

Afrotropical *Culicoides* (Diptera: Ceratopogonidae): description of the hitherto unknown male of *C. walkeri* Boorman, 1979 from South Africa

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The genus *Culicoides* Latreille is represented by 160 described species in the Afrotropical Region; of these, approximately 10 % are plain-wing species, the wing lacking a distinctive pattern of pale and dark spots. This plain-wing sector includes *C. walkeri* Boorman which, till now, has been known only in the female, based on nine specimens from Kenya. The hitherto unknown male of *C. walkeri* is described here (and the female redescribed) based on material collected in South Africa since 1970. *Culicoides walkeri* can be distinguished from other plain-wing species in its pale ochreous colour, the robust shape of the male genitalia, and the sensilla coeloconica distribution which, uniquely, is the same in both sexes (occurring on flagellomeres 1–12). Though the feeding habits of *C. walkeri* are not known, its greatly inflated third palpal segment and the copious number of sensilla found on the flagellum, indicate it to be ornithophilic. *Culicoides walkeri* would appear to be confined to the frost-free savannas of the eastern length of Africa, from the equator southwards; its limited distribution in South Africa is mapped and shows that this uncommon species is confined to the Central Bushveld, the Lowveld and the Mopane bioregions. We propose that *C. walkeri* remain unplaced to subgenus.

Key words: taxonomy, biting midges, plain-wing species.

INTRODUCTION

Culicoides walkeri Boorman was described originally from nine females collected in southeastern Kenya (Boorman, 1979); the male was not collected at the time. Cornet & Nevill (1980), in their review of the taxonomy of 12 species of Afrotropical plain-wing *Culicoides*, did not treat *C. walkeri* as it had been described only months earlier. Glick (1990), in his subsequent review of the genus *Culicoides* in Kenya, provided a more complete description of *C. walkeri* based on a paratype housed in the National Museum of Natural History, Washington (USNM). In this study we describe the hitherto unknown male of *C. walkeri* (and redescribe the female) based on material collected in South Africa since the 1970s. Its obscure higher taxonomic affinities are discussed. The restricted distribution of *C. walkeri* in South Africa is mapped based on collections made since 1970.

MATERIAL AND METHODS

All the specimens of *C. walkeri* examined in this study were collected using the Onderstepoort Vet-

erinary Institute (OVI) black light suction trap and slide-mounted in Canada balsam; the specimens are housed in the Insect collection of the Agricultural Research Council – Onderstepoort Veterinary Institute (ARC-OVI). Specimens were examined using a Zeiss Axiostar compound microscope equipped with an ocular reticule for measurements. The measurements of the spermatheca include the smooth, curved neck up to where it joins the more hyaline, rugose duct; the measurements of the spermathecae provided below are derived from a single specimen (slide number RSA 34, N'watimhiri, Kruger National Park, 22.II.1986, black light). All measurements are given in micrometres (μm), except wing length (mm). Photographs were taken using a Canon PowerShot A640 camera and enhanced in Adobe Photoshop elements 3.0. Terms for structures follow Khamala & Kettle (1971) and Boorman (1989), except that: (i) the flagellar segments are numbered 1–13, not 3–15, and (ii) the proboscis/head (P/H) ratio, instead of the inverse (H/P), is used (P being the distance from the tip of the proboscis to the tormae and H the distance from the tormae to the insertion

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alveolus of the interocular seta). Terms for the various sensillae found on the flagellum follow Meiswinkel (1989). Maps were generated in ArcGIS version 9.3 and the bioregions of South Africa overlaid using a shapefile from Mucina & Rutherford (2006).

TAXONOMY

Culicoides walkeri Boorman, 1979, Figs 1, 2

Culicoides walkeri Boorman, 1979: 69 (female).

Holotype: ♀, Kiboko, Kenya, 900 ft elev., A.R. Walker, at light, IV.72–I.73. Paratypes: 59, same data as holotype; 29, same data, III.74: 19, Makindu, A.R. Walker, XI.73 (NHM, AVRJ).

Culicoides walkeri Boorman; Glick 1990: 191. Kenya (one paratype re-examined).

Non-type material examined

Limpopo, Bela-Bela, Mabula Lodge, 29/i/1997, 27.93, –24.75, A. Grimbeeck, 2♂; Limpopo, Eendvogelsdrift, Ellisras, 13/ii/1970, 28.22, –22.84, J.D. Bezuidenhout, 5♂; Mpumalanga, Kruger National Park (KNP), Dzundwini Hills, 19/xi/1985, 31.15, –22.76, R. Meiswinkel, 2♂, 1♀; Mpumalanga, Kruger National Park (KNP), Mondzu Fountain, 18/x/1992, 27.93, –24.75, R. Meiswinkel, 9♂; Mpumalanga, Kruger National Park (KNP), N'watimhiri, 22/ii/1986, 31.71, –25.10, R. Meiswinkel, 11♀; Mpumalanga, Kruger National Park (KNP), Shingwidzi, 19/iv/1983, 31.44, –23.11, R. Meiswinkel, 2♂; 2♀; Mpumalanga, Phalaborwa, 24/x/1996, 31.17, –23.97, L. Alberts, 2♂, 15/x/1997, 1♀, 29/i/1997, 2♀; Mpumalanga, Eiland, 2/iii/1984, 30.39, –23.88, R. Meiswinkel, 1♂; Mpumalanga, Sabie, Lisbon, 3/xii/1991, 31.37, –24.96, R. Meiswinkel, 1♂; Mpumalanga, Timbavati, Ceylon, 21/iii/2004, 31.38, –24.47, K. Labuschagne, 3♀.

Diagnosis

Medium-sized species, fresh specimens ochreous to light brown in colouration, anterior promontories distinctly paler, whitish. Wing unicolorous, without pale or dark markings. Sensilla coeloconica present on flagellomeres 1–12 in both sexes. Female eyes narrowly separated, third palpal segment inflated, sensory pit wide and deep; three slightly unequal, elongate-ovoid spermathecae situated deep within abdomen (in region of fifth abdominal segment). Male genitalia robust, parameres and aedeagus distinctive, gonocoxite lacking ventral

root, sternital membrane densely spiculate. Parameres is blade-like, broad at the base tapering to long simple inward curved tips and the aedeagus is triangular with a broad apex, its posterior margin undulated and thickened.

Description

Female ($n = 22$)

Head. Eyes (Fig. 1E) bare, narrowly separated by distance less than half width of an ocular facet. Flagellum (Fig. 1B): Lengths of flagellomeres 1–13: 41/29/29/30/30/28/31/34/44/46/53/57/73 μm . Mean antennal ratio (AR) 0.92 (0.85–0.97). Mean number ($n = 22$) and distribution of sensilla coeloconica on flagellomeres 1–13: 5.0/2.1/2.1/1.85/1.85/2.0/1.6/1.9/1.7/2.0/2.0/4.6/0; range in number of sensilla coeloconica on flagellomeres 1–13: 4-7/1-3/1-3/1-3/1-3/1-2/1-3/1-2/1-3/1-3/3-7/0. Number of sensilla coeloconica on flagellomeres: 29 (24–37). Number and distribution of sensilla chaetica on flagellomeres 1–13: 9/7/7/7/6/7/7/3/3/4/5/6. Number and distribution of long and short blunt-tipped sensilla trichodea on flagellomeres 1–13: two long (LL) and two short (cc) on flagellomeres 1–8, two short on 9, 10 (arrowed in Fig. 1B). Number and distribution of sensilla ampullacea: three on flagellomere 1 and one on 2. Palpus (Fig. 1E) with lengths of segments 1–5: 8/12/27/10/10. Mean palpal ratio (PR) 2.05 (1.91–2.27, $n = 20$); third segment moderately to strongly inflated with single, moderately deep and wide sensory pit. Mean P/H ratio 0.65 (0.61–0.72; $n = 21$). Mandible (Fig. 1F) with 12 (10–13) teeth.

Thorax. Scutum ochreous to light brown in colour, anterior promontories markedly paler, whitish. Halter pale. Wing (Fig. 1A): Mean length 0.90 (0.84–1.0; $n = 20$) mm. Mean costal ratio (CR) 0.54 (0.51–0.59; $n = 20$). Mean wing length/width ratio 2.1 (2.0–2.24; $n = 20$). Wing pale, yellowish to light brown, without any markings visible even under dark field illumination. Macrotrichia moderately dense, absent only in radial cells (rc) and in r5 immediately below rc; radial cells completely formed. Legs yellowish, without pale bands; only middle leg bearing a pair of short, erect spines apically on tarsomeres 1–3, single spine on tarsomere 4. Hindtibial comb with four spines, that nearest the spur longest. Mean tarsal ratio (T/R) 1.72 (1.56–1.80; $n = 20$).

Abdomen. Three, fully functional, ovoid spermathecae (Figs 1C, D) adorned with hyaline puncta-

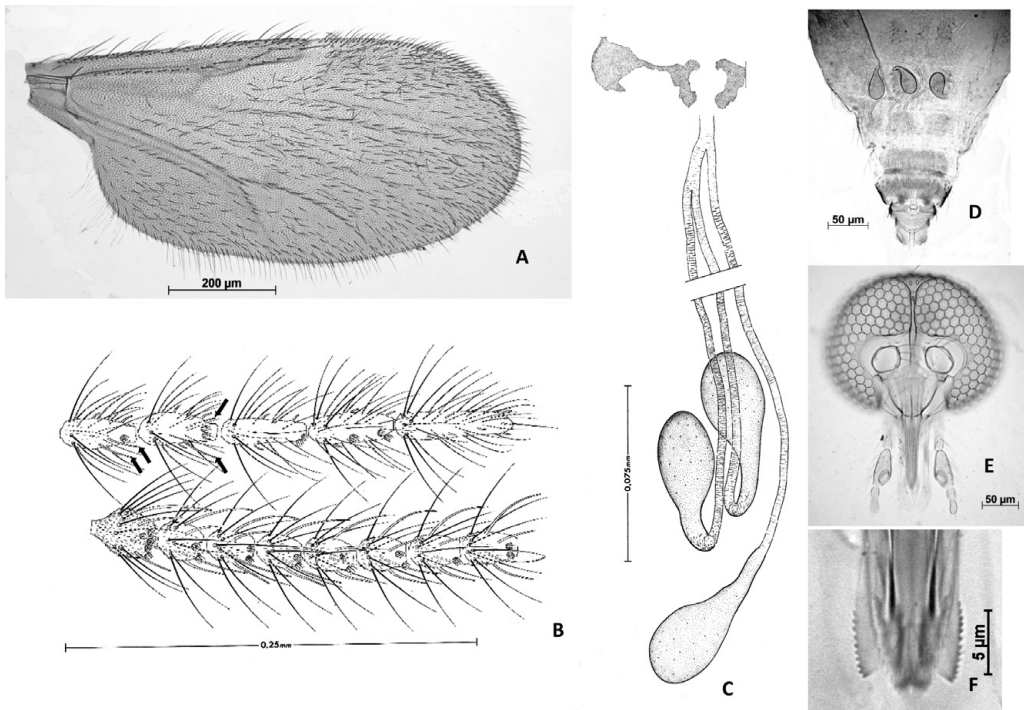


Fig. 1. Female of *Culicoides walkeri*. **A**, wing; **B**, antennal flagellum showing the arrangement of various types of sensillae; **C**, spermathecae including ducts and chitinous plates surrounding gonopore opening; **D**, abdomen illustrating the location of the spermathecae; **E**, head; **F**, mandibular teeth.

tions, each with long, curved sclerotized neck (approximately 20.5 µm), slightly unequal in size, measuring 86.3 × 39.5, 82.3 × 38.1 and 73.7 × 38.7 µm. Spermathecae situated deep within abdomen, between segments 4 and 5, ducts very long (one measured at 496 µm, *i.e.* almost six times length of spermatheca), unsclerotized, fused near gonopore, without sclerotized ring.

Male (Fig. 2) ($n = 25$)

Head (Fig. 2C). Eyes bare, separated by less than half width of an ocular facet. Flagellum (Fig. 2B): Lengths of flagellomeres 1–13: 75/33/29/27/25/25/25/25/28/78/72/77. Mean antennal ratio (AR) 0.97 (0.88–1.06; $n = 25$). Mean number ($n = 24$) and distribution of sensilla coeloconica on flagellomeres 1–13: 3.7/1.2/1.0/1.0/0.96/1.0/1.0/1.2/1.2/1.0/3.2/5.4/0; range in number of sensilla coeloconica on flagellomeres 1–13: 2–4/1–2/1/1–2/0–1/1–2/0–2/1–2/1–2/0–2/3–4/4–6/0. Number and distribution of sensilla chaetica on flagellomeres 11–13: 6/7/0. Number and distribution of long and short-tipped sensilla trichodea on flagellomeres 1–13: two long and two short

on flagellomeres 1–4 and two short on 5–10. Palpus (Fig. 2C): mean PR 1.98 (1.66–2.27; $n = 24$); third segment inflated with single deep, wide sensory pit. Mean P/H 0.53 (0.48–0.58; $n = 24$).

Thorax. Scutum ochreous to light brown in colour, anterior promontories markedly paler, whitish. Wing (Fig. 2A). Mean length 0.8 (0.68–0.89; $n = 25$) mm. Mean costal ratio (CR) 0.49 (0.46–0.52; $n = 25$). Mean wing length/width ratio 2.3 (2.2–2.4; $n = 25$). Legs: middle leg bearing a pair of spines on apices of tarsomeres 1–3 and 1 on 4.

Abdomen. Genitalia (Fig. 2D) stout, square. Gonocoxite significantly broader basally, lacking ventral root; dorsal root stout, moderately long and straight, projecting at 45°, its tip infuscate, rounded. Parameres erect, as two broad, closely approximated blades, basal third thickened and convoluted, not angled, directed anteriorly; apical two-thirds, initially broad, narrow abruptly into moderately long sharp, simple tips that halfway along lengths curve inwards and cross apically. Aedeagus robust, triangular, well-pigmented, narrowing gradually to broad apex, its posterior margin undulate, thickened, appearing to recurve

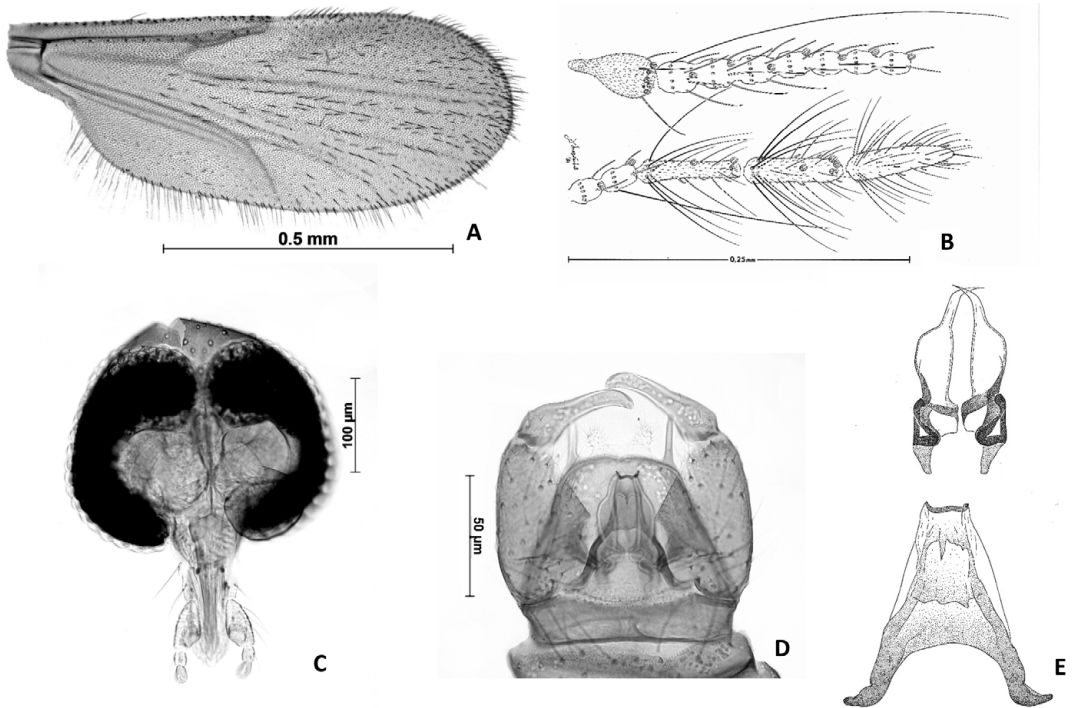


Fig. 2. Male of *Culicoides walkeri*. **A**, wing; **B**, schematic illustration of flagellum; **C**, head; **D**, male genitalia (above right and below), parameres (above left) and aedeagus (below left).

forwards fractionally; aedeagal arch moderately high, rounded, basal feet well-developed, projecting outwards at right angles. Sternum 9 broad but narrow, posterior margin wide but shallow, membranous area densely speculate up to 'feet' of aedeagus, spicules long. Tergum 9 trapezoidal, narrowing gradually, apicolateral processes long and slender throughout, not diverging, but parallel; gonostylus stout, terminating in slightly recurved tips.

Immatures

The immature stages and larval habitat of *C. walkeri* remain undescribed.

Distribution

Kenya: Kiboko, Makindu. South Africa: Limpopo Province and eastern Mpumalanga. For detailed distribution records within South Africa see Table 1 and Fig. 3.

DISCUSSION

In *Culicoides*, the female possesses either one, two or three fully developed spermathecae; most

species have two (including a rudimentary third, which in rare instances, may appear as a fully developed third spermatheca). Amongst the 160 described species of Afrotropical *Culicoides*, the females of only *C. ochrothorax* Carter, *C. fulvithorax* (Austen), *C. engubandei* de Meillon and *C. walkeri* possess three fully developed spermathecae. The first two belong to the subgenus *Trithecooides* Wirth & Hubert; their patterned wings help separate them easily from the plain-winged *C. engubandei* and *C. walkeri*. Fresh specimens of *C. engubandei* reveal a dark, almost blackish species with a slender third palpal segment; besides overall colouration, *C. engubandei* differs from *C. walkeri* in numerous other ways, the reduced number of sensilla on the flagellum and the kidney-shaped spermathecae being the most prominent. *Culicoides engubandei* belongs to the subgenus *Pontoculicoides* Remm. *Culicoides walkeri* remains unassigned.

The arrangement of the seven types of sensillae situated on the female flagellum is important for species identification, though most students of the genus document only the sensilla coeloconica. Amongst the six remaining types of sensillae, the long (L) and short (c) blunt-tipped sensilla

Table 1. Sites where *Culicoides walkeri* was collected with their GPS coordinates.

Site number	Collection site	Latitude (South)	Longitude (East)
1	Mpumalanga: KNP, Manyahule	25°03'	31°28'
2	Mpumalanga: KNP, Nwaswitshaka	25°02'	31°31'
3	Mpumalanga: KNP, Nwarivake	24°35'	31°35'
4	Mpumalanga: KNP, Skukuza	24°59'	31°35'
5	Mpumalanga: KNP, Manzimahle	24°55'	31°39'
6	Mpumalanga: KNP, Renosterkoppies	25°08'	31°39'
7	Mpumalanga: KNP, Nyamari fountain	24°09'	31°39'
8	Mpumalanga: KNP, Mutlumuvi	24°50'	31°39'
9	Mpumalanga: KNP, N'watimhiri	25°01'	31°43'
10	Mpumalanga: KNP, Ngotso-south	24°15'	31°45'
11	Mpumalanga: KNP, Mondzu fountain	24°45'	31°56'
12	Mpumalanga: KNP, Mlondosi	24°55'	31°50'
13	Mpumalanga: KNP, Nwanetsi, Gudzani dam	24°25'	31°5'8
14	Mpumalanga: Komatipoort	25°31'	31°58'
15	Mpumalanga: Hectorspruit	25°26'	31°40'
16	Limpopo: KNP, Dzundwini Hills	22°46'	31°09'
17	Mpumalanga: KNP, Mlondosi/Sabie rivers	25°09'	32°00'
18	Limpopo: KNP, Shingwidzi	23°07'	31°26'
19	Mpumalanga: Hazyview, Lisbon	24°58'	31°26'
20	Limpopo: Phalaborwa	23°58'	31°10'
21	Mpumalanga: Timbavati, Ceylon	24°28'	31°23'
22	Limpopo: Louisville	24°43'	30°29'
23	Limpopo: Tshipise	22°37'	30°10'
24	Limpopo: Eiland	23°53'	30°23'
25	Limpopo: Musina, Grasplaas	22°33'	29°59'
26	Limpopo: Ellisras, Eendvogelsdrift	22°50'	28°13'
27	Limpopo: Bela-Bela, Mabula	24°45'	27°56'
28	Limpopo: Ellisras, D'Nyala	23°44'	27°49'
29	Limpopo: Ellisras	23°40'	27°04'
30	Limpopo: Mokopane, Grootklip	24°34'	29°29'

trichodea found on flagellar segments 1–8 facilitate allocation of a species amongst one of two *Culicoides* groups: those with an LLc (more common) or an LLcc (rarer) distribution. With reference to the 16 described plain-wing Afrotropical species, three fall within the LLcc sector and along with *C. walkeri*, comprise *C. arenarius* Edwards and *C. murphyi* Clastrier & Wirth. All three species share also a 1–12 sensilla coeloconica distribution. Khamala & Kettle (1971), recorded it as 1–13 during their redescription of *C. arenarius*, but examination of one of Edwards' paratypes shows this was either made in error, or they were dealing with another species. The spermathecae in *C. arenarius* are small, round and unpigmented *sensu* Khamala & Kettle (1971); the male is unknown. *Culicoides murphyi* and *C. walkeri* differ from

C. arenarius in the larger size and shape of the spermathecae, pear-shaped in *C. murphyi* and elongate-ovoid in *C. walkeri*. *Culicoides murphyi* differs further from *C. walkeri* in having fewer sensilla coeloconica on the female flagellum (16–17 as opposed to 24–37 in *C. walkeri*). According to Cornet & Nevill (1980), the male of *C. murphyi* has only a single short (c) blunt-tipped sensilla trichodea on flagellar segments 2–10 as opposed to the two in *C. walkeri*. Boorman and Dipeolu (1979) recorded the sensilla coeloconica for the male of *C. murphyi* as 1–4, 11–12 compared to the 1–12 for *C. walkeri*. The same sensilla coeloconica distribution in both the males and female appears to be rare and unique for this species.

With reference to the male genitalia, there is a lack of consensus in the literature. According

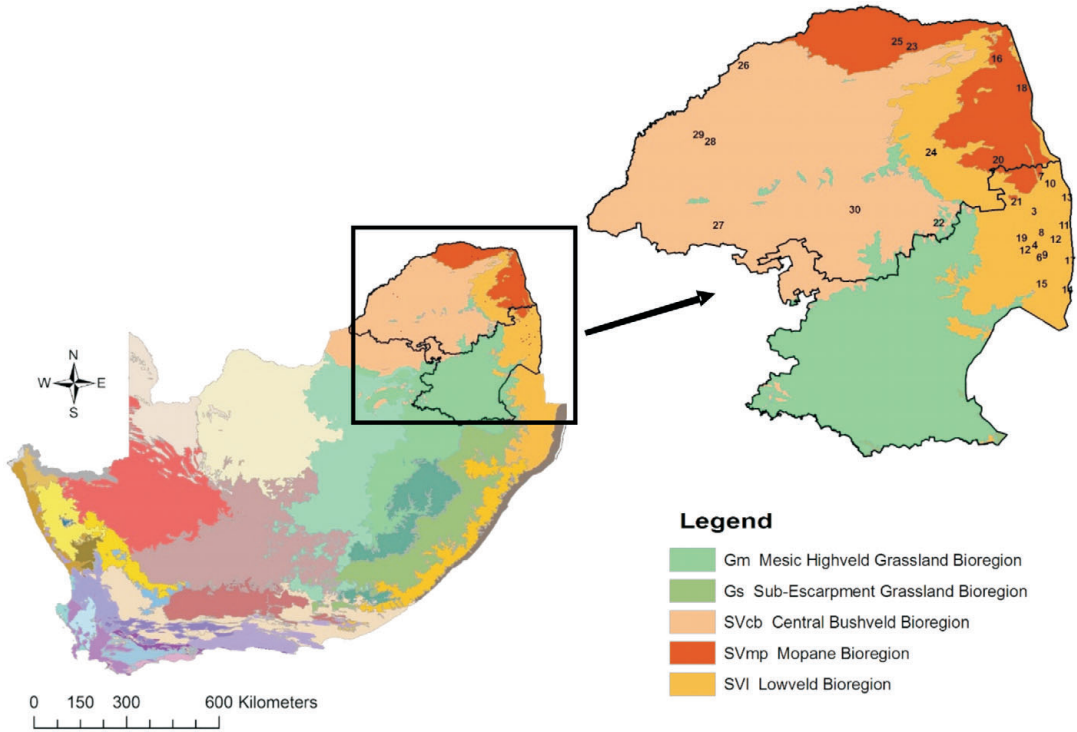


Fig. 3. Map showing the distribution of *Culicoides walkeri* in South Africa and the three savanna biomes to which it is restricted. Numbers indicate sites positive for *C. walkeri* (Table 1).

to Clastrier & Wirth (1961), the gonocoxite in *C. murphyi* lacks a ventral root, whereas Boorman & Dipeolu (1979) describe (and illustrate) it as ‘short, stout and pointed’; furthermore, Boorman & Dipeolu describe the sternital membrane as bare, whereas Clastrier & Wirth illustrate it as finely spiculate. Close examination of a photomicrograph of the male genitalia of a specimen of *C. murphyi* collected by M. Cornet in Senegal shows clearly that the gonocoxite possesses a slender, pointed ventral root and that the sternital membrane is quite bare. Re-examination of the genitalia figured in Clastrier & Wirth (1961) shows only the anterior body of the sternum to be finely (and densely) spiculate, the spiculation not extending posteriorly onto the membranous area. This suggests that the spiculation shown may in fact represent part of segment 8 that, during preparation, overlay segment 9 (causing it to be misinterpreted as finely spiculate). The female of *C. murphyi* as redescribed by Boorman & Dipeolu, based on material collected in Nigeria, complies with one of Clastrier & Wirth’s paratypes examined.

BIONOMICS

The blood-feeding habits of the adult female of *C. walkeri* are unknown. However, the copious numbers of sensillae of various types found on the flagellum, along with the inflated third palpal segment, suggest it to be ornithophilic (Isberg *et al.* 2013). The total sensilla coeloconica (24–37) on the female flagellum falls within the range Isberg *et al.* (2013) found (16–50) for ornithophilic species. A feeding preference for avian rather than mammalian hosts would also explain its overall rarity in light trap collections made near domesticated livestock. The 30 locality records (Table 1) for *C. walkeri* in South Africa, along with two from Kenya, all fall within a single biome, the ‘tropical and subtropical grasslands, savannas, shrublands, and woodlands’ of Burgess *et al* (2004). In South Africa, the savanna biome, one of nine biomes delimited by Mucina & Rutherford (2006), is subdivided further into six bioregions, with *C. walkeri* restricted to three of them, namely the central Bushveld, the Lowveld and the Mopane bioregions (Fig. 3). These low-

altitude (1800 m) bioregions experience seasonal rainfall and are mostly frost-free; their rich avian fauna includes all the larger species such as ostriches, bustards, wildfowl, herons, storks, and the like. It is perhaps no coincidence that the first records for *C. walkeri* in South Africa, which date back to 1970, came from the farm Eendvogelsdrift, meaning 'Duck crossing'. Within the Kruger National Park, the largest captures of *C. walkeri*, each comprising 100–300 specimens, were made at the Mondzu and Nyamari fountains and where *C. nivosus* de Meillon, an ornithophilic species, dominated the collections (>40 000/light trap). It is notable that the locality records for *C. walkeri*

include natural springs (Nyamari and Mondzu), thermal baths (Eiland), and salt works (Bergpan) of which the majority in South Africa occur in the Limpopo province. For example, local inhabitants used the thermal spring at Eiland as a source of salt long before European settlement; chemical analyses have shown that, unusually, its 'hot' saline waters share characteristics of seawater (Olivier, Venter & Jonker 2011).

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ACKNOWLEDGEMENTS

The authors thank K. Junker for help in editing the manuscript.