

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. RAGEAUI* MATTINGLY AND ADAM

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ABSTRACT. *Anopheles (Cellia) carnevalei* sp. nov. is described as a new species morphologically similar to *Anopheles nili*. This aggressive human biter was collected in Ivory Coast. *Anopheles (Cellia) hervyi* sp. nov. was collected in southern Niger and is described as a new species morphologically similar to *Anopheles salbai*. *Anopheles (Cellia) dualaensis* sp. nov. is a new species from Duala in southern Cameroon. The synonymy of *Anopheles cavernicolus* and *Anopheles smithii* is confirmed. Based on extensive reexamination of larval and adult morphology, the authors suggest that *Anopheles (Cellia) rageaui* Mattingly and Adam should no longer be considered as a synonym of *An. smithii*.

KEY WORDS Mosquitoes, anopheline, larva, adult, new species, new status, Africa

INTRODUCTION

Large collections of anopheline mosquitoes from the Afro-tropical region were recently examined during a project to develop identification software (Hervy et al., 1998). During this process we identified previously undescribed morphologic variation in some species and, in some cases, this led us to propose new species. This is the 3rd in a series of papers (Brunhes et al. 1997, 1998a, 1998b) describing new species of anopheline mosquitoes from the Afro-tropical region.

DESCRIPTIONS

Anopheles (Cellia) carnevalei, new species

Various authors have reported extensive morphologic, ecological, and ethological variation among *Anopheles nili* (Theobald) populations (Edwards 1912, Evans 1938, De Meillon 1947, Rivola and Holstein 1947, Mouchet and Gariou, 1961; Gillies and De Meillon, 1968; Gillies and Coetzee, 1987; Carnevale et al. 1992). We suggest that *An. nili* be considered a species complex. We describe a new species in this complex based upon mosquitoes collected in sympatry with *An. nili* s.s. from southern Ivory Coast. We dedicate this species to our colleague and friend, Pierre Carnevale, who devotes his research to malaria control in Africa.

Studied material: Holotype female, Tiassalé (5°54'N, 4°50'W), Ivory Coast, 16/06/1965, Hamon rec. Paratypes: 5 females caught in a light trap (Tiassalé, Ivory Coast, Hamon rec. 20/06/1965); 2 females caught on man (Niamoué [5°53'N, 4°49'W]), Tiassalé, Ivory Coast, Hamon and Brengues rec. 04/08/1963); 1 female caught in Cameroon by Rickenbach; date and locality not mentioned.

Type deposit: The holotype will be deposited in the Laboratoire de Taxonomie des Vecteurs, ORSTOM, Montpellier, France. One paratype will be

deposited in the Museum National d'Histoire Naturelle, Paris, France, and another will be deposited at the British Museum (Natural History), London, United Kingdom.

Description of female holotype: **Head:** Black labium and pale labella; the pale labella spot spreads over the labium apex. Maxillary palps: Disheveled scales on segment 2 and scales plastered down on segments 3-5; a white ring occupies the apex of segment 4 and all of the apex of segment 5 (Fig. 1). White raised scales, sloping progressively towards the front, occupy the interocular space. Other raised scales on the vertex are black. **Thorax:** The scutum between dorso-central hairs is light brown. Scutum is darker on the sides. Presence of light setiform scales towards the front becoming darker posteriorly. Fossa carrying hairs only. **Wings:** (Fig. 2). Size 3-3.5 mm. Costal, subcostal, and R1 veins ornamented with 4 white spots; the prehumeral spot is always present and well developed; it also occupies radial vein basis. The R3 and M1 veins have a white median spot. The CuA vein is widely covered with white spots. Alar fringe shows white spots on apex of R2, R4 + 5, M2, M3 + 4, and CuP veins. Anal vein is entirely black. Transverse veins are distinctly pale. **Legs:** Black; little clear areas are present on each segment extremity. These spots are particularly visible on leg III. **Abdomen:** Uniformly black, without scale overlay.

Distribution: *Anopheles carnevalei* is present in Ivory Coast and Cameroon; it seems to be associated with large forest clumps. Specimens of *An. nili* "clear form" from Sierra Leone, Ghana, and Nigeria (Gillies and De Meillon 1968) could be related to this new species.

Discussion: *Anopheles carnevalei* is distinct from *An. nili* s.s. based upon the abundance of clear spots ornamenting its wing. Particularly notable is the presence of a large white prebasal spot affecting the costa and all of the basal parts of R1; the CuP

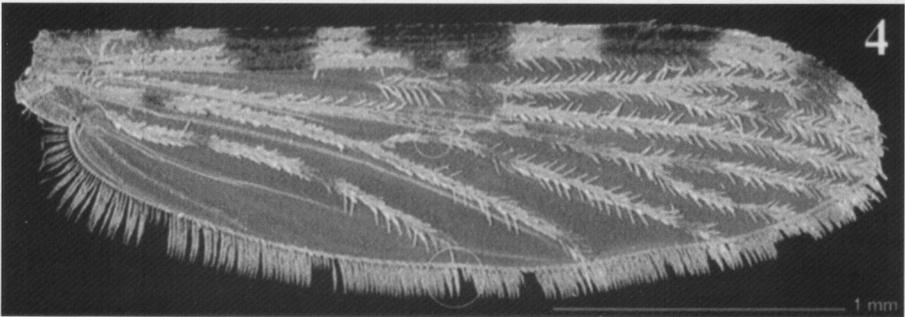
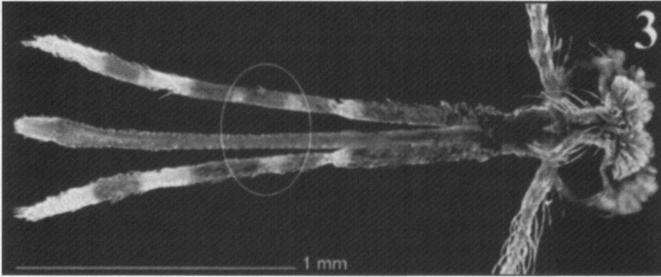
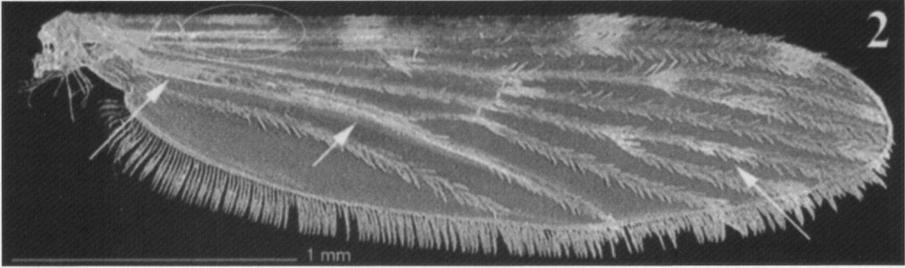
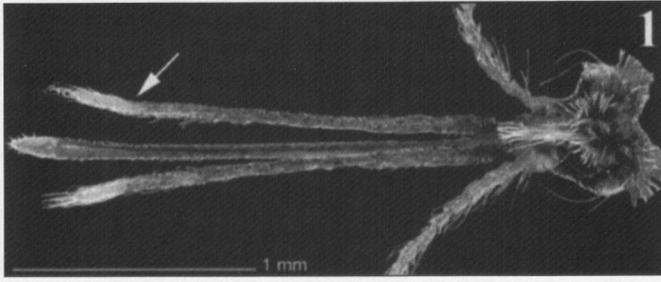


Fig. 1. *Anopheles carnevalei* sp. nov.: head.

Fig. 2. *An. carnevalei* sp. nov.: wing.

Fig. 3. *Anopheles hervyi* sp. nov.: head.

Fig. 4. *Anopheles hervyi* sp. nov.: wing.

vein is mostly entirely white; white spots are more or less marked on R3 and M1 and the M3 + 4 apex. Legs are not uniformly black but are marked with small apical white rings that are clearly visible on leg III. *Anopheles carnevalei*, like *An. nili*, is anthropophilic and its role in malaria transmission should be evaluated.

In the Congo basin, *An. nili* s.s. seems to live in

sympatry with lighter forms. However, these forms are not identical to *An. carnevalei*. This "clear form" from Zaïre possibly is a distinct species. However, we have too few collections from this area to give an opinion on the taxonomic status of the Congo form. This form should only be considered a distinct species if found in sympatry with *An. nili*.

Anopheles (Cellia) hervyi, new species

In 1963, Hamon, Dyemkouma, Ouedraogo, Mafi and Coluzzi reported that *Anopheles salbaii* was present near Zinder, Niger. In October 1965, one of us (J.B.) performed nighttime human landing collections near Zinder at Guidimouni and Guidiguir, and the species caught were identical to those previously collected by Hamon and colleagues. Based upon a comparison with *An. salbaii* from Ethiopia, we propose that the mosquitoes from Niger belong to a species close to but distinct from *An. salbaii*.

Studied material: Labeled holotype female: Holotype female, Zinder, Niger, x/1962, Dyemkouma rec. Paratypes: 3 females (Guidiguir [= Guidigri], 13°40'N, 9°51'E, Gouré circle, Niger, 10/1965); 2 females (Guidimouni, 13°42'N, 9°30'E, Zinder circle, Niger, 20/10/1965); 1 female (Guidimouni, Zinder circle, Niger, date unknown, Hamon et al. rec.).

Type deposit: The holotype and 3 paratypes will be deposited in the Laboratoire de Taxonomie des Vecteurs. One paratype will be deposited in the British Museum (Natural History), London, United Kingdom and another will be deposited in the the Museum National d'Histoire Naturelle, Paris, France.

Description of female holotype: **Head:** Black labium, pale labella. Interocular space and the anterior part of the vertex are occupied by a large, mostly rounded tuft of raised white scales. Long sinuous setiform scales lean over the interocular space. Other vertex-raised scales are black. Palps with disheveled scales on segment 2 and scales plastered down on segments 3–5. Presence of 3 white rings; the 1st, which is narrow, is located on the apex of segment 2, the 2nd covers the joint between segments 3 and 4, and the 3rd covers segment 5 entirely and the apex of segment 4. Segment 5 may be black at the apex. White grouped scales form conspicuous spots on segment 3. On segment 2, white scattered scales are often present (Fig. 3). **Thorax:** Scutum covered with white spatulate scales that are also inserted on scutellum. On fossa, hairs and scales are inserted. Lengthened spaces between dorso-central and supra-alar hairs have no scales. **Wings:** Size = 3.2 mm (Fig. 4). Costa are ornamented with 5 white spots. On the 1st large black spot, 2 small white spots are present on R1; the 1st of these can be linked to the sectorial spot. On the middle and posterior part of the wing, white spots decorate a large part of Rs, R4 + 5, M, and Cup. Anal vein with 2–3 well-defined small black spots. Presence of white scales on apex of all veins. A white spot on the alar fringe stretches out from R1 to R2, and from R3 to R4 + 5. **Legs:** The femur, tibia, and tarsomeres on all 3 pairs of legs are ornamented with white scale spots. Leg 1: Four white rings cover the 4 articulations of tarsomeres. On legs 2 and 3, small white rings (L < D) decorate

the extremity of segments 1–4. **Abdomen:** Presence of numerous yellowish scales on terga 1–8.

Ecology and distribution: In the Sahelian area of Gouré and Zinder, there are numerous clay-bottom depressions that fill with water during the rainy season. Also called dahia, these pools frequently contain numerous hydrophytes and amphibious plants. This habitat is typically dry in winter. *Anopheles hervyi* specimens were caught on humans near dahia. However, Hamon, Dyemkouma, and Ouedraogo also collected this species resting inside dwellings. At present, *An. hervyi* seems to be limited in distribution to the central portion of southern Niger. This species was discovered during brief surveys on malaria transmission in this region and we were able to find it a few years later at 2 locations in the same area. We do not consider it a rare species and it may occur in ecologically similar areas in northern Nigeria.

Discussion: *Anopheles hervyi* is morphologically similar to *An. salbaii*. Gillies and De Meillon (1968) were surprised by a collection of *An. salbaii* in an area geographically distant and ecologically distinct from its typical locality. Wing ornamentation is practically identical with *An. salbaii*. However, palps are clearly spotted with white on segment 3 and white rings occur on the tarsomeres 1-I/2-I and 2-I/3-I. These 2 characters distinguish this species.

Anophles hervyi is also morphologically close to *Anopheles dancalicus* Corrdetti but can be distinguished based upon the ornamentation at the wing apex not being entirely white, the mcu vein being marked with black, having 1 fringe spot opposite 1A, having speckled 1-I and 1-III tarsomeres, and by having clearly white spotted palps. Unlike *An. dancalicus* and *An. salbaii* that occur in brackish or salt waters, *An. hervyi* seems to live in fresh water habitats.

Anopheles (Cellia) dualaensis, new species

Studied material: Four larval pelts from Douala (4°03'N, 9°42'E, Cameroon) by J. Mouchet in December 1963. We have no information concerning larval ecology. We propose to call this new species *An. dualaensis* after its geographic origin.

Type deposit: The type series includes 4 larval pelts mounted and raised 2 by 2. Larval holotype as well as paratypes will be deposited in the Laboratoire de Taxonomie des Vecteurs.

Larval type description: **Head:** Cephalic hairs (Fig. 5a, 5b) are delicately barbed on their distal ½, their length does not exceed the antenna flagellum. Hairs 2-C are well separated 1 from another, but the distance separating them is always slightly less than the distance separating hairs 2-C and 3-C. The basal ¼–½ of 3-C is highly aciculate; its size is about ¾ of 2-C. Hair 4-C is smooth and thin, simple or divided into 2 or 3 branches at the apex; short, it exceeds only slightly the 2-C basis. Long frontal

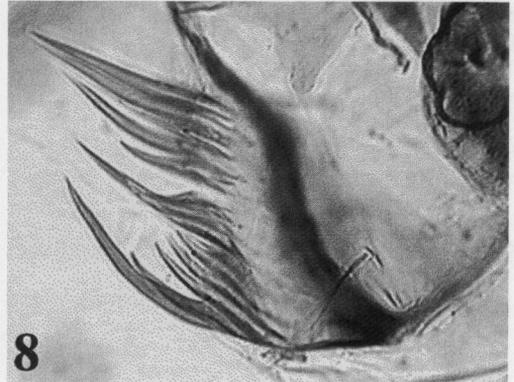
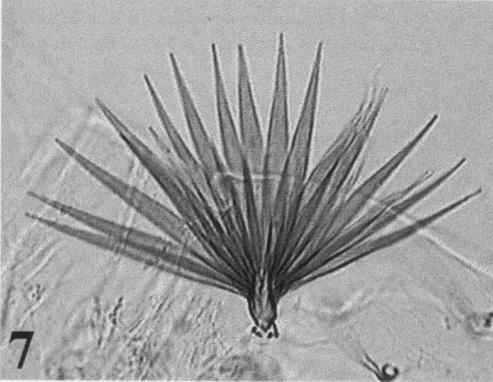
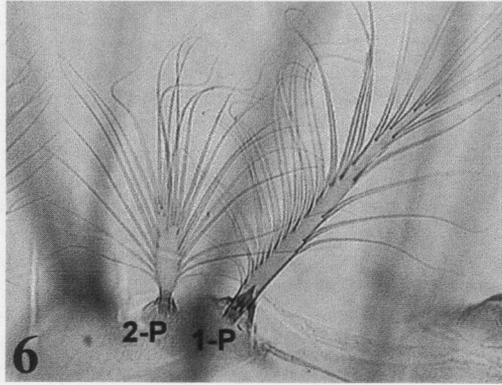
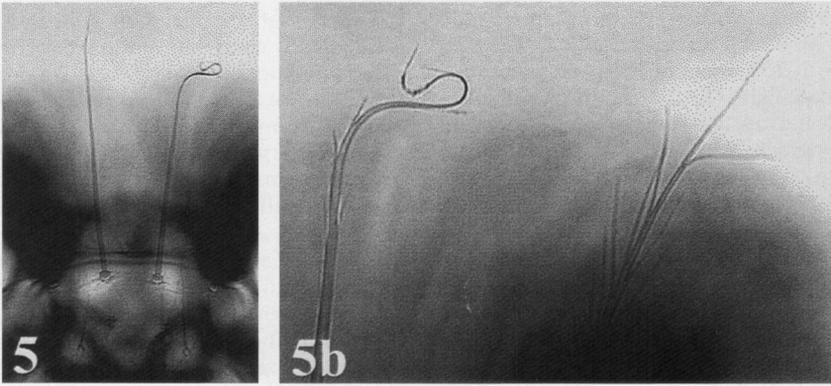


Fig. 5. (a) *Anopheles dualaensis* sp. nov.: cephalic seta 2-C. (b) *Anopheles dualaensis* sp. nov.: detail of cephalic seta 2-C apex

Fig. 6. *Anopheles dualaensis* sp. nov.: thoracic setae 1-P and 2-P.

Fig. 7. *Anopheles dualaensis* sp. nov.: palmate seta 1-V.

Fig. 8. *Anopheles dualaensis* sp. nov.: comb.

hairs have a regular plumosity. Other hairs: 8-C thin, simple or bifurcated; 9-C thin, simple or divided in 2 or 3 branches. Antenna: inner face, from basal $\frac{1}{4}$, with few very strong spines. Bifid 1-A (divided in 2–5 branches), its length is slightly greater than or equal to antenna diameter at the insertion point. *Thorax*: Prothoracic hairs (Fig. 6): Scape of 1-P hair slightly enlarged; branches, simple and thin, are regularly distributed on stem;

number = 24 (range: 19–25); 2-P with a thick stem; branching number is bigger on hair inner side than outer side. Hairs 1-P and 2-P insert on large tubercles joined at the bases. Hairs 9-P and 10-P long and simple; basal spine well developed. Mesothoracic hairs: 9-M and 10-M long and simple (10-M sometimes forked), 12-M simple or bifid; basal spine is very long. Metathoracic hairs: Hair 9-T simple; 10-T carrying 6–8 aciculum on the basal

1/5; 3-T palmate hairs with 6–10 rudimentary and lanceolate leaves. Notal thoracic plates: Thirteen plates (range = 7–13), most of them metathoracic. *Abdomen*: Palmate hairs (Fig. 7). Rudimentary segment I hair with narrow and lanceolate leaves; from segment II to segment VII, hairs are normal, with lanceolate leaves, without shoulder, and no serration. Their apex is sharp. Hair 1-V with 16–21 leaves. Other hairs: Antepalmate 2-V simple or bifid; 6-IV to 6-VI hairs are smooth, long, and simple. Main tergal plates narrow, with an anterior border slightly convex and a posterior border slightly concave; on segment V, their length ratio on distance between insertion of palmate hairs is included between 0.6 and 0.7. Accessory tergal plates: Two plates on segment I, 3 on II, then generally 5 on segments III–VII (sometimes, segments V and VI only have 3 or 4 accessory plates); anterior accessory plate, more developed than others, is in a median position. Comb (Fig. 8) with 5 large teeth and 9 small teeth; on their basal part they have a visible denticle, with a strong enlargement. Simple 1-X hair; its size is 1.5–2 times the saddle length.

Discussion: The most original morphologic characters of *An. dualaensis* are the presence of a very developed mesopleural basal spine as well as numerous accessory plates, both on thorax and abdominal segments. Furthermore, palmate hair leaves are lanceolate and without serration. Combination of these characters makes this species easy to identify. The clearly separated position of 2-C impels us to classify this species among *Cellia*. On the other hand, barbed aspects of 2-C hairs, form and insertion type of 1-P hairs, simple 10-M hairs, slightly aciculate 10-T hairs, and, finally, a long and simple 1-X hair, suggest that *An. dualaensis* is probably a *Neomyzomyia* close to *ardensis* Section.

CONFIRMATION OF *AN. CAVERNICOLUS* ABONNENC, 1954 SYNONYMY AND RESURRECTION OF *AN. RAGEAUI* MATTINGLY AND ADAM, 1954

In their synthesis on anopheline mosquitoes of the afrotropical area, Gillies and De Meillon synonymized *An. cavernicolus* (Abonnenc 1954) and *An. smithii* var. *rageaui* (Adam and Mattingly 1956) with *An. smithii*. Subsequent detailed examination of larvae and adults supports a different conclusion.

Anopheles cavernicolus Abonnenc, 1954

This species was described from preimaginal stages and adults caught in Dalaba cave bottom, in Guinea. Abonnenc based the identity of *An. cavernicolus* on its troglobie adaptation, on female mouth-pharyngeal armature, on male genitalia leaflet number, and on ornamentation of male wings.

He notes that it is a rather large mosquito because of its 4-mm wing size (Abonnenc 1956).

We examined 5 larvae and 38 imagoes of this species from Dalaba cave and observed its resemblance to *An. smithii*. Both *An. smithii* and *An. cavernicolus* larvae have 2-C divided at the apex, thus forming a small terminal tuft (Fig. 9). This larval peculiarity allows a clear distinction of the *An. smithii/An. cavernicolus* pair from other troglomorphic or troglobie species close to *An. smithii*.

The imago also presents a very close alar ornamentation with a white spot on bases of the subcostal and the radial veins (Fig. 10). Other wing light spots occupy the same places, but with variable sizes. Ornamentation of other body parts, where dark color predominates, does not facilitate comparison of these taxa.

The 1st observations of *An. cavernicolus* were actually made in the darker part of the cave. Adam (1965) reported that *An. cavernicolus* adults and larvae could also be found at the cave entrance. The biology of *An. cavernicolus* is similar to that of *An. smithii*, which also prefers cool areas with a relative high humidity and cave entrances. Therefore, we agree that *An. cavernicolus* is a synonym of *An. smithii*. However, we emphasize that its ornamentation is generally darker and that it is a mosquito that is clearly larger than *An. smithii*. The female wing length is between 2.8 and 3.5 mm in *An. smithii* and 3.7 and 4.2 mm in *An. cavernicolus*. Furthermore, we found *An. smithii* in J. Hamon's collection from Togo. This is a new locality for this species.

Anopheles rageaui Mattingly and Adam, 1954

Anopheles rageaui was described as a species by Mattingly and Adam (1954) but was subsequently reduced to a variety of *An. smithii* (Adam and Mattingly 1956). In 1968, Gillies and De Meillon, who based their study on male genitalia, synonymized *An. rageaui* with *An. smithii*.

Study of *An. rageaui* larvae and 101 adults from 6 Cameroon localities led us to different conclusion. We observed that larvae and adults of this taxon show morphologic peculiarities that cannot be reduced to simple intraspecific variations of *An. smithii*. The larva of *An. rageaui* has no characteristic apical 2-C branching with a tuft, as do *An. smithii* and *An. faini* Leleup (Fig. 11). This peculiarity distinguishes *An. rageaui* larvae from *An. smithii* and emphasizes the link between *An. rageaui* and all other micro-cave-dwelling species from central Africa and the Congo basin (Adam 1965). Furthermore, the 2-C scape of *An. rageaui* often has beards, making it closer to *An. hamoni* Adam, *An. caroni* Adam, *An. faini* var. *vanthieli* (Laarmann 1959), and even *An. vanhoofi* Wanson and Lebed, which sometimes have such beards.

Among imagoes, alar ornamentation of species belonging to the *smithii* group is rather variable but

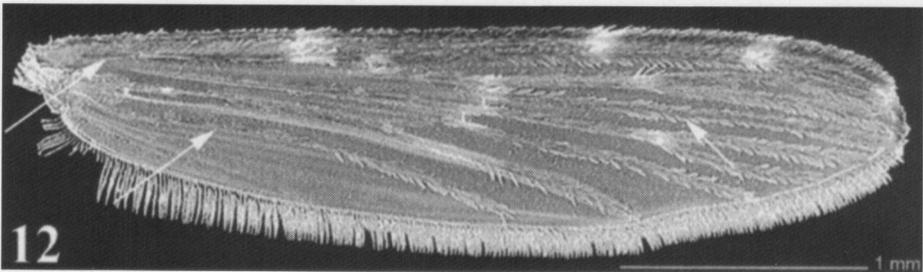
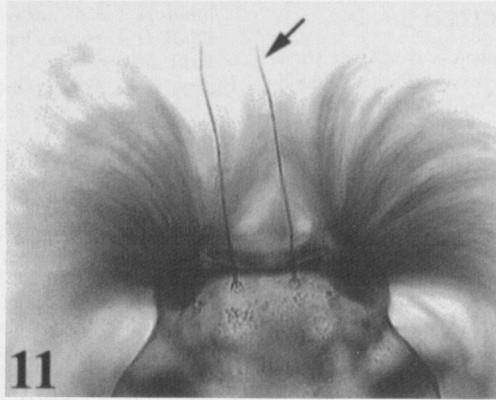
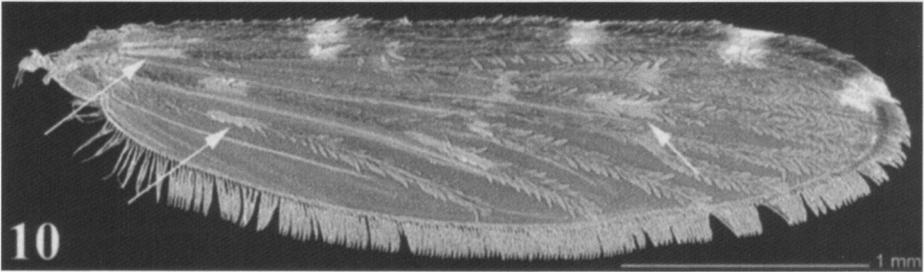
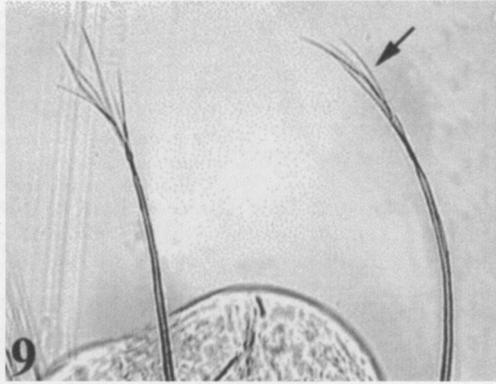


Fig. 9. *Anopheles smithii* sp. nov.: cephalic seta 2-C apex.
Fig. 10. *Anopheles smithii* sp. nov.: wing.
Fig. 11. *Anopheles rageaui* sp. nov.: cephalic seta 2-C.
Fig. 12. *Anopheles rageaui* sp. nov.: wing.

we note that the white spot constantly covering the basal part of the *An. smithii* wing (radial and subcostal vein bases) is regularly absent from *An. rageaui* wings. Furthermore, *An. rageaui* R4 + 5 and A1 (Fig. 12) veins are always homogeneously black, whereas they often have a small white spot in *An. smithii*.

These characters allow easy identification of *An. rageaui*. Adult *An. smithii* caught in Gabon and Congo should be reexamined in order to confirm or invalidate the identification. Taking into account larvae and adult morphological particularities, we propose that *An. rageaui* Mattingly and Adam should be elevated to the rank of species.

ACKNOWLEDGMENTS

We wish to thank all those who contributed to this work and notably the Ministère de la Coopération (Sous-Direction de la Santé et du Développement Social), without whom this work and the software program for anopheline mosquito identification would not have been possible. We also thank our colleague Jean-Paul Adam and our mentor Jacques Hamon, who left us remarkable Culicidae collections.

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