

RESEARCH

Open Access



Key to the females of Afrotropical *Anopheles* mosquitoes (Diptera: Culicidae)

Maureen Coetzee^{1,2*}

Abstract

Background: In 1987, Gillies and Coetzee published a pictorial key for the morphological identification of adult female mosquitoes. Since then, several new species of anopheline mosquitoes have been described.

Methods: The 1987 key to adult female mosquitoes was used as the template for the current key.

Results: New species described in the literature over the past 32 years have been included. A list of all currently known Afrotropical species is provided. *Anopheles stephensi* is included for the first time as occurring on the African continent.

Conclusions: An updated key for the morphological identification of Afrotropical anopheline species is presented.

Keywords: *Anopheles*, Morphology, Identification, Key

Background

Dichotomous keys for the morphological identification of groups of organisms have been used for over 300 years. These keys lead the reader through a series of couplets, each one giving two choices of characters, until a species name is reached. For the anopheline mosquitoes of the Afrotropical Region, which includes some of the most efficient transmitters of malaria parasites in the world, the first key for their identification was published in 1931 [1], and the most recent printed version in 1987 [2], this last being a pictorial key containing line graphics of characters mentioned in each couplet. In the 32 years that have passed since Gillies and Coetzee published their key [2], several new species have been discovered, described and named.

Methods

The pictorial key to adult female anophelines in the Afrotropical Region [2] was used as the template for the current key. New illustrations were produced and new

couplets inserted where appropriate to accommodate new species described since 1987.

Results

The present key is a revision of that presented in Gillies and Coetzee [2], with the addition of newly described species and the exclusion of subspecies. Table 1 provides a lists of species, authorship and current classification, while Table 2 gives the number of species described per decade since 1900. The user is encouraged to refer to both the 1968 volume of Gillies and De Meillon [3] and the 1987 supplement of Gillies and Coetzee for full species descriptions, biology and geographic distribution. More recent references include Sinka et al. [4], and Kyalo et al. [5].

The following species are not included in the keys: *Anopheles ethiopicus* lacks hindlegs [2], *Anopheles erythraeus* and *Anopheles dualaensis* adults are unknown [3, 6], and *Anopheles eouzani* lacks hindtarsomeres 4 and 5 [7]. The following new species are included: *Anopheles okuensis* [8] (Section I), *Anopheles hervyi* [6], *Anopheles millecampsii* [8] and *Anopheles multicinctus* [9] (Section IV), *Anopheles rageaui* [6] and *Anopheles seretsei* [10] (Section VII), *Anopheles kosiensis* [11] (Section IX),

*Correspondence: maureen.coetzee@wits.ac.za; maurenc@nicd.ac.za

¹ Wits Research Institute for Malaria, School of Pathology, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa
Full list of author information is available at the end of the article



Table 1 List of the species of *Anopheles* (excluding subspecies) in the Afrotropical Region, excluding Madagascar and associated islands

Subgenus	Series	Section	Group/complex*	Species	Authors		
Anopheles	Myzorhynchus		Coustani	<i>caliginosus</i>	De Meillon, 1943		
			Coustani	<i>coustani</i>	Laveran, 1900		
			Coustani	<i>crypticus</i>	Coetzee, 1994		
			Coustani	<i>namibiensis</i>	Coetzee, 1984		
			Coustani	<i>paludis</i>	Theobald, 1900		
			Coustani	<i>symesi</i>	Edwards, 1928		
			Coustani	<i>tenebrosus</i>	Dönitz, 1902		
			Coustani	<i>ziemanni</i>	Grünberg, 1902		
				<i>obscurus</i>	(Grünberg, 1905)		
				<i>concolor</i>	Edwards, 1938		
Cellia	Anopheles	Smithii		<i>caroni</i>	Adam, 1961		
	Neomyzomyia			<i>faini</i>	Leleup, 1952		
				<i>hamoni</i>	Adam, 1962		
				<i>jebudensis</i>	Froud, 1944		
				<i>lovettae</i>	Evans, 1934		
				<i>rageaui</i>	Mattingly & Adam, 1954		
				<i>smithii</i>	Theobald, 1905		
				<i>vanhoofi</i>	Wanson & Lebied, 1945		
				<i>wilsoni</i>	Evans, 1934		
			Ardensis		<i>ardensis</i>	(Theobald, 1905)	
					<i>buxtoni</i>	Service, 1958	
					<i>cinctus</i>	(Newstead & Carter, 1910)	
					<i>dualaensis</i>	Brunhes, Le Goff & Geoffroy, 1999	
					<i>deemingi</i>	Service, 1970	
					<i>dureni</i>	Edwards, 1938	
					<i>eouzani</i>	Brunhes, Le Goff & Boussès, 2003	
					<i>kingi</i>	Christophers, 1923	
					<i>machardyi</i>	Edwards, 1930	
					<i>maliensis</i>	Bailly-Choumara & Adam, 1959	
			Myzomyia		<i>millecampsi</i>	Lips, 1960	
					<i>multicinctus</i>	Edwards, 1930	
				<i>natalensis</i>	(Hill & Haydon, 1907)		
	Nili				<i>carnevalei</i>	Brunhes, Le Goff & Geoffroy, 1999	
					<i>nili</i>	(Theobald, 1904)	
					<i>ovengensis</i>	Awono-Ambene, Kengne, Simard, Antonio-Nkondjio & Fontenille, 2004	
	Rhodesiensis			Nili		<i>somalicus</i>	Rivola & Holstein, 1957
						<i>vernus</i>	Gillies & De Meillon, 1968
						<i>vinckeii</i>	De Meillon, 1942
						<i>cameroni</i>	De Meillon & Evans, 1935
					<i>lounibosi</i>	Gillies & Coetzee, 1987	
					<i>rhodesiensis</i>	Theobald, 1901	
					<i>rodhaini</i>	Leleup & Lips, 1950	
					<i>ruarinus</i>	Edwards, 1940	
					<i>azaniae</i>	Bailly-Choumara, 1960	
					<i>barberellus</i>	Evans, 1932	
			<i>bervoetsi</i>	D'Haenens, 1961			
			<i>brunnipes</i>	(Theobald, 1910)			
			<i>domicolus</i>	Edwards, 1916			

Table 1 (continued)

Subgenus	Series	Section	Group/complex*	Species	Authors
				<i>dthali</i>	Patton, 1905
				<i>erythraeus</i>	Corradetti, 1939
				<i>ethiopicus</i>	Gillies & Coetzee, 1987
				<i>flavicosta</i>	Edwards, 1911
				<i>fontinalis</i>	Gillies & De Meillon, 1968
				<i>gabonensis</i>	Rahola, Makanga & Paupy, 2014
				<i>moucheti</i>	Evans, 1925
				<i>schwetzi</i>	Evans, 1934
				<i>tcchedii</i>	De Meillon & Leeson, 1940
				<i>walravensi</i>	Edwards, 1930
		Funestus	Funestus	<i>aruni</i>	Sobti, 1968
			Funestus	<i>funestus</i>	Giles, 1900
			Funestus	<i>funestus-like</i>	(See Spillings et al. [26])
			Funestus	<i>parensis</i>	Gillies, 1962
			Funestus	<i>vaneedeni</i>	Gillies & Coetzee, 1987
		Rivulorum		<i>brucei</i>	Service, 1960
		Rivulorum		<i>fuscivenosus</i>	Leeson, 1930
		Rivulorum		<i>rivulorum</i>	Leeson, 1935
		Rivulorum		<i>rivulorum-like</i>	(see Cohuet, et al. [27])
				<i>confusus</i>	Evans & Leeson, 1935
				<i>culicifacies</i>	Giles, 1901
				<i>leesoni</i>	Evans, 1931
				<i>longipalpis</i>	(Theobald, 1903)
		Marshallii-Hancocki		<i>austeni</i>	(Theobald, 1905)
				<i>berghei</i>	Vincke & Leleup, 1949
				<i>brohieri</i>	Edwards, 1929
				<i>gibbinsi</i>	Evans, 1935
				<i>hancocki</i>	Edwards, 1929
				<i>hargreavesi</i>	Evans, 1927
				<i>harperi</i>	Evans, 1936
		Marshallii		<i>hughi</i>	Lambert & Coetzee, 1982
		Marshallii		<i>kosiensis</i>	Coetzee, Segerman & Hunt, 1987
		Marshallii		<i>letabensis</i>	Lambert & Coetzee, 1982
		Marshallii		<i>marshallii</i>	(Theobald, 1903)
				<i>mortiauxi</i>	Edwards, 1938
				<i>mousinhoi</i>	De Meillon & Pereira, 1940
				<i>njombiensis</i>	Peters, 1955
				<i>seydeli</i>	Edwards, 1929
		Wellcomei		<i>distinctus</i>	(Newstead & Carter, 1911)
				<i>erepens</i>	Gillies, 1958
				<i>theileri</i>	Edwards, 1912
				<i>wellcomei</i>	Theobald, 1904
		Demeilloni		<i>carteri</i>	Evans & De Meillon, 1933
				<i>demeilloni</i>	Evans, 1933
				<i>freetownensis</i>	Evans, 1925
				<i>garnhami</i>	Edwards, 1930
				<i>keniensis</i>	Evans, 1931
				<i>lloreti</i>	Gil Collado, 1935
				<i>sergentii</i>	(Theobald, 1907)

Table 1 (continued)

Subgenus	Series	Section	Group/complex*	Species	Authors
	Pyretophorus			<i>christyi</i>	(Newstead & Carter, 1911)
				<i>daudi</i>	Coluzzi, 1958
			Gambiae	<i>amharicus</i>	Hunt, Wilkerson & Coetzee, 2013
			Gambiae	<i>arabiensis</i>	Patton, 1905
			Gambiae	<i>bwambae</i>	White, 1985
			Gambiae	<i>coluzzii</i>	Coetzee & Wilkerson, 2013
			Gambiae	<i>fontenillei</i>	Barrón, Paupy, Rahola, Akone-Ella, Ngangue, Wilson-Bahun, Pombi, Kengne, Costantini, Simard, González & Ayala, 2019
			Gambiae	<i>gambiae</i>	Giles, 1902
			Gambiae	<i>quadriannulatus</i>	(Theobald, 1911)
			Gambiae	<i>melas</i>	Theobald, 1903
			Gambiae	<i>merus</i>	Donitz, 1902
	Paramyzomyia			<i>azevedoi</i>	Ribeiro, 1969
				<i>cinereus</i>	Theobald, 1901
				<i>listeri</i>	De Meillon, 1931
				<i>multicolor</i>	Cambouliu, 1902
				<i>seretsei</i>	Abdulla-Khan, Coetzee & Hunt, 1998
				<i>turkhudi</i>	Liston, 1901
	Neocellia			<i>dancalicus</i>	Corradetti, 1939
				<i>hervyi</i>	Brunhes, Le Goff & Geoffroy, 1999
				<i>maculipalpis</i>	Giles, 1902
				<i>pretoriensis</i>	(Theobald, 1903)
				<i>rufipes</i>	(Gough, 1910)
				<i>salbaii</i>	Maffi & Coluzzi, 1958
				<i>stephensi</i>	Liston, 1901
	Cellia			<i>argenteolobatus</i>	(Gough, 1910)
				<i>brumpti</i>	Hamon & Rickenbach, 1955
				<i>cristipalpis</i>	Service, 1977
				<i>cydippis</i>	De Meillon, 1931
				<i>murphyi</i>	Gillies & De Meillon, 1968
				<i>pharoensis</i>	Theobald, 1901
				<i>squamosus</i>	Theobald, 1901
				<i>swahilicus</i>	Gillies, 1964
Christya**				<i>implexus</i>	(Theobald, 1903)
				<i>okuensis</i>	Brunhes, Le Goff & Geoffroy, 1997

**Anopheles gambiae*, *An. nili* and *An. marshallii* are referred to as complexes, while *An. coustani*, *An. funestus* and *An. rivulorum* are groups

**Previously a Series in the subgenus *Anopheles*, *Christya* was elevated to subgeneric status by Harbach and Kitching in 2016 [28]

Anopheles gabonensis [12] (Section X), and *Anopheles carnevalei* [6] and *Anopheles ovengensis* [13] (Section XI).

Discussion

A major addition to the key is the inclusion of *Anopheles stephensi* (Section IV), the Asian malaria vector with distribution from the Middle East to China. This

species was first detected on the African continent in Djibouti in September 2012 and subsequently in February 2013 [14] through to December 2017 [15]. It has also recently been found in Ethiopia in 2016 [16]. The species is similar to those belonging to the *Anopheles gambiae* complex—mosquitoes with speckled legs—but differs by having the wing with two pale spots in the 2nd main dark area of the costa and vein 1, thus being

Table 2 Number of species of Afrotropical *Anopheles* described per decade since 1900

Decade	No. species	Author/co-author (number of species authored/co-authored)
1900–1910	35	Theobald (18), Giles (3), Donitz (2), Gough (2), Grunberg (2), Liston (2), Patton (2), Cambouliu (1), Carter (1), Haydon (1), Hill (1), Laveran (1), Newstead (1)
1911–1920	6	Edwards (3), Carter (2), Newstead (2), Theobald (1)
1921–1930	13	Edwards (9), Evans (2), Christophers (1), Leeson (1)
1931–1940	24	Evans (12), De Meillon (6), Edwards (4), Leeson (3), Corradetti (2), Gil Collado (1), Pereira (1)
1941–1950	6	De Meillon (2), Leleup (2), Froud (1), Lebiec (1), Lips (1), Vincke (1), Wanson (1)
1951–1960	13	Adam (2), Bailly-Choumara (2), Coluzzi (2), Service (2), Gillies (1), Hamon (1), Holstein (1), Leleup (1), Maffi (1), Mattingly (1), Peters (1), Rickenbach (1), Rivola (1)
1961–1970	11	Gillies (5), De Meillon (3), Adam (2), D'Haenens (1), Ribeiro (1), Service (1), Sobti (1)
1971–1980	1	Service (1)
1981–1990	8	Coetzee (7), Gillies (3), Lambert (2), Hunt (1), Segerman (1), White (1)
1991–2000	6	Brunhes (4), Le Goff (4), Geoffroy (4), Coetzee (2), Abdulla-Khan (1), Hunt (1)
2001–2010	4	Coetzee (2), Fontenille (2), Kengne (2), Simard (2), Antonio-Nkondjio (1), Awono-Ambene (1), Boussets (1), Brooke (1), Brunhes (1), Chiphwanya (1), Cohuet (1), Hunt (1), Koekemoer (1), Le Goff (1), Spillings (1), Toto (1)
2011–2020	4	Coetzee (2), Paupy (2), Rahola (2), Wilkerson (2), Akone-Ella (1), Ayala (1), Barrón (1), Costantini (1), González (1), Hunt (1), Kengne (1), Makanga (1), Ngangue (1), Pombi (1), Simard (1), Wilson-Bahun (1)

similar to *Anopheles maculipalpis* and *Anopheles pretoriensis*, from which it differs by not having hindtarsomeres 4 and 5 all pale.

There are several groups of species where morphological identification is not possible using only the adult females, either because the adults look identical or because of overlap in morphological variation. Some of these species can be identified on immature characters, thus requiring eggs or larvae [3], while others require genetical methods, such as chromosomal inversions [17] or molecular assays [18, 19]. Such groups include:

- the well-known *Anopheles gambiae* complex (*An. gambiae*, *Anopheles coluzzii* [20], *Anopheles arabiensis*, *Anopheles quadriannulatus*, *Anopheles amharicus* [20], *Anopheles fontenillei* [21], *Anopheles bwambae*, *Anopheles melas*, *Anopheles merus*);
- the *Anopheles funestus* group (*Anopheles funestus*, *An. funestus*-like, *Anopheles parensis*, *Anopheles vaneedeni*, *Anopheles aruni*, *Anopheles confusus*, *Anopheles lesoni*, *Anopheles rivulorum*, *An. rivulorum*-like, *Anopheles brucei*, *Anopheles fuscivenosus*);
- the *Anopheles nili* complex (*An. nili*, *Anopheles somalicus*);
- the *Anopheles marshallii* complex (*An. marshallii*, *Anopheles letabensis*, *Anopheles hughii*, *Anoph-*

eles kostiensis) and its allies *Anopheles hargreavesi*, *Anopheles gibbinsi* and *Anopheles mousinhoi*;

- Anopheles squamosus/cydippis*, the former of which is known to consist of at least five chromosomal forms (Green and Hunt, unpublished data);
- Anopheles coustani/crypticus/namibiensis* in southern Africa.

The definition of “complex”, as applied to the genus *Anopheles*, is a group of species that are virtually morphologically identical but are otherwise considered valid species. The use of the term “group” denotes species that are morphologically very similar at the adult stage but many can be distinguished at the immature stages.

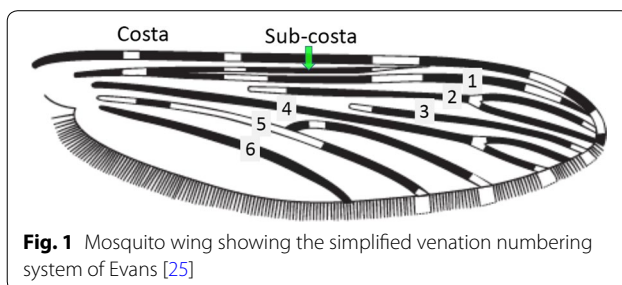
Except for those of medical importance, the above list is just a small sample of species groups about which we know very little biologically in terms of feeding/resting preferences or their role in malaria parasite transmission. Basic taxonomic research, aligned with molecular analyses, is still very much needed in the Culicidae.

Conclusions

An updated key for the morphological identification of Afrotropical anopheline species is presented. This key should be used in conjunction with earlier works giving full species descriptions, biology, medical importance and distribution.

Table 3 The terminology used for wing venation since 1938 [25] is given

	Evans [25]	Gillies & De Meillon [3]; Gillies & Coetzee [2]	Snodgrass [29]	Harbach & Knight [22]	McAlpine [30]	Cumming & Wood [24]
Costa	Costa	Costa	Costa	Costa	Costa	Costa
Sub-costa	Sub-costa	Sub-costa	Sub-costa	Sub-costa	Sub-costa	Sub-costa
1	1st vein	1st vein	R ₁ —1st vein	R ₁ —radius-one	R ₁ —anterior radius	R ₁ —anterior radius
2	2.1—2nd vein upper branch 2.2—2nd vein lower branch	2nd vein upper branch 2nd vein lower branch	R ₂ —2nd vein upper branch R ₃ —2nd vein lower branch	R ₂ —radius-two R ₃ —radius-three R ₂₊₃ —stem of vein	R ₂ —upper branch of 2nd radius R ₃ —lower branch of 2nd radius R ₂₊₃ —2nd branch of radius	R ₂ —upper branch of 2nd radius R ₃ —lower branch of 2nd radius R ₂₊₃ —2nd branch of radius
3	3rd vein	3rd vein	R ₄₊₅ —3rd vein	R ₄₊₅ —radius-four-plus-five	R ₄₊₅ —3rd branch of radius	R ₄₊₅ —3rd branch of radius
4	4.1—4th vein upper branch 4.2—4th vein lower branch	4th vein upper branch 4th vein lower branch	M ₁₊₂ —4th vein upper branch M ₃ —4th vein lower branch M—stem of vein	M ₁ —media-one M ₂ —media-two M ₁₊₂ —stem of vein	M ₁ —1st branch of media M ₂ —2nd branch of media	M ₁ —1st branch of media M ₂ —2nd branch of media
5	5.1—5th vein upper branch 5.2—5th vein lower branch	5th vein upper branch 5th vein lower branch	Cu ₁ —5th vein upper branch Cu ₂ —5th vein lower branch Cu—stem of vein	M ₃₊₄ —media-three-plus-four CuA—cubitus anterior M—stem of vein	CuA ₁ —1st branch of anterior cubital CuA ₂ —2nd branch of anterior cubital	M ₃₊₄ —3rd + 4th branch of media CuA—anterior cubital
6	6th vein	6th vein	A—anal vein	1A—anal vein	A ₁ —anal vein	CuP—posterior cubital



The key layout

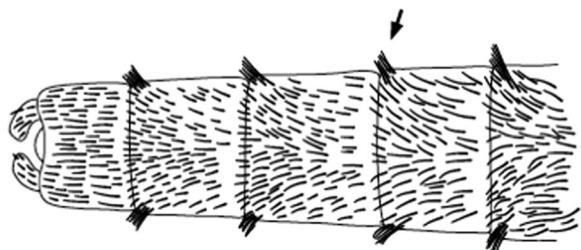
Characters are presented in ‘couplets’ where two options are presented, giving two different outcomes, eventually ending at a species name. The illustration(s) for the first option of each couplet is on the left (or rarely, in the centre) and for the second option on the

right. General terminology follows that of Harbach and Knight [22, 23].

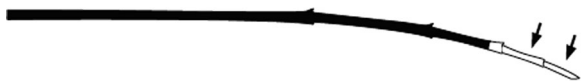
Terminology of the wing venation has changed over the past 80 years in attempts to align Culicidae with the rest of the Diptera Family (Table 3). The terminology proposed in the recent Manual of Afrotropical Diptera [24] has been challenged by culicid taxonomists (manuscript reviewers), specifically around the terms used for the posterior veins (veins 5 and 6 in Fig. 1). Since consensus on the terminology has not yet been reached, and given that the malaria vector control field workers in Africa have been using the *Anopheles* identification keys published 32 years ago [2] that use the numbering shown in Fig. 1, this simplified system is used here. It avoids unnecessary repetition of the various terms in each couplet and reference can be made to Table 3 where recent terminology is required.

Key to adult females

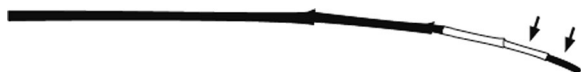
1. Abdominal segments with laterally projecting tufts of scales on segments II–VIISection I
- Abdominal segments not so2



2. Hindtarsus with at least last 2 hindtarsomeres entirely paleSection II
- Hindtarsus not so3



3. Hindtarsomere 5 mainly or entirely dark, hindtarsomere 4 whiteSection III
- Hindtarsus not so4



4. Legs speckled, sometimes sparselySection IV
- Legs not speckled5



5. Wing entirely dark or with pale spots confined to costa and vein 1Section V
- Wing not so6



6. Wing without a pale spot on basal 0.5 of costaSection VI.....
- Wing with at least 1 pale spot on basal 0.5 of costa ..7



7. Maxillary palpus with apex darkSection VII
- Maxillary palpus with apex pale8



8. Maxillary palpus with 4 pale bandsSection VIII
- Maxillary palpus with less than 4 pale bands9



9. Wing with pale interruption in 3rd main dark area (preapical dark spot) of vein 1, sometimes fused with preceding pale areaSection IX
- 3rd main dark area without pale interruption10



10. Wing with 2 pale spots on upper branch of vein 5Section X
- Wing with 1 pale spot on upper branch of vein 5Section XI



Section I. Mosquitoes with laterally projecting tufts of abdominal scales

1. Wing almost entirely dark, costa without pale spots*brumpti*
- Wing with abundant pale areas, costa with at least 4 pale spots2



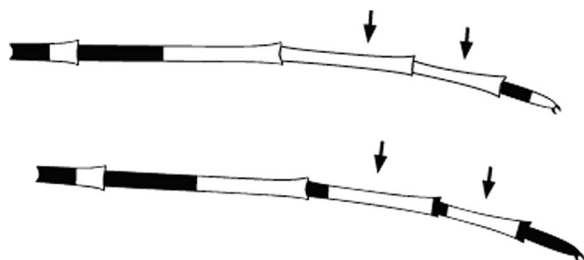
- 2 (1). Hindtarsomeres 1 to 5 entirely dark*argenteolobatus* (southern Africa)
murphyi (West Africa)
- Hindtarsomeres 1 to 4, at least, with apical pale bands3



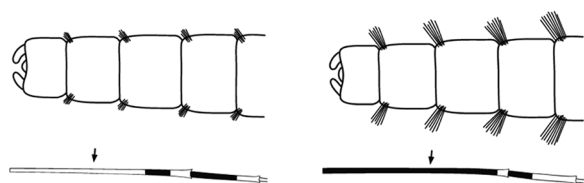
- 3 (2). Hindtarsomeres 1 and 2 with definite pale and dark rings in addition to apical pale bands*cinctus*
- Hindtarsomeres 1 and 2 with pale bands at apices only4



- 4 (3). Hindtarsomeres 3 and 4 all white or narrowly dark basally, 5 all dark or at least basal 0.5 dark.....5
 – Hindtarsomeres not so7



- 5 (4). Moderate-sized species; abdominal scale-tufts short and dark; 0.5 or more of hindtarsomere 1 pale*crispipalpis*
 – Very large species, abdominal segments II–VII with long lateral tufts of yellowish and dark scales; hindtarsomere 1 largely dark6



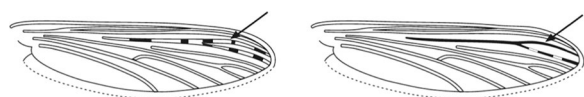
- 6 (5). Pale fringe spot present opposite lower branch of vein 5 *okuensis*
 – No pale fringe spot opposite lower branch of vein 5*implexus*



- 7 (4). Hindtarsomere 5 and about apical 0.5 of 4 pale*pharoensis*
 – Hindtarsomere 5 all dark and 4 with much less than apical 0.5 pale8



- 8 (7). Very small species (wing length 2.5–2.8 mm); wing with upper branch of vein 2 largely pale*swahilicus*
 – Small to moderate-sized species (wing length 2.7–4.5 mm); wing with upper branch of vein 2 either entirely dark apart from apex or with a few scattered pale scales only*squamosus cydippis*

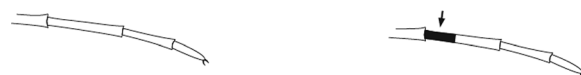


Section II. Mosquitoes with hindtarsomeres 4 and 5 entirely white; abdomen without laterally projecting tufts of scales

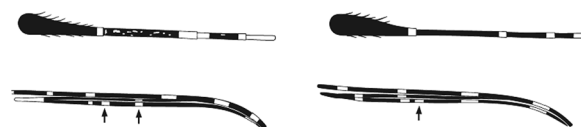
1. Legs speckled2
 – Legs not speckled8



- 2 (1). Hindtarsomeres 3 to 5 entirely pale3
 – Hindtarsomere 3 dark at base5



- 3 (2). Maxillary palpus with 3 pale bands, usually with some speckling; vein 1 of wing with 2 pale spots in 2nd main dark area (median dark spot) *maculipalpis*
 – Maxillary palpus with 4 pale bands, unspeckled; vein 1 of wing with at most 1 pale spot in 2nd main dark area4



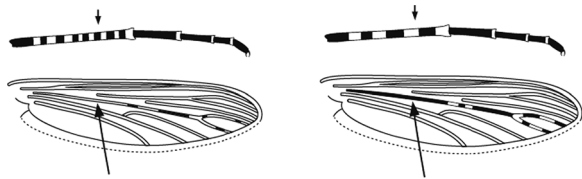
- 4 (3). Midtarsomeres 2 to 4 entirely dark; vein 1 of wing dark at base, basal 0.5 of stem of vein 4 with small pale areas*maliensis*
 – Midtarsomeres 2 to 4 with pale apices; vein 1 of wing pale at base, basal 0.5 of stem of vein 4 entirely pale*deemingi*



- 5 (2). Hindtarsomere 1 broadly pale at apex; vein 1 of wing with 2 pale spots in 2nd main dark area*preto-riensis*
 – Hindtarsomere 1 narrowly pale or dark at apex; vein 1 of wing with 1 pale spot in 2nd main dark area6



- 6 (5). Foretarsomere 1 with 5–9 pale rings; stem of vein 4 of wing largely pale *machardy*
 – Foretarsomere 1 with 2–4 pale rings; stem of vein 4 of wing largely dark7



- 7 (6). Fore- and midtarsomeres 2 and 3 pale at apex; wing with fringe spot opposite vein 6 *natalensis*
 – Fore- and midtarsomeres 2 and 3 dark apically; no fringe spot opposite vein 6 *buxtoni*



- 8 (1). Maxillary palpus very shaggy and unbanded or with 1–4 irregular narrow pale bands9
 – Maxillary palpus smooth with 3 pale bands, the 2 distal ones broad or rarely fused14



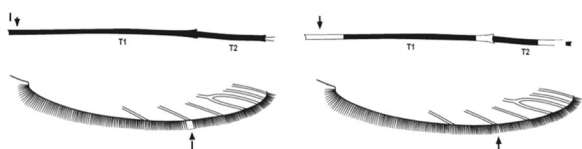
- 9 (8). Maxillary palpus without pale bands; no pale spot at apex of hindtibia or base of hindtarsomere 1 *caliginosus*
 – Maxillary palpus with 1–4 pale bands; apex of hindtibia broadly or narrowly pale10



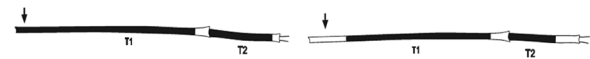
- 10 (9). Hindtarsomere 3 entirely pale11
 – Hindtarsomere 3 dark at base12



- 11 (10). Base of hindtarsomere 1 dark; pale fringe spot present opposite lower branch of wing vein 5 *paludis*
 – Base of hindtarsomere 1 broadly pale; no pale fringe spot opposite lower branch of wing vein 5 ... *coustani* (in part)



- 12 (10). Hind tarsomere 1 entirely dark basally or at most with a very narrow band of pale scales not as broad as the width of the tarsomere *tenebrosus* (in part)
 – Hind tarsomere 1 broadly pale at base, pale area at least as long as broad13



- 13 (12). Apex of hindtibia with a pale streak 3–5 times as long as broad; apical pale band on hindtarsomere 2 0.13–0.4 length of tarsomere *coustani* (in part)
crypticus (S. Africa only)
 – Pale streak on hindtibia 1–3 times as long as broad; apical pale band on hindtarsomere 2 narrow, 0.07–0.13 length of segment *ziemanni namibiensis*



- 14 (8). 3rd main dark area on wing vein 1 without a pale interruption; foretarsomeres 1 to 3 usually without distinct apical pale bands *rufipes* (in part)
 – 3rd main dark area on wing vein 1 with a pale interruption, or with a short extension of the subcostal pale spot into the dark area on vein 1; foretarsomeres 1 to 3 with apical pale bands15

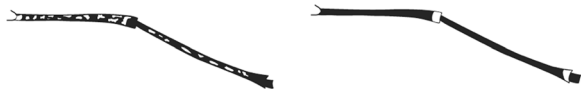


- 15 (14). Hindtarsomere 3 entirely pale. *hancocki brohieri* (in part)
 – Hindtarsomere 3 not so. *brohieri* (in part) W. Africa
theileri mainly E. & S. Africa

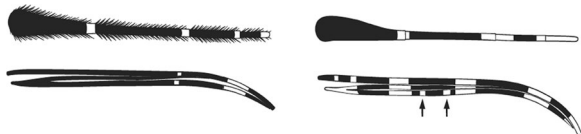


Section III. Mosquitoes with hind tarsomere 5 mainly or entirely dark, tarsomere 4 white; abdominal segments without laterally projecting tufts of scales

1. Femora and tibiae speckled*kingi*
 – Femora and tibiae with at most apical bands only2



- 2 (1). Maxillary palpus shaggy; costa and vein 1 of wing without usual main dark areas*symesi*
 – Maxillary palpus smooth; 2nd main dark area of wing vein 1 well defined and with 2 pale interruptions*rufipes* (in part)

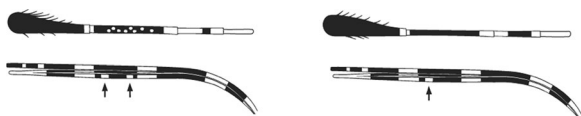


Section IV. Mosquitoes with speckled legs, hindtarsomeres 4 and 5 not entirely pale; abdominal segments without laterally projecting tufts of scales

1. Maxillary palpus with 3 pale bands2
 – Maxillary palpus with 4 pale bands6



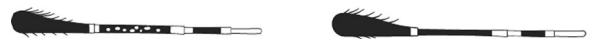
- 2 (1). Maxillary palpus with apical 2 pale bands very broad, speckling on palpus segment 3; 2nd main dark area on wing vein 1 with 2 pale interruptions*stephensi*
 – Maxillary palpus with apical dark spot about equal to or longer than apical pale band; 2nd main dark area on wing vein 1 with 1 pale interruption.....3



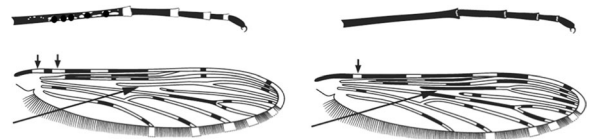
- 3 (2). 3rd main dark area of wing vein 1 with a pale interruption, sometimes fused with preceding pale spot; scaling on abdomen very scanty, confined to tergum VIII or rarely VII*gambiae* complex (in part)
 – 3rd main dark area of wing vein 1 without a pale interruption; abdominal terga fairly heavily clothed with cream or yellowish scales, especially on terga VI and VII4



- 4 (3). Maxillary palpus speckled*hervyi*
 – Maxillary palpus not speckled5



- 5 (4). Foretarsomere 1 with some speckling; base of costa with 2 pale spots; stem of wing vein 2 entirely pale*salbairi*
 – Foretarsomere 1 not speckled; base of costa with 1 pale spot; stem of wing vein 2 extensively dark*dancalicus*



- 6 (1). All tarsi completely dark; wing without pale fringe spots posterior to vein 3*vernus* (in part)
 – Tarsomeres 1 to 4 with conspicuous pale bands on at least the apices; wing with pale fringe spots up to lower branch of vein 5 or 67



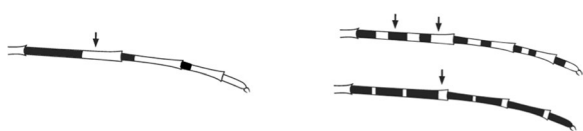
- 7 (6). 3rd main dark area of vein 1 with a pale interruption, sometimes fused with preceding pale area..... *gambiae* complex
(in part)

– 3rd main dark area without pale interruption8



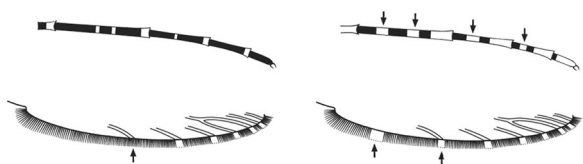
- 8 (7). Hindtarsomere 2 with about apical 0.4 to 0.5 white and the rest dark *multicinctus*

– Hindtarsomere 2 either with less than apical 0.4 white or else prominently marked with dark and pale bands9



- 9 (8). Hindtarsomeres 2 to 4 with apical pale rings and otherwise dark except for 1 to 2 pale spots; no pale fringe spot opposite wing vein 6 *ardensis*

– Hindtarsomeres 2 to 4 with conspicuous dark and pale rings in addition to apical pale bands; pale fringe spot present opposite vein 610



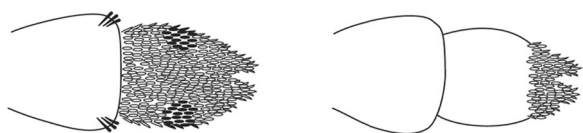
- 10 (9). Foretarsomeres mainly pale with narrow dark markings *vinckei*

– Foretarsomeres mainly dark with narrow pale rings11



- 11 (10). Scales on abdominal tergum VIII dense and distributed over whole tergum, sometimes with a few scales on lateral borders of tergum VII *dureni*

– Scales on tergum VIII scanty and confined to posterior margin *millecampsi*



Section V. Mosquitoes with wings entirely dark or with pale spots confined to costa and vein 1; legs not speckled, hindtarsomeres 4 and 5 not entirely pale; abdominal segments without laterally projecting tufts of scales

1. Wings entirely dark, or unicolorous2
– Wings with at least some areas of paler scales on costa or vein 1, these being sometimes inconspicuous5



- 2 (1). Maxillary palpus with 2 well-marked pale bands; hindfemur and hindtibia narrowly pale at apex *concolor*

– Maxillary palpus and legs entirely dark3



- 3 (2). Large species, wing length 4 mm or more *ruarinus*

– Small species, wing length 3.5 mm or less4

- 4 (3). Very pale brown species with glossy scutum; semi-arid regions only *rhodesiensis*
(in part)

– General coloration dark brown, scutum not so; cave-dwelling *caroni*
(in part)

- 5 (1). Maxillary palpus with 2 to 3 pale bands, pale at apex (sometimes indistinct)6

– Maxillary palpus with or without pale bands, dark at apex9



- 6 (5). Erect head scales narrow, rod-like, all scales yellowish throughout; semi-arid regions only *dthali*

– Erect head scales broader, scales white on vertex, dark laterally; all regions7



- 7 (6). Pale and dark areas on wing poorly contrasted; semi-arid regions only*rhodesiensis* (in part)

– Pale and dark areas on wing well contrasted8



- 8 (7). Pale areas on wing very narrow, subcostal pale spot present on costa only; cave-dwelling*rodhaini*

– Pale areas on wing broader, subcostal pale spot on costa and vein 1*rhodesiensis* (in part)
lounibosi



- 9 (5). Maxillary palpus with 3 pale bands, dark at apex*smithii* (in part)

– Maxillary palpus unbanded or banding indistinct10



- 10 (9). Cave-dwelling species; colour and contrast of dark and pale areas on wing variable*caroni* (in part)
hamoni
vanhoofi

– Semi-arid regions; pale brown species with poorly contrasting light and dark areas on wing11

- 11 (10). Erect head scales narrow, rod-like, all scales yellowish throughout*azaniae* (in part)

– Erect head scales broader, scales white on vertex, dark laterally...*rhodesiensis* (in part)



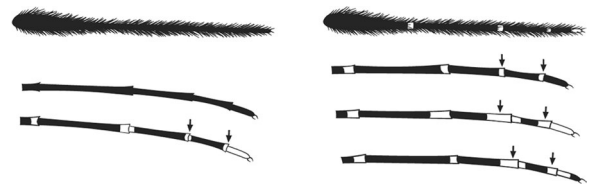
Section VI. Mosquitoes without a pale spot on basal 0.5 of costa; pale spots not confined to costa and vein 1; legs not speckled, hindtarsomeres 4 and 5 not entirely pale; abdomen without projecting tufts of scales

1. Maxillary palpus shaggy to near tip2
– Maxillary palpus smooth except at extreme base3



- 2 (1). Maxillary palpus entirely dark; hindtarsomeres 3 and 4 dark or narrowly pale at apices*obscurus* (in part)

– Maxillary palpus with pale scales forming more or less definite pale bands; hindtarsomeres 3 and 4 narrowly or broadly pale at apices*tenebrosus* (in part)



- 3 (1). Maxillary palpus with apex dark, sometimes only narrowly so4
– Maxillary palpus with apex pale5

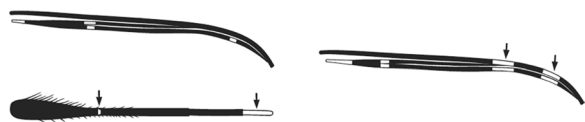


- 4 (3). Stem of wing vein 4 largely pale, upper branch of vein 5 with 2 pale spots or largely pale, fringe spots present opposite vein 4 and upper branch of vein 5*tchededii*

– Stem of wing vein 4 largely dark, upper branch of vein 5 with one narrow pale area, pale fringe spots absent*smithii* (in part)



- 5 (3). Costa entirely dark except for a few indistinct pale scales subapically; maxillary palpus with a broad apical pale band and otherwise dark except for a narrow basal pale band *daudi*
- Outer 0.5 of costa with 1–3 well-marked pale areas; maxillary palpus not so 6



- 6 (5). Maxillary palpus with 3 pale bands, subapical band broad and about equal in length to apical band .7
- Maxillary palpus either with 4 pale bands or if with 3 bands then subapical band much shorter than the apical band 9



- 7 (6). Wing, apart from costa, generally very pale, basal 0.5 of stems of veins 2 and 4 entirely pale *wellcomei* (in part)
- Dark areas on wing greater than or about equal to pale areas, basal 0.5 of stems of veins 2 and 4 largely dark 8



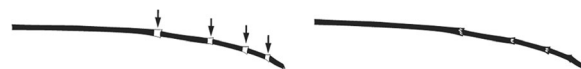
- 8 (7). No pale fringe spots posterior to wing vein 3, stem of vein 5 pale except at fork and sometimes narrowly near base *erepens*
- Pale fringe spots present opposite all veins from wing apex to vein 5, stem of vein 5 broadly dark near base *keniensis* (in part)



- 9 (6). Wing vein 5 entirely dark except for a single pale spot on the upper branch *fuscivenosus* (in part)
- Wing vein 5 with extensive pale areas, upper branch of vein 5 with 2 pale spots 10



- 10 (9). Hindtarsomeres 1 to 4 with distinct apical pale bands; scutum clothed with very narrow scales *distinctus*
- Hindtarsomeres 1 to 4 entirely dark or with a few pale scales at apices of 1 to 3; scutum scales broad 11



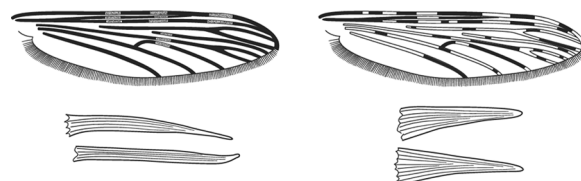
- 11 (10). Median scutal scales yellowish or bronze, white elsewhere *schwetzi* (in part)
- Scutal scales white throughout *walravensi* (in part)
- schwetzi* (in part)

Section VII. Mosquitoes with maxillary palpus dark at apex or without distinct apical pale band; at least 1 pale spot on basal 0.5 of costa, pale scales not confined to costa and wing vein 1; legs not speckled, hindtarsomeres 4 and 5 not entirely pale; abdomen without laterally projecting tufts of scales

1. Maxillary palpus entirely dark or without distinct pale bands 2
- Maxillary palpus with 3 pale bands 5



- 2 (1). Small, pale brown species, pale patches on wing indistinct, basal 0.25–0.5 of costa entirely dark; head scales narrow and yellowish *azaniae* (in part)
- Wing with well-contrasting pale and dark areas, basal 0.25 of costa with at least 1 pale area, even if narrow; head scales not so 3



- 3 (2). Costa with humeral pale spot, no subapical (preapical) pale spot on costa and vein 1*obscurus* (in part)
 – Costa without a humeral pale spot, subapical pale spot present on costa and vein 14



- 4 (3). Wing with pale fringe spots opposite all veins except vein 6*jebudensis*
 – Wing with no pale fringe spots posterior to vein 3*faini*



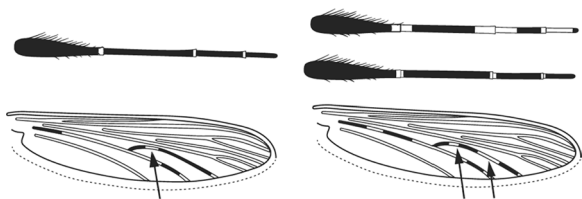
- 5 (1). Wing generally pale, contrast between pale and dark areas, apart from costa and vein 1, poorly defined*turkhudi*
 – Wing with well-contrasting pale and dark areas.....6



- 6 (5). 2nd main dark area of wing vein 1 with 2 pale interruptions7
 – 2nd main dark area of wing vein 1 with at most 1 pale interruption8



- 7 (6). Pale bands on maxillary palpus very narrow, at apices of segments 2 to 4 and not overlapping the joints; upper branch of wing vein 5 with a single pale spot*wilsoni* (in part)
 – Pale bands on maxillary palpus variable in width, distal 2 bands overlapping the joints; upper branch of wing vein 5 with 2 pale spots*rufipes* (in part)



- 8 (6). Wing, apart from costa and vein 1, predominantly dark, no pale spots on basal 0.25 of costa9
 – Pale and dark areas on wing about equally distributed, humeral and presector pale spots present on costa12



- 9 (8). Wing vein 6 dark*rageaui*
 – Wing vein 6 with proximal pale spot10



- 10 (9). Basal 0.2 of wing vein 1 either dark or with a proximal pale patch not extending to base.....*smithii* (in part)
 – Basal 0.2 of wing vein 1 entirely pale11



- 11 (10). Wings scantily scaled, all wing scales very narrow*fontinalis*
 – Wings heavily scaled, upstanding scales moderately broad*lovettae*



- 12 (8). Basal pale band of maxillary palpus about equal to or slightly shorter than median band, broadly overlapping base of 3rd segment*cinereus* (in part)
 – Basal pale band of maxillary palpus either much shorter than median band, scarcely overlapping base of 3rd segment, or both basal and median pale bands very narrow13



- 13 (12). Base of costa pale*multicolor*
(north-east Africa only)
– Base of costa dark ...*listeri*
(southern Africa only)
azevedoi
(south-western Africa only)
seretsei
(Botswana only)

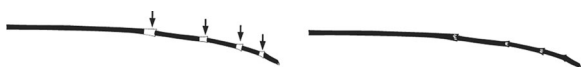


Section VIII. Mosquitoes with smooth, 4-banded maxillary palpus, pale at apex; at least 1 pale spot on basal 0.5 of costa, pale scales not confined to costa and wing vein 1; legs not speckled, hindtarsomeres 4 and 5 not entirely pale; abdomen without laterally projecting tufts of scales

1. 3rd main dark area of wing vein 1 with a pale interruption2
– 3rd main dark area without a pale interruption3



- 2 (1). Abdominal terga clothed with yellowish scales; hindtarsomeres 1 to 4 with broad apical pale bands.*christyi*
– Abdominal terga without such scales; hindtarsomeres entirely dark or with a few pale scales at apices of hindtarsomeres 1 to 3*schwetzi*
(in part)



- 3 (1). 2nd main dark area of wing vein 1 with 2 pale interruptions*wilsoni*
(in part)
– 2nd main dark area of wing vein 1 with 1 pale interruption4



- 4 (3). Pale bands on maxillary palpus broad, basal band overlapping base of 3rd segment*cinereus*
(in part)
– Pale bands on maxillary palpus mostly narrow, basal band not overlapping base of 3rd segment5



- 5 (4). No pale fringe spots on wing posterior to vein 3; femora and tibiae inconspicuously speckled*vernus*
(in part)
– Pale fringe spots on wing present opposite veins posterior to vein 3, sometimes including vein 6; femora and tibiae not speckled.6



- 6 (5). Stem of wing vein 5 pale, at and adjacent to the fork*garnhami*
(in part)
– Fork of wing vein 5 dark7



- 7(6). Wing length 4 mm or less; decumbent scutal scales not extending onto scutellum*demeilloni*
(Berg River form)
– Wing length 4.4 mm or more; some decumbent scales present on scutellum as well as scutum .*carteri*
(in part)

Section IX. Mosquitoes with a pale interruption in 3rd main dark area (preapical dark spot) of wing vein 1 or this area entirely pale; at least 1 pale spot on basal 0.5 of costa, pale scales not confined to costa and vein 1; maxillary palpus with 3 pale bands, pale at apex; legs not speckled, hindtarsomeres 4 and 5 not entirely pale; abdomen without laterally projecting tufts of scales

1. 2nd and 3rd main dark areas of wing (median and preapical dark spots) absent from vein 1*wellcomei*
(in part)
– 2nd and 3rd main dark areas present on vein 12



- 2 (1). Hindtarsomere 5 entirely pale, hindtarsomere 4 with broad apical and basal pale bands*seydeli*
– Hindtarsomere 5 entirely dark, hindtarsomere 4 with narrow apical and basal pale bands3



- 3 (2). Upper branch of wing vein 5 with 1 pale spot,
sometimes a vestigial 2nd pale spot4
– Upper branch of wing vein 5 with 2 well-developed
pale spots.....5



- 4 (3). Pale fringe spot present opposite wing vein 6; foretarsomeres 1 to 4 with conspicuous basal and apical pale bands *mortiauxi*
 – No pale fringe spot opposite wing vein 6; foretarsomeres 1 to 4 narrowly pale apically only *berghei*



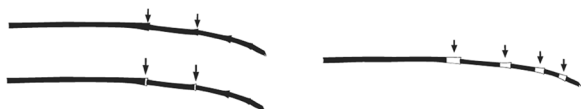
- 5 (3). Subapical pale band on maxillary palpus very narrow, confined to apex of 3rd segment6
– Subapical pale band on maxillary palpus broad, overlapping apex of 3rd and base of 4th segment7



- 6 (5). Wing with base of costa with 2 pale interruptions*brunnipes*
– Basal 0.25 of costa entirely dark *walravensi*
(in part)

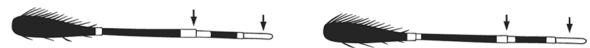


- | | |
|---|----|
| 7 (5). Hindtarsomeres either all dark or with pale bands on tarsomeres 1 and 2 only | 8 |
| – Hindtarsomeres 1 to 4 with well-marked apical pale bands | 10 |



- 8 (7). Scutal fossae and lateral areas of scutum above wing root (supraalar area) without scales*harperi*
 – Scutal fossae and lateral areas of scutum above wing root (supraalar area) with scattered or abundant broadish scales9

- 9 (8). Subapical pale band on maxillary palpus
about equal to or slightly shorter than apical band
..... *njombiensis*
– Subapical pale band on maxillary palpus much nar-
rower than apical band *walravensi*
(in part)



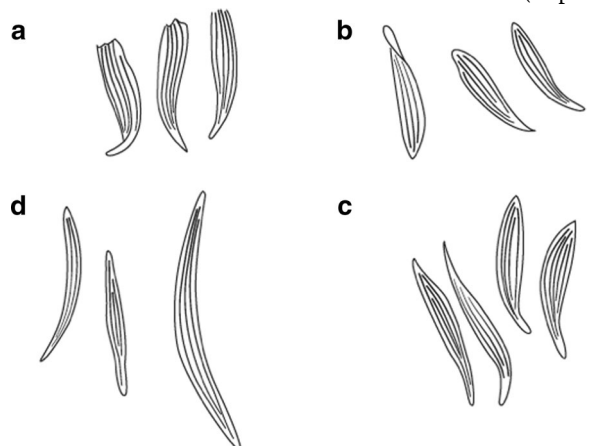
- 10 (7). Apical pale bands on hindtarsomeres 1 to 4
very broad, at least twice the apical width of the tar-
someres..... *austenii*
– Hindtarsomeres 1 to 4 with narrow pale bands, as
long or shorter than the width of the tarsomeres11



- 11 (10). Wing vein 3 largely dark or broadly dark at
either end; scutal scales very narrow and golden
.....*gibbinsi*
(in part)
– Wing vein 3 narrowly dark at ends; scutal scales vari-
ous12



- 12 (11). Scutal scales as in A*hargreavesi*
Scutal scales as in B*mousinhoi*
Scutal scales as in C*marshallii*
letabensis
kosiensis
hughi
– Scutal scales as in D*gibbinsi*
(in part)



Section X. Mosquitoes with upper branch of wing vein 5 with 2 pale spots, no pale interruptions in 3rd main dark area of vein 1, at least 1 pale spot on basal half of costa, pale scales not confined to costa and vein 1; maxillary palpus with 3 pale bands or less, pale at apex; legs not speckled, hindtarsomeres 4 and 5 not entirely pale; abdomen without laterally projecting tufts of scales

1. Maxillary palpus with only apical pale band*gabonensis*
 Maxillary palpus with 3 pale bands.....2



- 2 (1). Subapical pale band on maxillary palpus broad, about equal to or longer than apical dark band3
 – Apical dark band much longer than subapical pale band17



- 3 (2). Apical pale band on hindtarsomere 4, and sometimes on hindtarsomeres 2 and 3, extending onto bases of succeeding tarsomeres4
 – Bases of hindtarsomeres dark7



- 4 (3). 2nd main dark area on wing vein 1 with 2 pale interruptions; bases of hindtarsomeres 4 and 5 broadly or narrowly pale *rufipes* (in part)
 – 2nd main dark area on wing vein 1 with 1 pale interruption; bases of hindtarsomeres 4 and 5 at most narrowly pale5



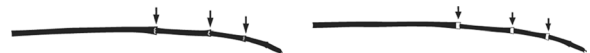
- 5 (4). Base of costa with 1 pale interruption, 3rd main dark area on costa and vein 1 much broader than subcostal pale spot *domicolus*
 – Base of costa with 2 pale interruptions, 3rd main dark area equal to or narrower than subcostal pale spot6



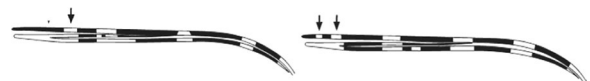
- 6 (5). Pale fringe spot present opposite wing vein 6 *lloreti*
 – No pale fringe spot opposite vein 6 *barberellus*



- 7 (3). Apices of hindtarsomeres 3 and 4 dark or at most with a few pale scales8
 – Apices of hindtarsomeres 1 to 3 and sometimes 4, distinctly pale banded13



- 8 (7). Base of costa with 1 or no pale interruption9
 – Base of costa with 2 pale interruptions10



- 9 (8). Wing vein 6 either with pale fringe spot or with pale scales at apex *brucei* (in part)
 – Wing vein 6 without pale fringe spot and no pale scales at apex *rivulorum* (in part)



- 10 (8). Scutal scales fairly broad, extending over whole scutum and onto scutellum *carteri* (in part)
 – Scutal scales variable, but decumbent scales confined to at most anterior 0.66 of scutum11
 11 (10). Very small species, wing length 2.8 mm or less *brucei* (in part)

- Small or moderate species, wing length 2.9 mm or more12

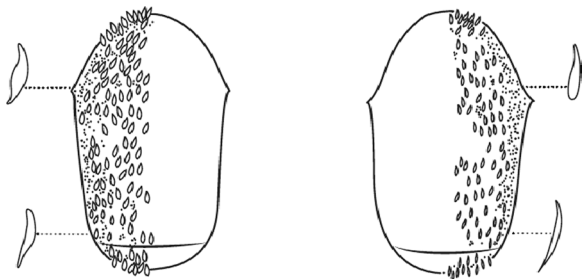
- 12 (11). Hindtarsomeres entirely dark; preaccessory dark spot on wing vein 1 usually absent *freetownensis*
 – Hindtarsomeres 1 and 2 narrowly but distinctly pale apically; preaccessory dark spot present on wing vein 1 *demeilloni* (in part)



- 13 (7). 3rd main dark area of costa equal to or shorter than subapical pale spot *flavicosta* (in part)
 – 3rd main dark area much longer than subapical pale spot14



- 14 (3). Scutal scales broadish and white, only slightly less dense on posterior 0.33 of scutum than anteriorly, and extending onto scutellum *flavicosta* (in part)
 – Scutal scales on posterior 0.33 of scutum scanty, narrow and yellowish-brown15



- 15 (14). Moderate-sized species, wing length more than 3.2 mm *keniensis* (in part)
 – Small species, wing length 3.0 mm or less16
 16 (15). Foretarsomere 4 dark or indistinctly pale at apex; wing usually without pale fringe spot opposite vein 6 *moucheti*
 – Foretarsomere 4 with well-marked apical pale band; wing with fringe spot opposite vein 6 *bervoetsi*



- 17 (2). 3rd main dark area of costa equal to or shorter than subapical pale spot *flavicosta* (in part)
 – 3rd main dark area of costa much longer than subapical pale spot18



- 18 (17). Wing with fork of vein 5 pale..... *garnhami* (in part)
 – Wing with fork of vein 5 dark19



- 19 (18). Base of costa with 2 pale interruptions *demeilloni* (in part)
 – Base of costa with 1 or no pale interruption20



- 20 (19). Small species, wing length about 2.4–3.3 mm *rivulorum* (in part)
 – Small or moderate-sized species, wing length 2.9–4.2 mm *demeilloni* (in part)

Section XI. Mosquitoes with upper branch of wing vein 5 with 1 pale spot, no pale interruptions on 3rd main dark area of vein 1, at least 1 pale spot on basal 0.5 of costa, pale scales not confined to costa and vein 1; maxillary palpus with 3 pale bands or less, pale at apex; legs not speckled, hindtarsomeres 4 and 5 not entirely pale; abdomen without laterally projecting tufts of scales

1. Maxillary palpus with only apex pale2
 Maxillary palpus with 3 pale bands.....5



- 2 (1). Base of costa with large (presector) pale spot, base of vein 1 pale3
 Base of costa dark or with small pale spot, base of vein 1 dark4

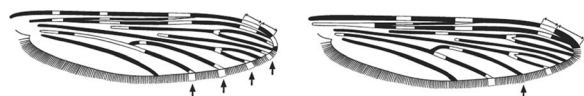


- 3 (2). Lower branch of wing vein 2 and upper branch of vein 4 with distinct pale spots *carnevalei*
 – These veins dark *ovengensis*



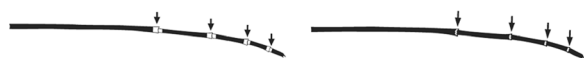
- 4 (2). Subapical pale spot on costa and wing vein 1 about as long as apical dark spot, fringe spots present opposite veins 3, lower branch of 4 and both branches of 5 *nili*

- Congo form
– Subapical pale spot shorter, usually much shorter, than apical dark spot, no pale fringe spot opposite upper branch of vein 5 *nili somalicus*



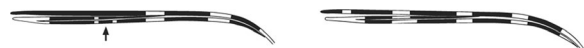
- 5 (1). Hindtarsomeres 1 to 4 with pale bands overlapping the joints, at least hindtarsomere 5 pale basally *longipalpis*

- Pale banding on hindtarsomeres narrow and apical only 6



- 6 (5). Preaccessory dark spot on wing vein 1 about twice as long as pale spot on either side of it *fuscivenosus* (in part)

- Preaccessory dark spot absent or, if present, shorter or only slightly longer than adjoining pale spots 7



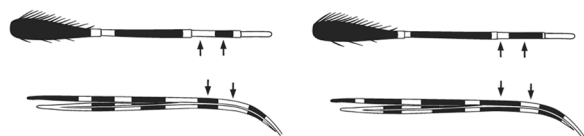
- 7 (6). Basal area of wing vein 1 proximal to 1st main dark area, pale with a broad dark spot *culicifacies*

- Basal area of wing vein 1 entirely pale 8



- 8 (7). Subapical pale band on maxillary palpus longer than or equal to apical dark band AND 3rd main dark area of costa and vein 1 equal to or shorter than subapical pale spot *aruni*

- Subapical pale band on maxillary palpus much shorter than apical dark band, OR 3rd main dark area longer than subapical pale spot 9



- 9 (8). Moderate-sized species, wing length more than 3.3 mm *demeilloni* (in part)

- Small species, wing length 3.2 mm or less 10

- 10 (9). Tip of wing vein 6 with a few pale scales, sometimes with fringe spot present *parensis*

- Tip of wing vein 6 dark with no fringe spot *funestus* group

sergentii

demeilloni

(in part; mainly highlands)

cameroni

(extreme S. Africa only)



Acknowledgements

Dr. Louise Coetzee is thanked for redrawing the illustrations. The following are thanked for comments and input on the keys: Seth Irish, Nil Rahola, Vincent Robert, Michael Faulde, Lizette Koekemoer and Basil Brooke. Two anonymous reviewers are thanked for comments.

Authors' contributions

The author read and approved the final manuscript.

Funding

The South African National Research Foundation (Grant No. 113300) is thanked for funding.

Availability of data and materials

Not applicable.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The author declares no competing interests.

Author details

¹ Wits Research Institute for Malaria, School of Pathology, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa. ² Centre for Emerging Zoonotic & Parasitic Diseases, National Institute for Communicable Diseases, Johannesburg, South Africa.

Received: 23 August 2019 Accepted: 29 January 2020

Published online: 13 February 2020

References

- De Meillon M. Illustrated keys to the full-grown larvae and adults of South African anopheline mosquitoes. Publ Sth Afr Inst Med Res. 1931;28:275–375.
- Gillies MT, Coetzee M. A supplement to the Anophelinae of Africa South of the Sahara. Publ Sth Afr Inst Med Res. 1987;55:1–143.
- Gillies MT, De Meillon B. The Anophelinae of Africa South of the Sahara. Publ Sth Afr Inst Med Res. 1968;54:1–343.

4. Sinka ME, Bangs MJ, Manguin S, Coetzee M, Mbogo CM, Hemingway J, et al. The dominant *Anopheles* vectors of human malaria in Africa, Europe and the Middle East: occurrence data, distribution maps and bionomic précis. *Parasit Vectors*. 2010;3:117.
5. Kyalo D, Amratia P, Mundia CW, Mbogo CM, Coetzee M, Snow RW. A geo-coded inventory of anophelines in the Afrotropical Region south of the Sahara: 1898–2016. *Wellcome Open Res*. 2017;2:57.
6. Brunhes J, Le Goff G, Geoffroy B. Afro-tropical anopheline mosquitoes III. Description of three new species: *Anopheles carnevalei* sp. nov., *An. hervyi* sp. nov., and *An. dualaensis* sp. nov., and resurrection of *An. rageai* Mattingly and Adam. *J Am Mosq Control Assoc*. 1999;15:552–8.
7. Brunhes J, Le Goff G, Boussès P. Anopheles Afrotropicaux. V. Description du mâle et des stades pré-imaginaux d'*An. deemingi* Service, 1970 et description d'*An. eouzani* n. sp. (Diptera: Culicidae). *Ann Soc Entomol Fr*. 2003;39:179–85.
8. Brunhes J, Le Goff G, Geoffroy B. Anopheles Afro-tropicaux. I. Descriptions d'espèces nouvelles et changements de statuts taxonomiques (Diptera: Culicidae). *Ann Soc Entomol Fr*. 1997;33:173–83.
9. Brunhes J, Le Goff G, Manga L, Geoffroy B. Anopheles Afrotropicaux. IV. Mise au point sur le complexe *Anopheles moucheti*, réhabilitation d'*An. multincinctus* et d'*An. garnhami basilewskyi* (Diptera: Culicidae). *Ann Soc Entomol Fr*. 1998;34:397–405.
10. Abdulla-Khan R, Coetzee M, Hunt RH. Description of *Anopheles (Cellia) seretsei* sp. nov. from Kasane Botswana. *J Am Mosq Control Assoc*. 1998;14:248–52.
11. Coetzee M, Segerman J, Hunt RH. Description of a new species *Anopheles (Cellia) kosiensis* (Diptera: Culicidae) from Zululand, South Africa. *Syst Entomol*. 1987;12:23–8.
12. Rahola N, Makanga B, Yangari P, Jiolle D, Fontenille D, Renaud F, et al. Description of *Anopheles gabonensis*, a new species potentially involved in rodent malaria transmission in Gabon, Central Africa. *Infect Genet Evol*. 2014;28:628–34.
13. Awono-Ambene HP, Kengne P, Simard F, Antonio-Nkondjio C, Fontenille D. Description and bionomics of *Anopheles (Cellia) ovengensis* (Diptera: Culicidae), a new malaria vector species of the *Anopheles nili* group from South Cameroon. *J Med Entomol*. 2004;41:561–8.
14. Faulde MK, Rueda LM, Khaireh BA. First record of the Asian malaria vector *Anopheles stephensi* and its possible role in the resurgence of malaria in Djibouti, Horn of Africa. *Acta Trop*. 2014;139:39–43.
15. Seyfarth M, Khaireh BA, Abdi AA, Bouh SM, Faulde MK. Five years following first detection of *Anopheles stephensi* (Diptera: Culicidae) in Djibouti, Horn of Africa: populations established—malaria emerging. *Parasitol Res*. 2019;118:725–32.
16. Carter TE, Yared S, Gebresilassie A, Bonnell V, Damodaran L, Lopez K, et al. First detection of *Anopheles stephensi* Liston, 1901 (Diptera: Culicidae) in Ethiopia using molecular and morphological approaches. *Acta Trop*. 2018;188:180–6.
17. Lambert DM, Coetzee M. A dual genetical and taxonomic approach to the resolution of the mosquito taxon *Anopheles (Cellia) marshallii* (Diptera: Culicidae). *Syst Entomol*. 1982;7:321–32.
18. Scott JA, Brogdon WG, Collins FH. Identification of single specimens of the *Anopheles gambiae* complex by the polymerase chain reaction. *Am J Trop Med Hyg*. 1993;49:520–9.
19. Koekemoer LL, Kamau L, Hunt RH, Coetzee M. A cocktail polymerase chain reaction (PCR) assay to identify members of the *Anopheles funestus* (Diptera: Culicidae) group. *Am J Trop Med Hyg*. 2002;66:804–11.
20. Coetzee M, Hunt RH, Wilkerson R, Della Torre A, Coulibaly MB, Besansky NJ. *Anopheles coluzzii* and *Anopheles amharicus*, new members of the *Anopheles gambiae* complex. *Zootaxa*. 2013;3619:246–74.
21. Barrón MG, Paupy C, Rahola N, Akone-Ella O, Ngangue MF, Wilson-Bahun TA, Pombi M, Kengne P, Costantini C, Simard F, González J, Ayala D. A new species in the major malaria vector complex sheds light on reticulated species evolution. *Sci Rep*. 2019;9:14753.
22. Harbach RE, Knight KL. Taxonomists' glossary of Mosquito Anatomy. New Jersey: Plexus Publ; 1980.
23. Harbach RE, Knight KL. Corrections and additions to *Taxonomists' Glossary of Mosquito Anatomy*. *Mosq Syst*. 1981;13:201–17.
24. Cumming JM, Wood DM. Adult morphology and terminology. 3. In: Kirk-Spriggs AH, Sinclair BJ, Eds Manual of Afrotropical Diptera. Vol. 1. Introductory chapters and keys to Diptera families. Suricata 4. South African National Biodiversity Institute, Pretoria; 2017. p. 89–133.
25. Evans AM. Mosquitoes of the Ethiopian Region. II. Anophelini Adults and Early Stages. *Brit Mus (Nat Hist)*, London; 1938.
26. Spillings BL, Brooke BD, Koekemoer LL, Chiphwanya J, Coetzee M, Hunt RH. A new species concealed by *Anopheles funestus* Giles, a major malaria vector in Africa. *Am J Trop Med Hyg*. 2009;81:510–5.
27. Cohuet A, Simard F, Toto JC, Kengne P, Coetzee M, Fontenille D. Species identification within the *Anopheles funestus* group of malaria vectors in Cameroon and evidence for a new species. *Am J Trop Med Hyg*. 2003;69:200–5.
28. Harbach RE, Kitching IJ. The phylogeny of Anophelinae revisited: inferences about the origin and classification of *Anopheles* (Diptera: Culicidae). *Zoo Scripta*. 2016;45:34–47.
29. Snodgrass RE. The anatomical life of the mosquito. *Smithsonian Institution*. 1959;139:1–87.
30. McAlpine JF. Morphology and terminology—adults. 2. In: McAlpine JF, Peterson BV, Shewell GE, Teskey HJ, Vockeroth JR, Wood DM, Eds. Manual of Nearctic Diptera. Vol. 1. Monograph, Research Branch, Agriculture, Canada; 1981;27:9–63.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Ready to submit your research? Choose BMC and benefit from:

- fast, convenient online submission
- thorough peer review by experienced researchers in your field
- rapid publication on acceptance
- support for research data, including large and complex data types
- gold Open Access which fosters wider collaboration and increased citations
- maximum visibility for your research: over 100M website views per year

At BMC, research is always in progress.

Learn more biomedcentral.com/submissions

