer than basal dark mark on costa (b2), 23



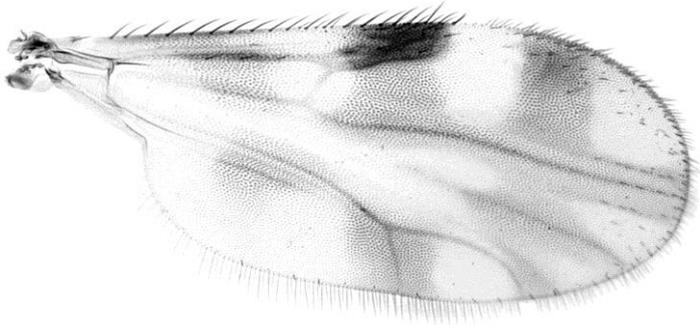
23. Stigma (a1) distinctly longer than basal dark mark on costa (a2), dark marking at base of vein M₂ more or less discrete and not part of other dark markings (a3) *flavipunctatus*
 Stigma (b1) of similar length to basal dark mark on costa (b2), dark marking at base of vein M₂ an extension of the dark marking at base of vein M₁ (b3) *fulvus*



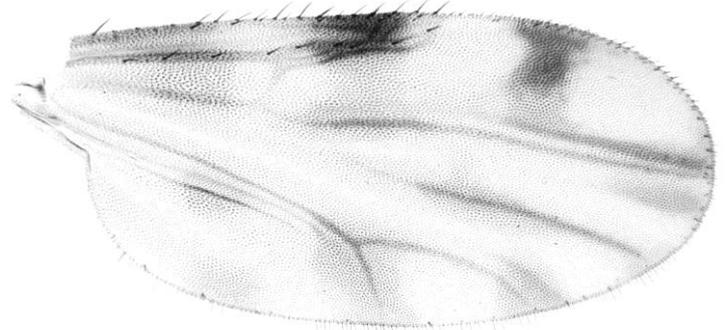
Acknowledgements

Wing photos of most species provided by Ian Roper and Craig O'Brien. Luke Halling, Stacey Anderson, participants at the Bluetongue Vector Identification workshop in Chennai, India, July 2013 assisted with testing the key. Lara Harrup, Simon Carpenter and YK Reddy organised the workshop that inspired production of this key.

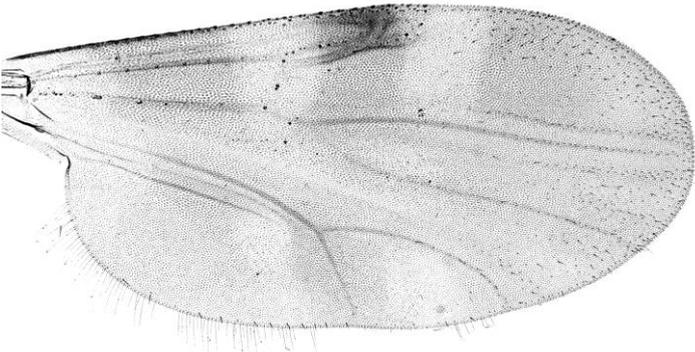
Wing picture atlas of Austro-Oriental *Avaritia*



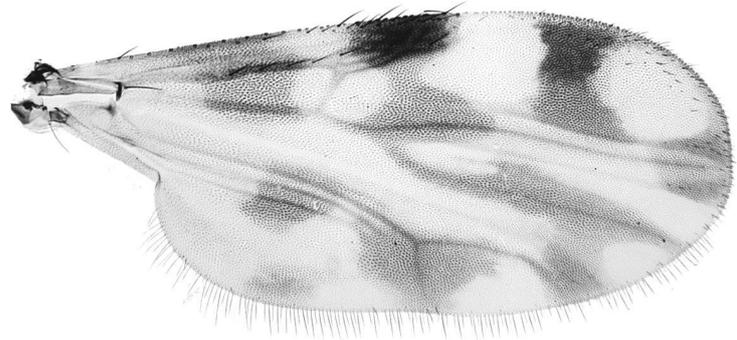
C. actoni



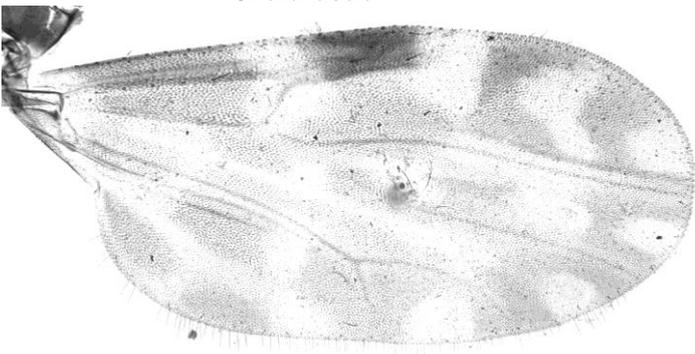
C. brevipalpis



C. albifascia



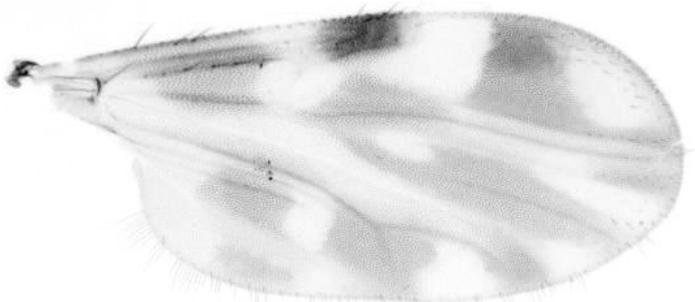
C. brevitarsis



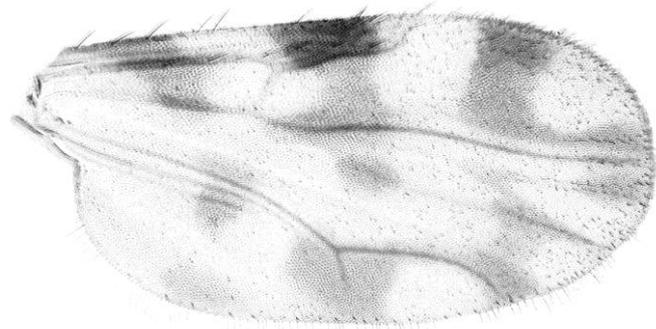
C. annandalei



C. dumdumi



C. asiana



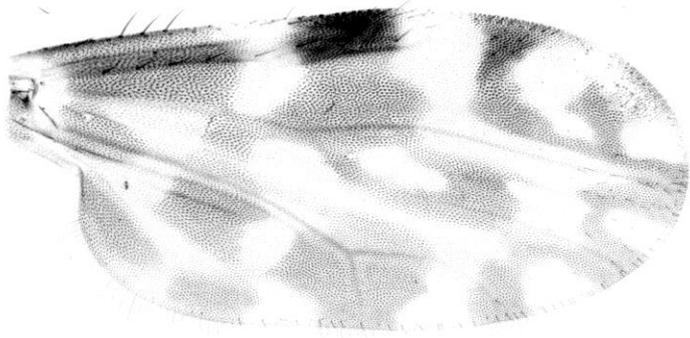
C. flavipunctatus



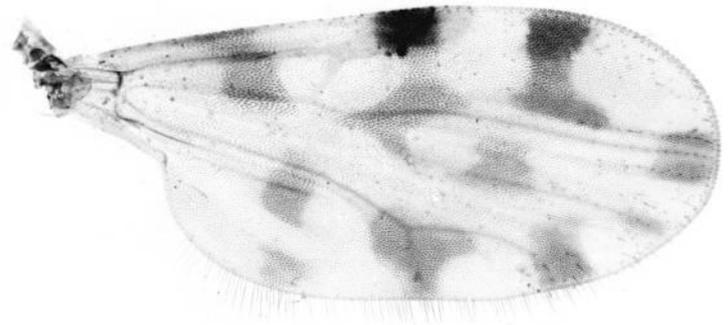
C. boophagus



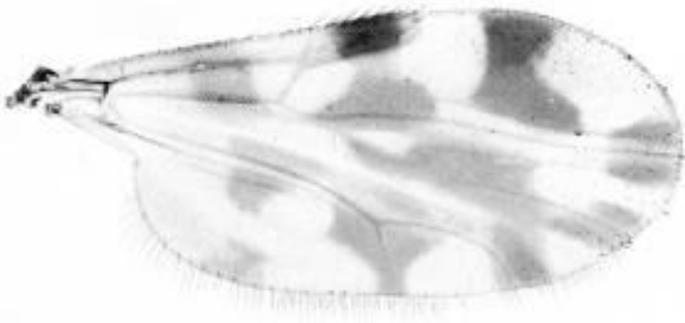
C. fulvus



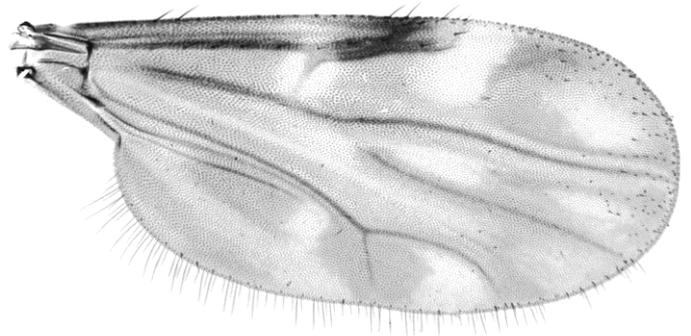
C. hui



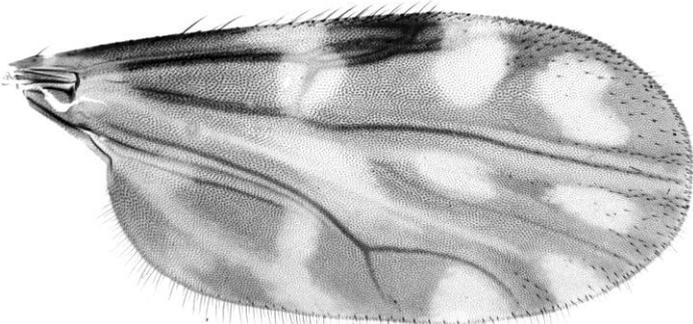
C. nudipalpis



C. imicola



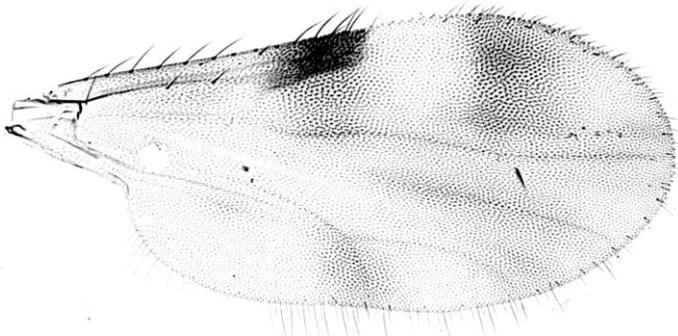
C. obscurus



C. jacobsoni



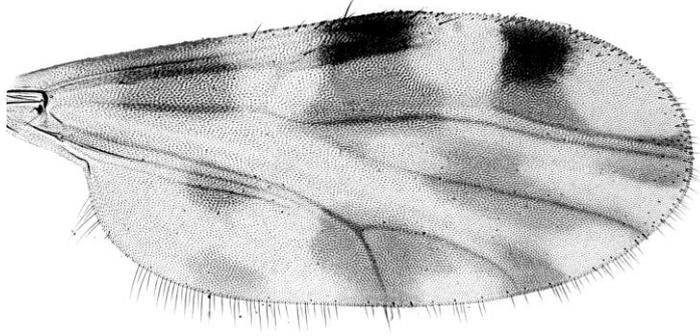
C. orientalis



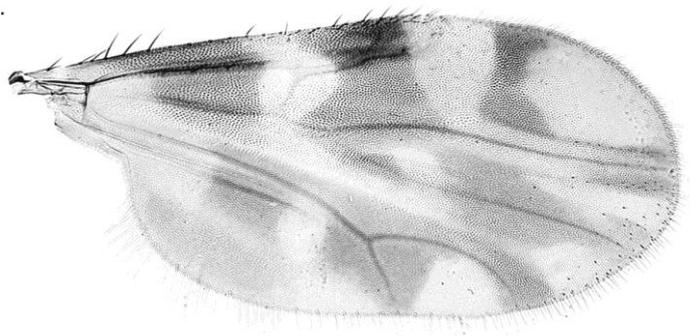
C. minimus



C. pastus



C. near pastus



C. tainanus



C. wadai