

Systematics and Identification of Afrotropical Toxorhynchitinae (Diptera: Culicidae)

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ABSTRACT I define two new species groups of *Afrorhynchus* from the Afrotropical Region and examine the taxonomic structure of the genus in the region. Keys are provided for the identification of adult males and females of all known Afrotropical *Toxorhynchites*.

KEY WORDS *Toxorhynchites*, *Afrorhynchus*, systematics, identification keys

THE TOXORHYNCHITINAE ARE CURRENTLY considered a monotypic subfamily, with the only genus, *Toxorhynchites*, distributed in tropical and temperate areas. Within the genus, four subgenera are now recognized (WRBU 2001): *Ankylorhynchus* Lutz, 1904 and *Lynchiella* Lahille, 1904 in the Americas; *Toxorhynchites* Theobald, 1901, widely distributed in the Old World, including Africa; and *Afrorhynchus* Ribeiro, 1991, endemic to the Afrotropical Region. The first-described Afrotropical toxorhynchitines were *Toxorhynchites brevipalpis*, *Tx. lutescens*, *Tx. phytophagus* (Theobald 1901a, 1909) and *Tx. conradti* (Grünberg 1907), followed by the description of *Tx. barbipes*, *Tx. viridibasis*, *Tx. evansae*, *Tx. erythrurus* (Edwards 1913, 1935, 1936, 1941), and *Tx. aeneus* (Evans 1926). The next important contributions to the knowledge of the Afrotropical Region representatives of the genus were made by Van Someren (1946, 1948), with the description of *Tx. nairobiensis*, *Tx. kaimosi*, and *Tx. ruwenzori*. At the beginning of the second half of the last century, the first Malagasy toxorhynchitine, *Tx. pauliani*, was described by Doucet (1951), making a total of 13 species known from the region. Since then, with the exception of the works of Hopkins (1952) on larvae and Mattingly (1969) on eggs, little attention was paid to the systematics of the toxorhynchitines, and no new Afrotropical species were described until the nineties. The influential works of Belkin (1962) in the South Pacific and Steffan and Evenhuis (1985) in the Far East and Australasia led to studies of the Afrotropical *Toxorhynchites*, and descriptions of five new species and one subspecies from the continent (Ribeiro 1991), one new species from the island of São Tomé (Ribeiro 1992/93), two new species from Angola (Ribeiro 1992a), three other species and one subspecies from the collections of several European museums (Ribeiro 2005), and five other species from Madagascar, to be added to *Tx. pauliani* (Ribeiro 2004).

Here, I define two new species groups of *Afrorhynchus* in the Afrotropical Region, examine the taxonomic structure of the genus in the same region, and propose an identification key for adult males and females of all known Afrotropical *Toxorhynchites*. The studies reported in this article are based on specimens from the collections of the Department of Medical Entomology, IHMT (Lisbon, Portugal), the Natural History Museum (London, United Kingdom), the Institut Pasteur de Paris (Paris, France), the Muséum National d'Histoire Naturelle (Paris, France), the Musée Royal de l'Afrique Centrale (Tervuren, Belgium), and the IRD, ex-ORSTOM, (Montpellier, France) (Ribeiro 1991a, b, 1992, 1992/93, 2004, 2005).

The morphological terminology and abbreviations adopted are basically those of Harbach and Knight (1980, 1981), whereas the format adopted is that of Ribeiro (1991a).

Species Groups in Subgenus *Afrorhynchus*

Besides the already established Malagasy Pauliani Group, two other groups are here defined in the Afrotropical Region species of *Afrorhynchus*.

Erythrurus Group nov.

This group is typified by *Toxorhynchites* (*Afrorhynchus*) *erythrurus* (Edwards 1941) and may be defined as follows. MF: Without scales on postspiracular and subspiracular areas; mesokatepisternum without patch of white scales at lower angle, below the golden scales; with five to 11 mesokatepisternal setae each side; mesepimeron bare at lower 1/5–1/4; caudolateral tufts well developed, orange, orange red, or red. M: Vestiture of fourth palpomere characteristic, with dorso-medial and ventrolateral pectens of four to 15 stout, erect setae on each palpus; ratio of width of dorsal aedeagal bridge to length of aedeagus 0.12–0.18; lobes of tergum IX with 18–40 setae each; gonostylus with

7–13 sensilla trichoidea; ratio of length of gonostylar claw to length of gonostylus 0.34–0.37. The group includes the following eight species mainly distributed in the West African Subregion of Chapin (1932): *Tx. erythrurus* (Edwards 1941), *Tx. aeneus* (Evans 1926), *Tx. nairobiensis* (Van Someren 1946), *Tx. kaimosi* (Van Someren 1946), *Tx. angolensis* Ribeiro 1992/93, *Tx. helenae* Ribeiro 1992/93, and *Tx. nigeriensis* and *Tx. wolfsi* Ribeiro (Ribeiro 2005).

Lutescens Group Edwards 1941 (s.str.)

This group is typified by *Toxorhynchites* (*Afrorhynchus*) *lutescens* Theobald, 1901 and may be defined as follows. MF: Without scales on postspiracular and subspiracular areas; mesokatepisternum with a distinct patch of white scales at lower angle, below the golden scales; without mesokatepisternal setae or, at most, with one or two such setae; mesepimeron clothed with flat scales, without obvious bare areas; caudolateral tufts rather small, inconspicuous, golden, orange, or reddish. M: Fourth palpomere without pectens, with two to six short, stout decumbent setae dispersed among the scales; ratio of width of dorsal aedeagal bridge to length of aedeagus 0.12–0.14; lobes of tergum IX with 11–25 setae each; gonostylus with four to 13 sensilla trichoidea; ratio of gonostylar claw to gonostylus \approx 0.35. The group includes the following six species and subspecies, mainly distributed in the East and South African Subregion of Chapin (1932): *Tx. lutescens* Theobald, 1901; *Tx. viridibasis viridibasis* (Edwards 1935); *Tx. ruwenzori* (Van Someren 1948), *Tx. capelai* Ribeiro, 1993, and *Tx. zairensis* Ribeiro, 2005; and *Tx. viridibasis voltaicus* Ribeiro, 2005.

For the sake of completeness, I make reference to the corresponding adult characters in Pauliani Group, the first described group of *Afrorhynchus*. MF: Usually with at least a few translucent scales on the postspiracular and/or subspiracular areas; mesokatepisternum with a small, distinct patch of white scales at lower angle, below the golden scales; without mesokatepisternal setae or, at most, with one or two such setae; mesepimeron clothed with flat scales, without obvious bare areas; caudolateral tufts moderately to well developed, from pale yellow to orange red. M: Fourth palpomere without pectens, with 4–20 short, stout decumbent or semierect setae dispersed among the scales; ratio of width of dorsal aedeagal bridge to length of aedeagus 0.13–0.26; lobes of tergum IX with 11–22 setae each; gonostylus with 6–18 sensilla trichoidea; ratio of gonostylar claw to gonostylus 0.29–0.34. Typified by *Tx. pauliani* Doucet, 1951; the group also includes *Tx. madagascarensis*, *Tx. brunhesi*, *Tx. grjebine*, *Tx. fontenillei*, and *Tx. lemuriae*, described recently (Ribeiro 2004).

Taxonomic Structure of Genus *Toxorhynchites* in the Afrotropical Region

Edwards (1941) recognized two well-defined groups in the Afrotropical Region species of subgenus *Toxo-*

rhynchites, the Brevipalpis and Lutescens groups. Later, the Brevipalpis Group was redefined and split into the Brevipalpis Subgroup s.str. and the Phytophagus Subgroup, clearly separable in the adult male (Ribeiro 1991a), whereas Edward's Lutescens Group was given subgeneric status as *Afrorhynchus* (Ribeiro 1991b). Recently, (Ribeiro 2004) all known species of genus *Toxorhynchites* from Madagascar were considered to belong to the new, endemic Pauliani Group, within subgenus *Afrorhynchus*. The above-mentioned descriptions of *Erythrurus* and *Lutescens* s.str. groups completed our present knowledge of the somewhat complex taxonomic structure of genus *Toxorhynchites* in the Afrotropical Region, which may be summarized as follows.

Subgenus *Afrorhynchus* Ribeiro, 1991

Erythrurus Group nov.

- Tx. (Afr.) aeneus*
- Tx. (Afr.) angolensis*
- Tx. (Afr.) erythrurus*
- Tx. (Afr.) helenae*
- Tx. (Afr.) kaimosi*
- Tx. (Afr.) nairobiensis*
- Tx. (Afr.) nigeriensis*
- Tx. (Afr.) wolfsi*

Lutescens Group Edwards, 1941 (s.str.)

- Tx. (Afr.) capelai*
- Tx. (Afr.) lutescens*
- Tx. (Afr.) viridibasis viridibasis*
- Tx. (Afr.) viridibasis voltaicus*
- Tx. (Afr.) ruwenzori*
- Tx. (Afr.) zairensis*

Pauliani Group Ribeiro, 2004

- Tx. (Afr.) brunhesi*
- Tx. (Afr.) fontenillei*
- Tx. (Afr.) grjebine*
- Tx. (Afr.) lemuriae*
- Tx. (Afr.) madagascarensis*
- Tx. (Afr.) pauliani*

Subgenus *Toxorhynchites* Theobald, 1901

Brevipalpis Group Edwards, 1941

Brevipalpis Subgroup Ribeiro, 1991

- Tx. (Tox.) brevipalpis abyssinicus*
- Tx. (Tox.) brevipalpis brevipalpis*
- Tx. (Tox.) brevipalpis conradi*

Phytophagus Subgroup Ribeiro, 1991

- Tx. (Tox.) barbipes*
- Tx. (Tox.) camaronis*
- Tx. (Tox.) dumdo*
- Tx. (Tox.) evansae*
- Tx. (Tox.) lewisi*
- Tx. (Tox.) phytophagus*
- Tx. (Tox.) rickenbachi*
- Tx. (Tox.) rodhaini*

Identification Key to the Afrotropical *Toxorhynchites*

Separate identification keys were already proposed for the Brevipalpis Group of subgenus *Toxorhynchites* (Ribeiro 1992/93); the Afrotropical Region species of subgenus *Afrorhynchus* (Ribeiro 2005); and the Mal-

agasy Pauliani Group, also in *Afrorhynchus* (Ribeiro 2004).

Here, I present a unified identification key to the adults of all known species and subspecies of toxorhynchitines in the Afrotropical Region, including subgenera, species groups, and subgroups.

1. MF: Mesokatepisternum densely clothed with white scales; scales on coxae all white; pale scales on abdomen white; laterotergite densely scaled; caudolateral tufts on abdominal terga white, yellowish, pale orange, brown, or black. M: Midungues unequal, one of them stronger and toothed; gonostylus slender, not widened at middle; gonostylar claw pointed and short, <0.20 of gonostylus; dorsal aedeagal bridge very narrow, at most ≈1/10 of aedeagus; paraproct without transverse unsclerotized band. Sub-Saharan Africa Subgenus *Toxorhynchites*, Group *Brevipalpis* 2

MF: Mesokatepisternum with a patch of golden or golden brown scales below, usually also above; fore coxae, at least, all, or almost all golden-scaled; pale scales on abdomen golden; laterotergite with few or no scales; caudolateral tufts on abdominal terga yellow, orange or red, never white, brown, or black. M: Midungues small, equal, and simple; gonostylus noticeably widened at middle; gonostylar claw blunt-tipped and long, from ≈0.25 to 0.37 of gonostylus; dorsal aedeagal bridge wider, 0.12 or more of aedeagus; paraproct appearing divided by a transverse, unsclerotized band. Afrotropical Region, including Madagascar Subgenus *Afrorhynchus* 22

2(1). Males⁽¹⁾ 3
 Females⁽²⁾ 12

3(2). Hind femur without row of long, thin setae; first hind tarsomere without long setae; gonocoxite without exceptionally strong setae on the inner side *Brevipalpis* Subgroup 4

Hind femur and first hind tarsomere with a row of long setae on about the distal half, beneath; inner aspect of gonocoxite with one to four exceptionally long and strong setae *Phytophagus* Subgroup 6

4(3). Second foretarsomere extensively white-scaled at base *brevipalpis*
 Second foretarsomere all dark 5

5(4). Tuft of tergum VI all or almost all black; lobes of tergum IX with ≈16 setae each *br. conradti*
 Tuft of tergum VI all or almost all white; lobes of tergum IX with eight to 10 setae *br. abyssinicus*

6(3). Caudolateral tuft of tergum VIII black, as that of tergum VII *evansae*

Caudolateral tuft of tergum VIII white, yellow or orange, not black 7
 7(6). Tuft of tergum VI all or almost all white 8
 Distal one-third or more of the tuft of tergum VI black 9
 8(7). Lobes of tergum IX with ≈23 setae; interlobar space narrow *barbipes*
 Lobes of tergum IX with 11–16 setae; interlobar space wide *dumdo*
 9(7). No white scales on postpronotum; long setae on first hind tarsomere coarse, most of them on the distal half of the segment *rickenbachi*
 Postpronotum with at least a few white scales below; long setae on first hind tarsomere dense, either extending along all the tarsomere or more evident only at basal half 10
 10(9). Mesokatepisternum with a few brownish scales in middle, among the white scales; second and third abdominal terga mainly metallic green above, with golden reflections; lobes of tergum IX each with 18 or 19 setae *camaronis*
 Mesokatepisternum without darker scales in middle; second and third terga dark purple, with violet or blue reflections; lobes of tergum IX with at most 16 setae 11
 11(10). Scales on mesonotum with intense blue green reflections; with a patch of metallic light blue green scales on supra-alar area; sterna V and VI almost all dark purple, with inconspicuous apicolateral white patches; lobes of tergum IX with 11–16 setae *phytophagus*
 Scales on mesonotum with golden reflections; without patch of metallic light blue green scales on supra-alar area; sterna V and VI with well developed lateral patches of white scales; lobes of tergum IX with approximately seven setae *lewisii*
 12(2). Caudolateral tuft of tergum VIII black, as that of tergum VII *evansae*
 Tuft of tergum VIII orange, yellow or white, never black 13
 13(12). First tarsomeres of fore and midlegs all white *rickenbachi*
 First tarsomeres of fore and midlegs all dark or, at most, white at base only 14
 14(13). Fifth tarsomere of midleg either all white or, at least, with white basal markings 15
 Fifth tarsomere of midleg all dark 16
 15(14). Fourth and fifth tarsomeres of midleg white at base and obviously dark apically *barbipes*
 Fourth and fifth tarsomeres of midleg all white *rodhaini*
 16(14). Third tarsomere of midleg all or almost all white 17
 Third tarsomere of midleg dark 18
 17(16). Distal one-third or more of tuft of tergum VI black; mesokatepisternum with ≈20

⁽¹⁾ The male of *Tx. rodhaini* is not known.

⁽²⁾ The female of *Tx. brevipalpis abyssinicus* is not known.

- strong setae; radiomedial crossvein (rm) index ≈ 2.5 *phytophagous*
 Tuft of tergum VI all or almost all white; mesokatepisternum with ≈ 10 weak setae; rm index 1.5–2 *dundo*
- 18(16). Second foretarsomere all dark 19
 Second foretarsomere with, at least, a white patch at base 20
- 19(18). Tuft of tergum VI white on basal one-third or more *camaronis*
 Tuft of tergum VI all or almost all black *br. conradti* in part
- 20(18). Tuft of tergum VI all or almost all white *br. brevipalpis*
 Tuft of tergum VI black on about distal half or more 21
- 21(20). Tuft of tergum VI all or almost all black *br. conradti* in part
 Basal one-third to one-half of tuft on tergum VI white *lewisi*
- 22 (1). MF: Mesepimeron bare at lower one-fifth to one-fourth; M: Fourth palpomere with stout erect setae in a dorsomedial and a ventrolateral pecten; lobes of tergum IX with 18–40 setae each. Mainly West African Subregion . . . Erythrurus Group . . . 23
 MF: Mesepimeron entirely clothed with scales; M: Stout setae on fourth palpomere, if present, decumbent or semi-erect, and scattered among the scales, not in rows; lobes of tergum IX with 11–25 setae 33
- 23(22). Males⁽³⁾ 24
 Females⁽⁴⁾ 30
- 24(23). Mesoposnotum with a small patch of green golden scales in middle; second hind tarsomere white-scaled at base; with well developed caudolateral tuft on tergum V *wolfsi*
 Mesoposnotum without scales; second hind tarsomere dark; without tuft on tergum V 25
- 25(24). Fourth palpomere with rows of only four specialized setae above and five below; hind tibia dark; lobes of tergum IX unusually flat, with ≈ 20 setae each *nairobiensis*
 Fourth palpomere with rows of 7–15 specialized setae above and below; hind tibia with postmedian white ring; lobes of tergum IX round, with 23–40 26
- 26(25). Postpronotum with patches of golden scales in middle and behind, blue green scales above, and white scales below; second midtarsomere purple; ratio of gonostylar claw to gonostylus 0.370–0.375 27
 Postpronotum not as above, without white scales; second midtarsomere with pale scaling below; gonostylar claw ratio 0.33–0.35 28
- 27(26). First and third midtarsomeres pale-scaled beneath; rm index 2; with two lower mesepimeral setae each side; lobes of tergum IX with 28–30 setae *kaimosi*
 First and third midtarsomeres purple, without pale markings; rm index 3; one lower mesepimeral seta each side; lobes of tergum IX with 23–24 setae *helenae*
- 28(26). Fourth palpomere with rows of 15 specialized setae above and 14 setae beneath; postpronotum clothed with golden scales *erythrurus*
 Fourth palpomere with seven to nine setae on each such rows; postpronotum clothed with brown scales with intense blue green reflections 29
- 29(28). With two lower mesepimeral setae each side; tergum II mainly purple, with admixture of greenish golden scales; sternum II golden; lobes of tergum IX with 38–40 setae each; with two cercal setae *angolensis*
 With one lower mesepimeral seta; tergum II extensively green-scaled proximally, purple distally; sternum II purple in middle; lobes of tergum IX with 31 or 32 setae; with three cercal setae . . . *nigeriensis*
- 30(23). Postpronotum with a patch of white scales *kaimosi*
 Postpronotum entirely or mainly golden, with or without blue green reflections, but without white scales 31
- 31(30). Hind tibia dark purple, without white markings *nairobiensis*
 Hind tibia with postmedian patch or ring of white scales 32
- 32(31). Scales on midcoxa all golden; second tarsomere of foretarsus pale beneath *aeneus*
 Midcoxa with patch of silvery white scales at base; second tarsomere of foretarsus dark *erythrurus*
- 33(22). MF: Without postspiracular scales; rm index 2–3; caudolateral tufts inconspicuous. Mainly East and South African Subregion . . . Lutescens s.str. Group⁽⁵⁾ . . . 34
 MF: At least a few postspiracular scales usually present; rm index 3–3.5; caudolateral tufts conspicuous, moderately to well developed. Malagasy Subregion. Pauliani⁽⁶⁾ Group 43
- 34(33). Males 35
 Females 40
- 35(34). Golden scales on mesokatepisternum restricted to the lower portion of the sclerite 36

⁽³⁾ The male of *Tx. aeneus* is not known.
⁽⁴⁾ The females of *Tx. angolensis*, *Tx. helenae*, *Tx. nigeriensis*, and *Tx. wolfsi* are not known.
⁽⁵⁾ The females of *Tx. viridibasis voltaicus* and *Tx. zairensis* are not known.
⁽⁶⁾ The male of *Tx. lemuriae* and the females of *Tx. fontenillei* and *Tx. pauliani* are not known.

- A patch of golden scales also present on the upper portion of mesokatepisternum, at base of the prealar knob 37
- 36(35). Postpronotum golden green; tergum II metallic green; caudolateral tufts well developed, orange red *v. viridibasis*
 Postpronotum creamy white below, golden above; tergum II coppery purple; caudolateral tufts inconspicuous, yellow *ruwenzori*
- 37(35). Tergum III with abundant metallic green scales; caudolateral tufts well developed, orange red *v. voltaicus*
 Tergum III purple, almost devoid of green scales; caudolateral tufts small, inconspicuous, golden 38
- 38(37). Hindtibia purplish, without white ring; tergum II golden with green and purple scales. *capelai*
 Hind tibia with postmedian white ring; tergum II coppery or purplish golden, without green scales 39
- 39(38). Without mesokatepisternal setae; sterna II-VI golden; distal portion of paraproct gently curved, as usual *lutescens*
 With two mesokatepisternal setae; sterna with purple gloss distally, not entirely golden; distal portion of paraproct bent at right angle *zairensis*
- 40(34). Postpronotum white-scaled below, with narrow line of golden scales above *ruwenzori*
 Postpronotum entirely or mainly golden-scaled 41
- 41(40). Hind tibia dark purple, without white markings *capelai*
 Hind tibia with postmedian patch or ring of white scales. 42
- 42(41). Scales on prealar area silvery white; second midtarsomere dark *v. viridibasis*
 With golden scales on prealar area; second midtarsomere white *lutescens*
- 43(33). Males 44
 Females⁽⁷⁾ 48
- 44(43). Mean number of setae of both lobes of tergum IX 22-25 45
 Mean of the setae of both lobes of tergum IX 11-22 46
- 45(44). Scutum clothed with light green scales; midfemur yellow, with a dark patch at about middle of hind surface . . *pauliani*
 Scutum clothed with golden brown scales, greenish scutal scales restricted to the prescutellar area; midfemur dark above and at distal half, without patch of dark scales behind *fontenillei*
- 46(44). Mean number of setae of both lobes of tergum IX 12.5-14.5; mean number of sensilla trichoidea of both gonostyles

- 6.5-10; midfemur violaceous and golden, without defined line of blue scales in front *grjebinei*
- Mean number of setae of both lobes of tergum IX 13.5-25; mean number of sensilla trichoidea of both gonostyles 9-18; midfemur with or without line of blue scales in front 47
- 47(46). Scutum with brownish scales with metallic reflections; midfemur with line of metallic blue scales in front, usually well developed; mean number of setae of both lobes of tergum IX 13.5-18; mean number of gonostylar sensilla 9-13.5 *madagascariensis*
 Scutal scales brown, golden and silvery, without obvious metallic green reflections; blue scales on midfemur, if present, few in number and sparse; mean number of setae of both lobes of tergum IX 17.5 or more; mean number of gonostylar sensilla 13-18 *brunhesi*
- 48(43). Upper surface of second palpomere mainly with whitish scales, dark scales present only at tip; foretarsomeres II-IV pale-scaled, slightly darker at joints *lemuriae*
 Upper surface of palpus with purple and golden scales; at least foretarsomeres III and IV dark 49
- 49(48). Front surface of midfemur usually with well developed line of metallic blue scales *madagascariensis*
 Midfemur without line of blue scales, at most a few sparse blue scales present *brunhesi grjebinei*

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⁽⁷⁾ With the exception of *Tx. lemuriae*, females cannot be identified with certitude.

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