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Autor: Gattolliat, Jean-Luc

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Bugilliesia Lugo-Ortiz and McCafferty and allied genera (Baetidae, Ephemeroptera), with emphasis on West African fauna

JEAN-LUC GATTOLLIAT

Museum of Zoology, Palais de Rumine, Place de la Riponne 6, CH-1014 Lausanne, Switzerland;
e-mail: Jean-Luc.Gattoliat@vd.ch

The four Afrotropical genera *Bugilliesia*, *Kivua*, *Mutelocloeon* and *Rhithrocloeon* are highly remarkable among the Baetidae, the male imagos possessing unique 2-segmented forceps instead of 3-segmented as in all the other genera of this family. Examination of new material from West Africa allows the description at the imaginal stage of three new species of *Bugilliesia*: *B. biloba* n.sp. *B. cavallensis* n.sp. and *B. truncata* n.sp. New diagnoses, new records and a key for identification of the male imagos are provided. The generic attribution of the single Malagasy species with 2-segment forceps, *Mutelocloeon thomasorum*, is discussed as dubious.

Key words: Baetidae, *Bugilliesia*, taxonomy, new species, Afrotropics.

INTRODUCTION

More than 40 genera and 200 species of Baetidae are presently known from the Afrotropical area. With about 20 genera and 33 species, this family is relatively well-known and diversified in West Africa. In his revision of the African species previously assigned to *Centroptilum* Eaton, 1869, Gillies (1990) established the genus *Afroptilum* Gillies, 1990 that was composed of two subgenera and four species groups. The *sudanense* group encompassed five species with remarkably modified male genitalia (referred to as «ankylosed» by Demoulin (1957)). Gillies (1990) noticed that these remarkable gonopods presented similarities with those of other African genera such as *Rhithrocloeon* Gillies, 1985 and *Mutelocloeon* Gillies and Elouard, 1990, but considered, however, that the larvae of the *sudanense* group did not differ to a sufficient extent from other *Afroptilum* larvae to be included in a new genus. Gillies' concept of *Afroptilum* proved to be polyphyletic (McCafferty & de Moor 1995), and Lugo-Ortiz & McCafferty (1996) established the genera *Bugilliesia* Lugo-Ortiz and McCafferty, 1996 and *Kivua* McCafferty and Lugo-Ortiz, 1996 for species with complex genitalia and created the *Bugilliesia* complex for genera with a conspicuous basomedial protuberance on the male genitalia. This complex originally included the genera *Afrobaetodes* Demoulin, 1970, *Bugilliesia*, *Kivua*, *Mutelocloeon*, *Potamocloeon* Gillies, 1990 and *Rhithrocloeon*. The genus *Cheleocloeon* Wuillot and Gillies, 1993 was later included in the complex (Lugo-Ortiz & McCafferty 1997a), then excluded by the same authors to be assigned to the *Centroptiloides* complex (Lugo-Ortiz & McCafferty 1999). The concept of the *Bugilliesia* complex was only based on the apparent similarities of the process on the male genitalia; larval characters were not considered. The larval stages of each genus included in the complex were highly distinctive, but no larval characters could

be found to typify the complex as originally defined (Lugo-Ortiz & McCafferty 1996).

Further examinations of male gonopods as well as larval features provided evidence that the *Bugilliesia* complex is polyphyletic. Only *Bugilliesia*, *Kivua*, *Mutelocloeon* and *Rhithrocloeon* shared larval and imaginal characters and constituted a monophyletic group. It ensued that the *Bugilliesia* complex must be restricted to these four genera (Gattoliat 2003; Gillies 2001).

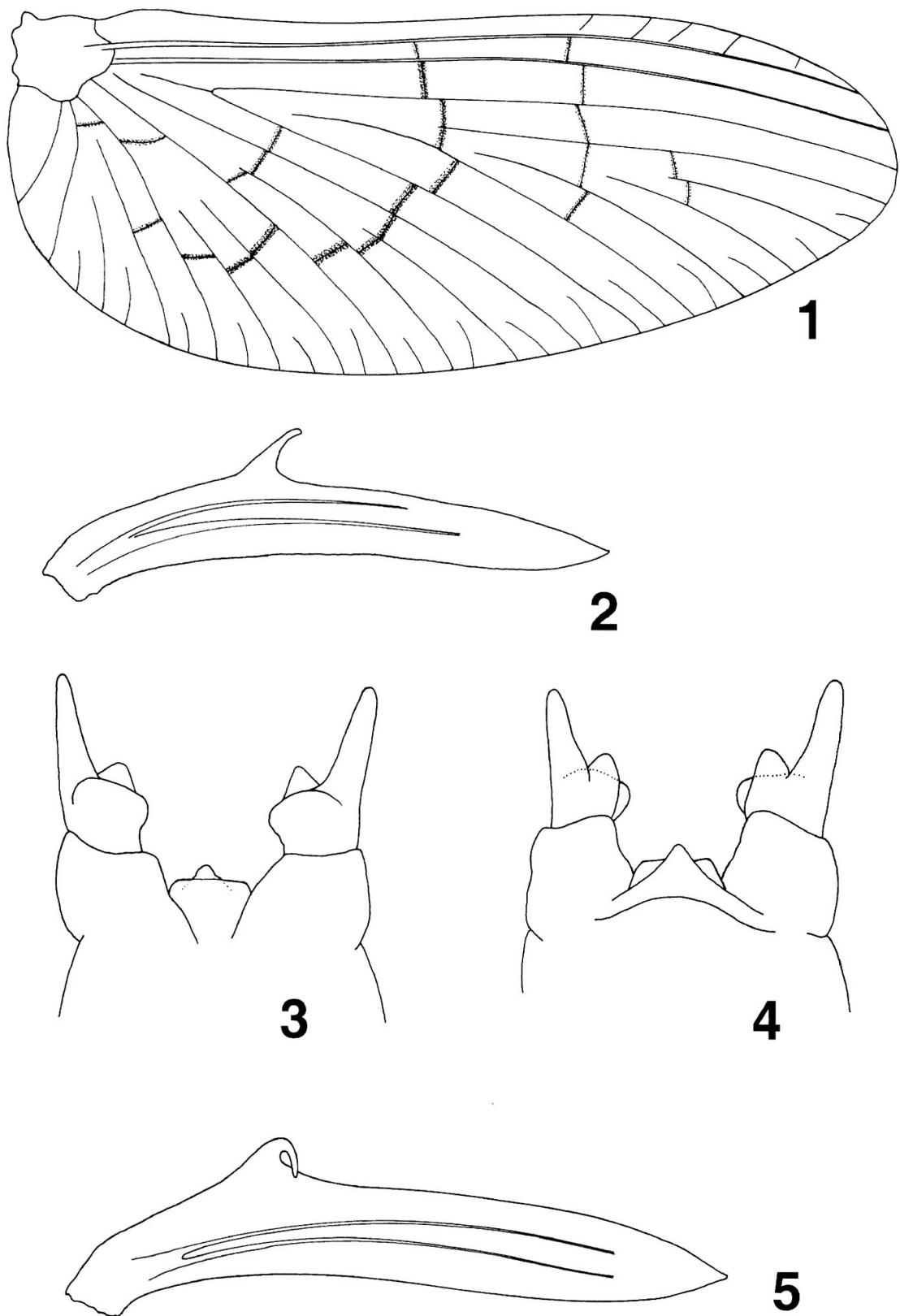
Simultaneously, a non-ranking classification of Ephemeroptera was produced by Kluge; this classification was originally only exposed via the internet («Draft Revision of supra species taxa of Ephemeroptera» (<http://www.famu.edu/acad/research/mayfly/kluge/12baet4.html>)). The four genera *Bugilliesia*, *Kivua*, *Mutelocloeon* and *Rhithrocloeon* are assigned to the non-ranking hierarchical name «*Rhithrocloeon/g1*».

The present work focuses on the imaginal stage of the genera *Bugilliesia*, *Kivua*, *Mutelocloeon* and *Rhithrocloeon* (*Bugilliesia* complex sensu Gillies, 2001 or *Rhithrocloeon/g1* sensu Kluge). In contrast to most African Baetidae, the male imagos of these four genera provide useful characters for accurate and relatively easy identification. Most of the larval associations, especially in the genus *Bugilliesia*, are dubious and need to be confirmed (see comments below). The larval stage will be treated elsewhere. In the literature, only *Bugilliesia*, *Kivua* and *Mutelocloeon* are mentioned from West Africa (Gillies 1989, 1990; Gillies & Elouard 1990; Lugo-Ortiz & McCafferty 1996). Larvae of *Rhithrocloeon* from Guinea have been found in the material examined; therefore, all four genera are present in West Africa. Three new species of *Bugilliesia* are described herein at the imaginal stage.

MATERIAL AND METHOD

Between 1974 and 1989, the French ORSTOM (presently IRD: Institut de Recherche pour le Développement) collected aquatic macroinvertebrates in about 100 localities, mainly in Guinea, Ivory Coast, Mali and Sénégäl. Most localities were sampled several times (including different seasons and over a period of several years). These collections constituted part of an important onchocerciasis control program (fight against the black fly vector and evalutation of the impact on non-target invertebrates (Lévêque *et al.* 2003)). Adults were attracted by light traps at dusk and dawn; larvae were collected in streams with various kinds of nets. The majority of Baetidae known from West Africa were recently described based on material collected during this program. However, only a part of this material was sorted and identified. All the remaining unidentified material is now housed in the Museum of Zoology at Lausanne (Switzerland). The present study is mainly based on this material. It is notable that a huge amount of material was sorted and all the species of *Bugilliesia* and related genera were present in just a few samples. Other material deposited in the Natural History Museum, London, England [BMNH] was also examined for comparison. All the material has been preserved for a long while in 70 % ethanol, making colouration observation difficult.

The holotypes and part of the paratypes are housed in the Museum of Zoology, Lausanne, Switzerland. Other paratypes are deposited in the Museum National d'Histoire Naturelle, Paris.



Figs 1–5. Wings and male genitalia of *Bugilliesia* spp.: 1–4: *Bugilliesia biloba* n.sp. 1: forewing. 2: hindwing. 3: male genitalia (ventral view). 4: male genitalia (dorsal view). 5: *Bugilliesia notabilis*: hindwing.

TAXONOMY

1. Genus *Bugilliesia* Lugo-Ortiz and McCafferty, 1996

Diagnosis. Male imagos of *Bugilliesia* are characterized by the following characters: hindwings present; gonopods moderately elongated and apically rounded. The 8 species can be separated into two species-groups. The first group of species is represented by *Bugilliesia cavallensis* n.sp., *Bugilliesia grisea* (Gillies, 1990), *Bugilliesia guineensis* (Gillies, 1990), *Bugilliesia sudanensis* (Ulmer, 1916) and *Bugilliesia truncata* n.sp.; this group is characterized by hyaline forewings and crossveins without marginal pigmentation (Figs 6–8); hindwings relatively broad with a rounded apex (Figs 9–11); and elongate male genitalia (Figs 12–19). The second group of species encompasses *Bugilliesia biloba* n.sp., *Bugilliesia nitida* (Ulmer, 1916) and *Bugilliesia notabilis* (Kimmings, 1956). This group is characterized by adults having hyaline forewings with at least part of the cross-veins with fuscous margins (Fig. 1); hindwings slender and acute (Figs 2 and 5); male genitalia relatively short (Figs 3–4).

Type species. *Bugilliesia guineensis* (Gillies, 1990)

Species included. *Bugilliesia biloba* n.sp., *Bugilliesia cavallensis* n.sp., *Bugilliesia grisea* (Gillies, 1990), *Bugilliesia guineensis* (Gillies, 1990), *Bugilliesia nitida* (Ulmer, 1916), *Bugilliesia notabilis* (Kimmings, 1956), *Bugilliesia sudanensis* (Ulmer, 1916), *Bugilliesia truncata* n.sp.

1.1 *Bugilliesia biloba* n.sp.

Diagnosis. Male and female imagos with the veins of proximal half of the forewings fuscous bordered (Fig. 1), hindwings apically pointed with an erect costal spur, longitudinal veins relatively short and faded (Fig. 2). Male imagos are easily separated by the first segment of the gonopods with an additional dorsal lobe (Figs 3–4). This character is unique among species with 2-segmented gonopods.

Material examined. Holotype: 1 ♂ imago, Mali, Niger bas., Niger riv., Loc. Tienfala (= Tyenfala), 28.05.1986. Leg J.-M. Elouard, IRD.

Paratypes: 31 ♂ imagos, 3 ♀ imagos, same data as holotype. Leg J.-M. Elouard, IRD. 1 ♂ imago, same locality as holotype, 27.05.1986. 2 ♂ imagos, Guinea, Kolente bas., Kolente riv., Loc. South of Kora, 10.02.1986. 1 ♂ imago, 1 ♀ imago, Guinea, Niger bas., Niger riv., Loc. Kouroussa, 27.01.1987. 3 ♂ imagos, Ivory Coast, Cavally bas., Cavally riv., Loc. Tai (Cavally), 10.02.1988. 2 ♂ imagos, Ivory Coast, Cavally bas., Cavally riv., Loc. Tiboto, 11.02.1988. 1 ♂ imago, Ivory Coast, Cavally bas., Cavally riv., Loc. Tiboto-Grabo (road), 11.02.1988. All specimens leg J.-M. Elouard, IRD.

Other material: Numerous male and female imagos (partially damaged), same data as holotype. Leg J.-M. Elouard, IRD.

Description. Length: Body 4.2–4.5 mm. Forewing 4.2–4.3 mm. Hindwing 0.5–0.6 mm.

Head. Uniformly light brown. Turbinate eyes short and broad apically, purple brown, darker laterally. Antennae light brown.

Thorax. Light brown, slightly darker dorsally than ventrally. Forewing (Fig. 1) with long single intercalary veins (at least subequal to intervein space), absent

from three distal and two proximal interspaces; pterostigma with about five cross-veins reaching or almost reaching subcostal vein. Fuscous margination of crossveins mainly developed in basal half of wing, no additional fuscous marking. Hindwing (Fig. 2) with two barely visible longitudinal veins reaching at most $\frac{3}{4}$ of hindwing length; spur on costal margin erect and slender. Legs without visible markings.

Abdomen. Terga colourless, without markings except tergum 4 (and generally 5 and 7) with longitudinal brown band sublaterally. Sterna colourless.

Genitalia (Figs 3–4) with forceps compact, apically rounded, basal lobe well developed and apically flat, with additional triangular lobe dorsally.

Comments. The imagos of both sexes of *B. biloba* can be easily separated from other species with fuscous marginations on the forewing by characters listed in the diagnoses; additionally the fuscous marking on forewings (Fig. 1) are less developed than in *Bugilliesia nitida* or *Bugilliesia notabilis* and the shape of the hindwings differs (Fig. 2). The additional dorsal lobe of the male gonopods is unique among species with 2-segmented gonopods (Figs 3–4).

B. biloba is present in Guinea, Ivory Coast and Mali. It is not a common species, but can be locally quite abundant. In some localities, *B. biloba* and *B. notabilis* co-occur.

Etymology. The specific name is Greek for bi-lobed, in reference to the two lobes of the first segment of the male genitalia.

1.2 *Bugilliesia cavallienensis* n.sp.

Diagnosis. Male imagos are well characterized by the poorly developed basal lobe of the male gonopods (Figs 12–14). Female imagos cannot be separated with certainty from other species of *Bugilliesia* without fuscous markings on forewings (Fig. 6).

Material examined. Holotype: 1 ♂ imago, Ivory Coast, Cavally bas., N'ze riv., Loc. Tai (N'ze), 10.02.1988. Leg J.-M. Elouard, IRD.

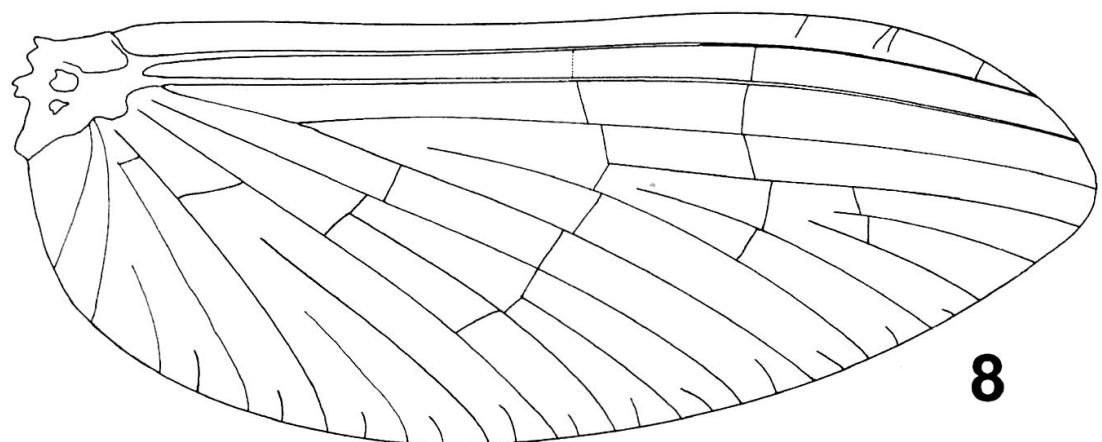
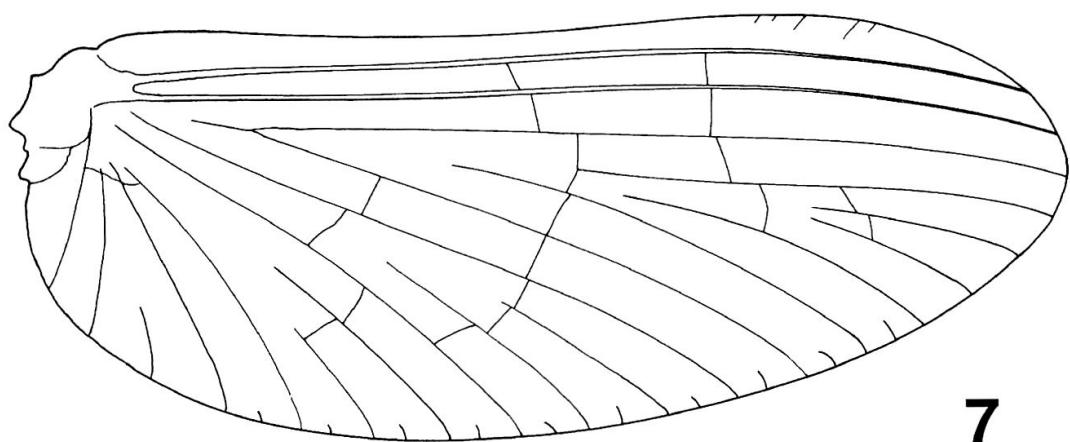
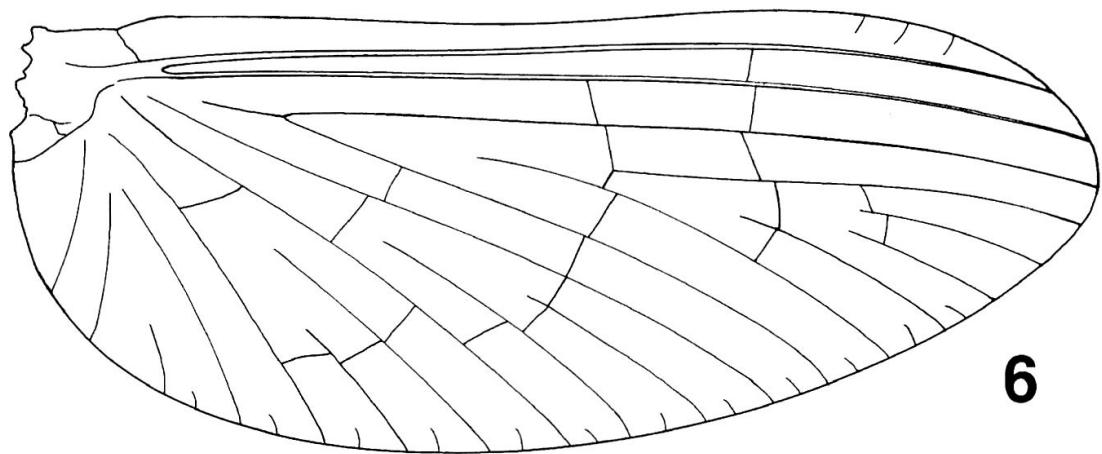
Paratypes: 2 ♂ imagos, 1 ♂ subimago, same data as holotype. 2 ♂ imagos, Ivory Coast, Cavally bas., Cavally riv., Loc. Grié (near Toulepleu), 04.02.1988. 2 ♂ imagos, 4 ♂ subimagos, Ivory Coast, Cavally bas., Cavally riv., Loc. Tai (Cavally), 10.02.1988. 6 ♂ imagos, Guinea, Cavally bas., Cavally riv., Loc. Oueyakolé, 02.02.1988. 4 ♂ imagos, same locality, 22.01.1988. All specimens leg J.-M. Elouard, IRD.

Description. Length: Body 3.7–4.4 mm. Forewing 3.5–4.3 mm. Hindwing 0.5–0.6 mm.

Head. Almost uniformly light brown. Turbinate eyes short and broad apically, honey brown. Antennae light brown.

Thorax. Yellowish brown. Forewing (Fig. 6) with single intercalary veins relatively short (at most less than one third of interspace length), absent from five distal and two proximal interspaces; pterostigma with about three crossveins, none of them reaching subcostal vein; base of costal and subcostal veins fuscous. Hindwing (Fig. 9) with two well-marked longitudinal veins, joined at the base; spur on the costal margin as in Fig. 9. Legs without visible markings.

Abdomen. Terga colourless, first tergum laterally without triangular patch, tergum 3 with broad longitudinal brown band sublaterally more or less faded. Sterna colourless.



Figs 6–8. Forewings of *Bugilliesia* spp.: 6: *Bugilliesia cavalliensis* n.sp. 7: *Bugilliesia guineensis*. 8: *Bugilliesia truncata* n.sp.

Genitalia (Figs 12–14) with forceps elongated, blade-shaped, apically regularly rounded, basal lobe poorly developed, turned inwards (Fig. 12).

Comments. *B. cavallienensis* differs from all other species of *Bugilliesia* by the poorly developed basal lobe of the male gonopods (Figs 12–14). The abdominal colour pattern restricted to tergum 3, although faded in most specimens, appears different from other species. This species was collected only in localities of the Cavally basin in Ivory Coast and Guinea.

Etymology. This species is named after the single basin from which it has been collected, the Cavally basin.

1.3 *Bugilliesia grisea* (Gillies, 1990)

Afroptilum griseum Gillies, 1990

Bugilliesia grisea (Gillies): Lugo-Ortiz & McCafferty 1996

Material examined. Holotype: 1 ♂ imago, Amani, Tanzania. 25.02.[19]85. Det Gillies (as *Afroptilum griseum*). [BMNH].

Other material (material corresponding to the paratypes but without designation): 1 ♂ imago, Amani, Tanzania. 03.09.[19]52. Det Gillies (as *Afroptilum griseum*). [BMNH]. 1 ♂ imago, Amani, Tanzania. 25.01.[19]53. Det Gillies (as *Afroptilum griseum*). [BMNH]. 1 ♀ imago, Amani, Tanzania. 10.10.[19]55. Det Gillies (as *Afroptilum griseum*). [BMNH]

Comments. This species was described from Tanzania and has never been reported subsequently. Examination of the type material shows that the abdominal tergum has a triangular patch laterally (as in Gillies 1990, Fig. 63) that was previously considered as a character specific to *Bugilliesia guineensis* (Gillies 1990). This peculiar patch appears brown (more or less faded depending on the specimens) instead of deep blood-red, as in the original description of *B. guineensis*; this difference in colour is probably due to the long stay in alcohol. Therefore, this character cannot be used for specific identification. *B. grisea* differs from all other West African species, including the new species described herein, by the shape of the forceps, especially of the basal lobe. This species is also significantly larger than the others (length of the male imago more than 5.0 mm, whereas others species are generally less than 4.5 mm).

1.4 *Bugilliesia guineensis* (Gillies, 1990)

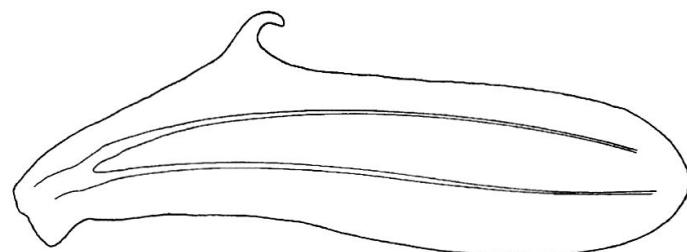
Afroptilum guineense Gillies, 1990

Bugilliesia guineensis (Gillies): Lugo-Ortiz & McCafferty 1996

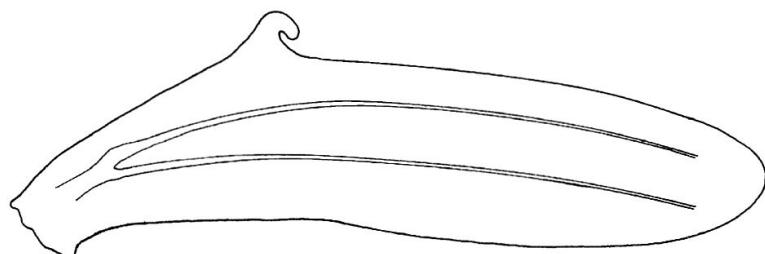
Material examined. Holotype: 1 ♂ imago, Tributary of R. Cavally at Oueyakolé. 02.02.[19]88. X681. Det Gillies (as *Afroptilum guineense*). [BMNH].

Topotypes: 19 ♂ imagos, 4 ♂ subimagos, Guinea, Cavally bas., Cavally riv., Loc. Oueyakolé, 22.01.1988. 3 ♂ imagos, 1 ♂ subimago, same locality, 01.02.1988. 20 ♂ imagos, 28 ♂ subimagos, same locality, 02.02.1988. 2 ♂ imagos, Ivory Coast, Cavally bas., unnamed riv., Loc. Tiboto-Grabo (road), 11.02.1988. All specimens leg J.-M. Elouard, IRD.

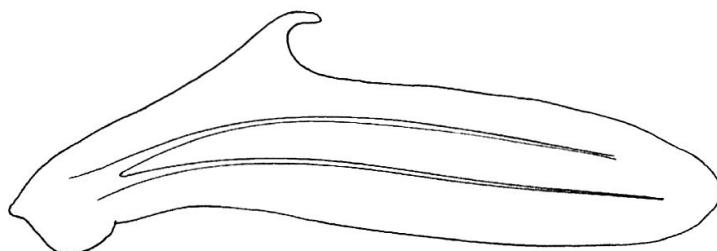
Other material: 3 ♂ imagos, Togo, Mono bas., Mono riv., Loc. Kpessi, 30.11.1985. 5 ♂ imagos, Ivory Coast, Cavally bas., Cavally riv., Loc. Grié (near Toulepleu), 04.02.1988. 1 ♂ imago, Guinea, Niger bas., Niandan riv., Loc. Sas-



9



10



11

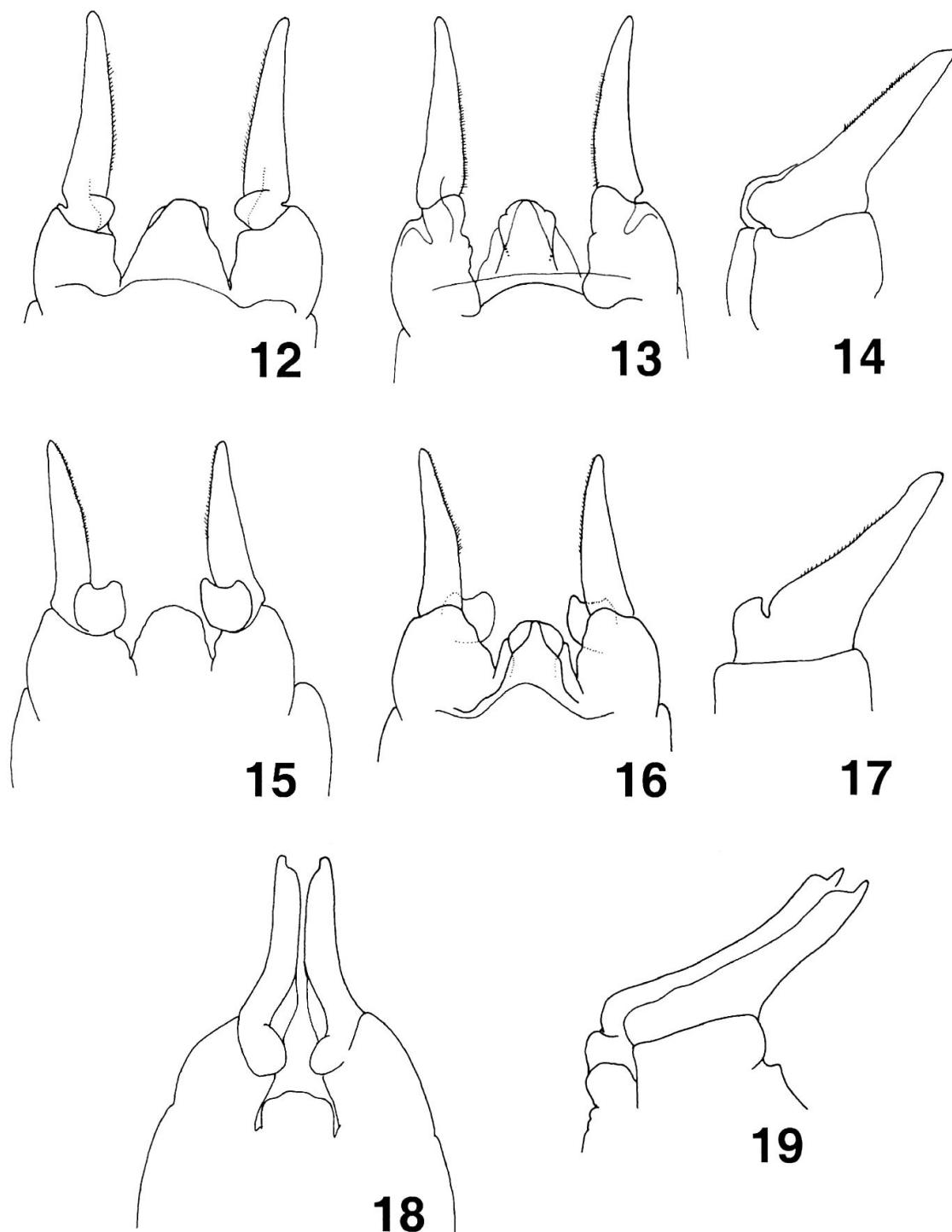
Figs 9–11. Hindwings of *Bugilliesia* spp.: 9: *Bugilliesia cavallienensis* n.sp. 10: *Bugilliesia guineensis*. 11: *Bugilliesia truncata* n.sp.

sambaya, 06.05.1987. 1 ♂ imago, same locality, 19.03.1985. All specimens leg J.-M. Elouard, IRD.

Description. Length: Body 4.4–4.7 mm. Forewing 3.5–4.3 mm. Hindwing 0.5–0.6 mm.

Head. Almost uniformly light brown. Turbinate eyes longer than broad, honey brown. Antennae light brown, except with dark brown dot at apex of inner margin.

Thorax. Amber brown; dorso-lateral sutures bordered with dark brown bands. Forewing (Fig. 7) with single intercalary veins very reduced in size, absent from six distal and three proximal interspaces; pterostigma with four to six crossveins reduced in size, none of them reaching subcostal vein; base of costal and subcostal veins fuscous. Hindwing (Fig. 10) with two well-marked longitudinal veins, joined at base; costal margin with single relatively broad spur. Legs without visible markings.



Figs 12–19. Male genitalia of *Bugilliesia* spp.: 12–14: *Bugilliesia cavallienensis* n.sp. 12: ventral view. 13: dorsal view. 14: lateral view. 15–17: *Bugilliesia guineensis*. 15: ventral view. 16: dorsal view. 17: lateral view. 18–19: *Bugilliesia truncata* n.sp. 18: ventral view. 19: lateral view.

Abdomen. Abdomen colourless and without markings except first tergum laterally with distinctive, brown, triangular patch (Gillies 1990, Fig. 63); no other pattern apparent.

Genitalia (Figs 15–17) with forceps elongated and blade-shaped; basal lobe well-developed with apical margin clearly incurved (Fig. 15).

Comments. Gillies (1990) considered the lateral red triangular patch of tergum I as a specific character of *B. guineensis*. Examination of specimens from East and West Africa have shown that this triangular patch can also be present in other species (see comments under *B. sudanensis* and *B. grisea*). In the original description, Gillies (1990) only represented the male forceps in the lateral position. The basal lobe (Fig. 15) with its incurved apical margin cannot be observed. The shape of the basal lobe is the only reliable character for separating *B. guineensis* from other related species. Therefore, only the male imago can be determined with confidence. The subimagoes listed above are only tentatively attributed to *B. guineensis* because they were caught simultaneously with apparently conspecific imagoes.

Gillies (1990) described both larval and imaginal stages. The larval description was very succinct and contained little informative details; only one figure, that of the right prostheca, was provided. Consequently, subsequent identifications of larvae are difficult to impossible. Moreover, the association of larvae with adults was based on two subimagoes and the corresponding larval skins. No other imagos were available from this locality. Because male subimagoes of the genus *Bugilliesia* cannot be attributed with certainty to a species, Gillies' larval skin cannot be attributed to this species with confidence.

B. guineensis was originally described from Guinea and Ivory Coast (Gillies 1990). All of the material I have examined was collected from localities within the previously known geographic range of the species, except for some material from Togo. Records included herein represent the first report of the species from this country and thereby extend the known distribution of *B. guineensis* to the East.

1.5 *Bugilliesia nitida* (Ulmer, 1916)

Centroptilum nitidum Ulmer, 1916

Cloeon nigroalbum Navàs, 1932: Demoulin 1957

Cloeon bredoanum Navàs, 1932: Demoulin 1957

Afroptilum nitidum (Ulmer): Gillies 1990

Bugilliesia nitida (Ulmer): Lugo-Ortiz & McCafferty 1996

No material examined.

Comments. This species was described originally from the Democratic Republic of Congo (Ulmer 1916). Subsequently, Demoulin (1957) recognized new synonyms of the species and redescribed it. No new records of the species have been reported since the original descriptions of each of its various synonyms. Its distribution seems restricted to the DRC. This species should be recognized at least by the subapical fuscous dot at the apex of the forewings (Demoulin 1957, Fig. 2). The male genitalia remain unknown.

1.6 *Bugilliesia notabilis* (Kimmings, 1956)

Centroptilum notabile Kimmings, 1956

Afroptilum notabile (Kimmings): Gillies 1990

Bugilliesia notabilis (Kimmings): Lugo-Ortiz & McCafferty 1996

Material examined. 2 ♂ imagos, 1 ♀ imago, Guinea, Niger bas., Niger riv., Loc. spring of Niger, 06.02.1985. 2 ♂ imagos, Guinea, Niger bas., Niandan riv., Loc. Sassambaya, 26.11.1986. 1 ♂ imago, 1 ♀ imago, Guinea, Niger bas., Niandan riv., Loc. Sassambaya, 10.12.1986. 1 ♂ imago, Guinea, Niger bas., Niandan riv., Loc. Kissidougou, 22.01.1987. 1 ♂ imago, Guinea, Little Scarcies (= Kaba) bas., Kaba riv., Loc. Faranah-Mamaou (road), 23.01.1987. 1 ♀ imago, Guinea, Rio Corubal (= Tomine) bas., Tomine riv., Loc. Télimélé, 27.01.1987. 4 ♂ imagos, 5 ♂ subimagos, 1 ♀ imago, Guinea, Niger bas., Tinkisso riv., Loc. Dabola, 01.02.1987. 4 ♂ imagos, Mali, Sénégal bas., Baoule riv., Loc. Missira, 04.12.1987. 1 ♂ imago, Guinea, Cavally bas., Cavally riv., Loc. Oueyakolé, 22.01.1988. 1 ♂ imago, Guinea, same locality, 02.02.1988. 1 ♂ imago, Guinea, Saint Paul (= Diani) bas., Saint Paul (= Diani) riv., Loc. N'Zébéla, 31.01.1988. 1 ♂ imago, Guinea, Cavally bas., Cavally riv., Loc. Mt Nimba (nord-ouest), 01.02.1988. 1 ♂ imago, Ivory Coast, Cavally bas., Cavally riv., Loc. Grié (near Toulepleu), 04.02.1988. 1 ♂ imago, Ivory Coast, Cavally bas., N'ze riv., Loc. Tai (N'ze), 10.02.1988. 9 ♂ imagos, 2 ♂ subimagos, Ivory Coast, Cavally bas., unnamed riv., Loc. Tiboto-Grabo (road), 11.02.1988. 4 ♂ imagos, 1 ♂ subimago, Ivory Coast, Cavally bas., Cavally riv., Loc. Tiboto, 11.02.1988. 3 ♀ imagos, Guinea, Fatala riv., près de Mahbé, 01.02.1989. All specimens leg J.-M. Elouard, IRD.

Comments. This species is characterized by a forewing with all the crossveins fuscous-margined and by having no fuscous distal dot (Kimmings 1956, Fig. 3). The hindwing has longitudinal veins that almost reach the apex and a curved costal spur (Fig. 5). The male forceps are similar to those of *B. biloba*, but do not possess the second dorsal lobe (Kimmings 1956, Fig. 5).

B. notabilis was originally described from Uganda (Kimmings 1956) and then reported from Tanzania (Demoulin 1965). Our data constitute the first mention of this species for West Africa. Male and female imagos were collected in different localities of Guinea, Mali and Ivory Coast. This species appears relatively abundant and widespread.

1.7 *Bugilliesia sudanensis* (Ulmer, 1916)

Centroptilum sudanense Ulmer, 1916

Afroptilum sudanense (Ulmer): Gillies 1990

Bugilliesia sudanensis (Ulmer): Lugo-Ortiz & McCafferty 1996

Material examined. 2 ♂ imagos, Tanzania, Muhega, Tanya, 17.08.1961. Det. Gillies (as *Centroptilum sudanense*). [BMNH]. 3 ♂ imagos, Gambia, Bansang. 25.11.1979. Det. Gillies (as *Centroptilum sudanense*). [BMNH]. 2 ♂ imagos, Gambia, Basse. 26.02.1983. Det. Gillies (as *Centroptilum sudanense*). [BMNH].

Comments. This species was originally described from southern Sudan (Ulmer 1916), then reported from Uganda (Kimmings 1956) and from West Africa (Guinea, Gambia and Ivory Coast) (Gillies 1990). No other specimens were found in our collection. This species appears quite similar to *B. guineensis* but differs in the convex shape of the distal margin of the basal lobe (Kimmings 1956, Fig. 2). Some of the specimens from East and West Africa also show the triangular patch of the tergum I (similar to Fig. 63 in Gillies 1990).

1.8 *Bugilliesia truncata* n.sp.

Diagnosis. Male imagos are well characterized, especially by the concavity at the apex of the last segment and the poorly developed basal lobe of the male gonopods (Figs 18–19). Female imagos cannot be separated with certainty from other species of *Bugilliesia* without fuscous marking on forewings.

Material examined. Holotype: 1 ♂ imago, Sierra Leone, Mongo riv., Loc. Mu-saia, 13.02.1989. Leg J.-M. Elouard, IRD.

Paratypes: 7 ♂ imagos, same data as holotype. 2 ♂ imagos, 1 ♂ subimago, Sierra Leone, Rockel riv., Loc. Katik, 13.02.1989. 5 ♂ imagos, 1 ♂ subimago, Guin-nea, Saint Paul (= Diani) bas., Saint Paul (= Diani) riv., Loc. N'Zébéla, 31.01.1988. 1 ♂ imago, 1 ♂ subimago, Guinea, Moa (=Makona) bas., Moa riv., Loc. Nangoa, 19.02.1982. All specimens leg J.-M. Elouard, IRD.

Description. Length: Body 4.4–4.8 mm. Forewing 4.0–4.5 mm. Hindwing 0.5–0.7 mm.

Head. Almost uniformly light brown. Turbinate eyes yellow brown. Antennae light brown.

Thorax. Forewing (Fig. 8) with single intercalary veins relatively long (at least half intervein space), absent from five distal and two proximal interspaces; ptero-stigma with about four crossveins reaching or almost reaching subcostal vein; base of costal and subcostal veins fuscous. Hindwing (Fig. 11) with two well-marked lon-gitudinal veins, joined at base; spur on costal margin relatively slender and erected. Legs without visible markings.

Abdomen. Terga colourless, first tergum laterally without triangular patch.

Genitalia (Figs 18–19) with forceps elongated and blade-shaped, with distal concavity, basal lobe poorly developed, only visible in ventral view (Fig. 18).

Comments. This species differs from others mainly in details of the male for-ceps (see diagnosis). Because of the long stay in alcohol, no peculiar pattern on the abdomen or legs can be observed and used as diagnostic.

Bugilliesia truncata is restricted to the South West of West Africa (Guinea and Sierra Leone). This distribution is provisional, as no material is available from nearby countries such as Liberia. Contrary to most other species, *B. truncata* seems not to co-occur with any other *Bugilliesia* species.

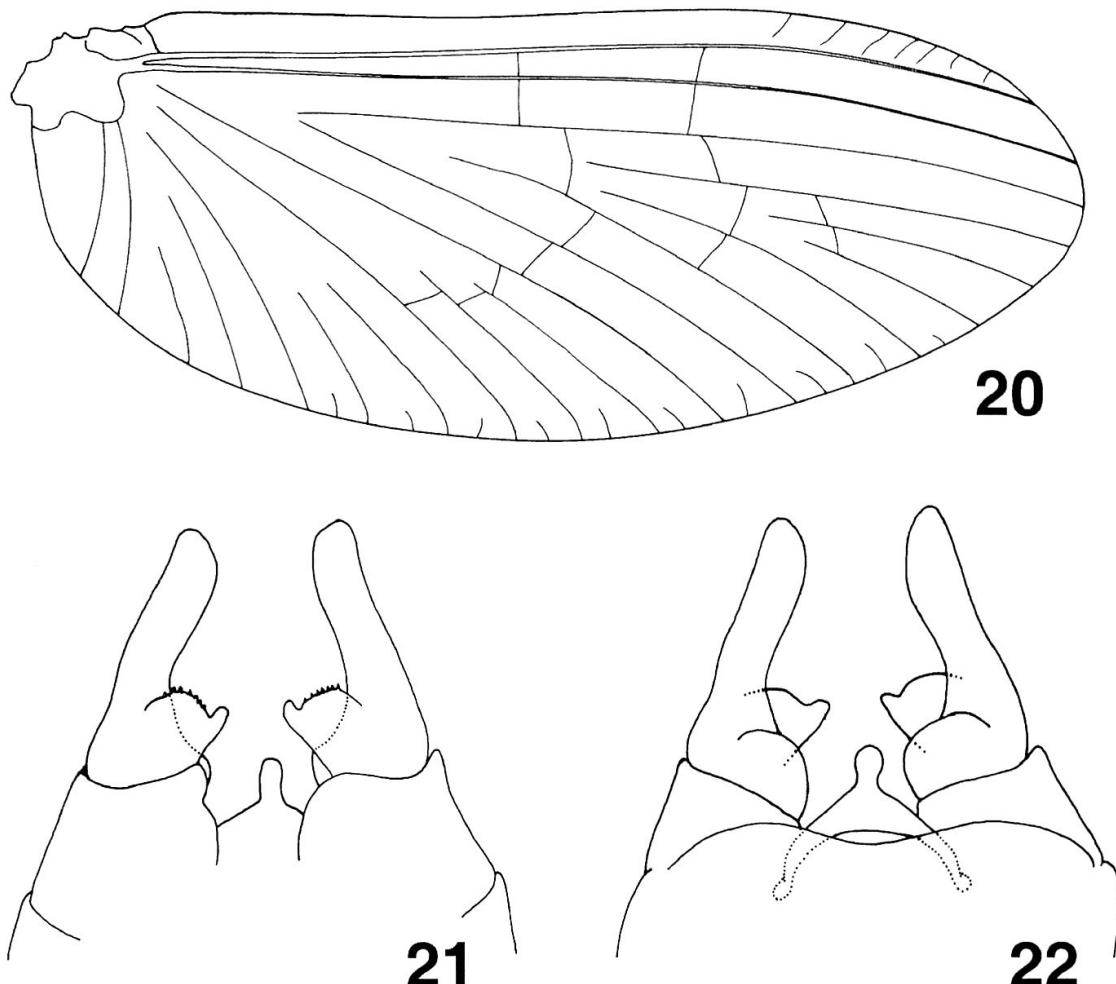
Etymology. The specific epithet is Latin for truncated, in reference to the peculiar shape of the apex of the male genitalia.

2. Genus *Kivua* McCafferty and Lugo-Ortiz, 1996

Diagnosis. Male imagos of *Kivua* are characterized by the following charac-ters: hindwings absent; gonopods elongated, first segment with a broad lateral lobe, second segment apically nippled with the inner margin inwardly bowed (Figs 21–22).

Type species. *Kivua insueta* (Kopelke, 1980)

Species included. *Kivua elouardi* (Gillies, 1989), *Kivua insueta* (Kopelke, 1980).



Figs 20–22. Forewing and male genitalia of *Kivua elouardi*: 20: forewing. 21: male genitalia (ventral view). 22: male genitalia (dorsal view).

2.1 *Kivua elouardi* (Gillies, 1989)

Rhithrocloeon elouardi Gillies, 1989

Kivua elouardi (Gillies): Lugo-Ortiz & McCafferty 1996

Material examined. Topotypes: 17 ♂ imagos, 9 ♂ subimagos, Ivory Coast, Cavally bas., unnamed riv., Loc. Tiboto-Grabo (road), 11.02.1988. Leg J.-M. Elouard, IRD.

Comments. The original description was based only on two specimens. Examination of a series of male adults showed that the original description was mainly correct except for the length of the intercalary veins, which were found to be generally longer than previously illustrated (Fig. 20; Gillies 1989, Fig. 1). The male genitalia are illustrated in both the ventral and dorsal views (Figs 21, 22). All legs were lost in the type specimens, but examination of new specimens did not reveal any useful characters on the legs.

The larval stage of the two species of *Kivua* remains unknown. Knowledge of this stage would greatly improve our understanding of the relationship of *Kivua* with *Rhithrocloeon* and with *Bugilliesia*.

Despite other samples taken from near the type-locality, this species was restricted to a single locality where it co-occurred with *Bugilliesia guineensis*, *B. biloba* and *B. notabilis*.

2.2 *Kivua insueta* (Kopelke, 1980)

Cloeon insuetum Kopelke, 1980

Kivua insueta (Kopelke): Lugo-Ortiz & McCaffery 1996

No material examined.

Comments. *Kivua insueta* mainly differs from *Kivua elouardi* in some characters of the male genitalia: the length of the second segment, the shape of the ventral extension of the first segment and the shape of the apex of the genital plate (Kopelke 1980, Figs 21, 22). Others characters such as the wing shape and venation are quite similar.

3. Genus *Mutelocloeon* Gillies and Elouard, 1990

Diagnosis. Male imagos of *Mutelocloeon* are characterized by the following characters: hindwings extremely reduced or absent; gonopods short and stocky.

Type species: *Mutelocloeon bihoumi* Gillies and Elouard, 1990

Species included. *Mutelocloeon bihoumi* Gillies and Elouard, 1990, *Mutelocloeon corbetti* (Kimmings, 1956), *Mutelocloeon thomasorum* Lugo-Ortiz and McCafferty, 1997, incertae sedis.

3.1 *Mutelocloeon bihoumi* Gillies and Elouard, 1990

Material examined. Topotypes: 1 ♂ subimago, Guinea, Niger bas., Niandan riv., Loc. Sassambaya, 10.02.1986. 7 larvae, same locality, 22.01.1987. Leg J.-M. Elouard, IRD.

Other material: 1 ♂ subimago, Guinea, Niger bas., Milo riv., Loc. Boussoulé, 28.03.1985. 2 ♂ subimagos, same locality, 31.05.1985. 1 ♂ imago, 2 ♂ subimagos, same locality, 20.04.1986. 4 ♂ subimagos, same locality, 21.04.1986. 14 ♂ subimagos, 16 ♀ subimagos, same locality, 07.05.1987. 1 ♂ imago, Guinea, Niger bas., Niandan riv., Loc. Kissidougou, 22.01.1987. 1 ♂ subimago, 2 larvae, Guinea, Sénégal bas., Bafing riv., Loc. Timbo, 31.01.1987. 1 ♂ imago, 3 ♂ subimagos, 1 ♀ imago, 1 ♀ subimago, Sierra Leone, Pampana bas., Pampana riv., Loc. Magburaka (near), 05.02.1989. 9 ♂ imagos, 1 ♀ subimago, Sierra Leone, Seli (= Rockel) bas., Seli riv., Loc. Katik, 07.02.1989. 2 ♀ imagos, Sierra Leone, Seli (= Rockel) bas., Seli riv., Loc. Bumbuna, 10.02.1989. All specimens leg J.-M. Elouard, IRD.

Comments. Larvae of *Mutelocloeon* are obligatory commensalists of freshwater mussels (Gillies & Elouard 1990); *Symbiocloeon* Müller-Liebenau, 1979 is the only other case of mussel association known in Baetidae (Gillies & Elouard 1990; Müller-Liebenau & Heard 1979). The ecology of *Mutelocloeon bihoumi* was described in detail by Gillies & Elouard (1990). The number of positive findings was limited to 5 or 6 different species of large mussels and was restricted to a few

sites. This peculiar symbiotic larval habitat makes the rearing of these larvae nearly impossible. However, the distinct abdominal pattern of larva and adult, a large size unusually correlated with an extreme reduction to absence of hindwings or hindwingpads, and the presence of larva and adult in the same localities are evidence that support this association.

Mutelocloeon bihoumi was previously only known from Mali and Guinea (Gillies & Elouard 1990; Lugo-Ortiz & McCafferty 1996); records included herein constitute the first report from Sierra Leone.

3.2 *Mutelocloeon corbetti* (Kimmings, 1956)

Centroptilum corbetti Kimmings, 1956

Mutelocloeon corbetti (Kimmings): Gillies & Elouard 1990

No material examined.

Comments. This species was originally described from male and female imagoes from Uganda, and the larval stage remains unknown (Kimmings 1956), and it probably never has been collected subsequently (Demoulin 1970; Lugo-Ortiz & McCafferty 1996). *Mutelocloeon corbetti* is rather similar to *M. bihoumi*, differing only slightly in the shape of the male forceps and the abdominal markings (Gillies & Elouard 1990).

3.3 *Mutelocloeon thomasorum* Lugo-Ortiz and McCafferty, 1997, incertae sedis

Material examined. 1 ♂ imago, 1 ♂ subimago, Madagascar, Mangoro Bas., unnamed river, road to Anosibe An'ala (20.4 km from Moramanga). 23.10.1998. J.-M. Elouard, J. Legrand and N. Raberiaka.

Comments. The generic attribution of *Mutelocloeon thomasorum* remains enigmatic. This report was considered as the first occurrence of a symbiotic mayfly-mussel association in Madagascar (Lugo-Ortiz & McCafferty 1997b). During the last 15 years, more than 1000 samplings were performed throughout Madagascar in every kind of fresh water habitat. No freshwater mussels or similar bivalves were collected, indicating that in all probability, no potential host for *Mutelocloeon* occurs in Madagascar (Elouard & Gibon 2001). This is strong circumstantial evidence that the larva of *M. thomasorum* cannot have the same symbiotic ecology as the African species of *Mutelocloeon* and casts into doubt the attribution of *M. thomasorum* to *Mutelocloeon*.

Moreover, the shape of genitalia [medium long with a broad projection in *Mutelocloeon thomasorum* (Lugo-Ortiz & McCafferty 1997b, Fig. 20) instead of short with a conspicuous invagination as in the African species of *Mutelocloeon* (Gillies & Elouard 1990)] and the completely different general habitus clearly indicate that *M. thomasorum* does not belong to *Mutelocloeon*. The shape of the male genitalia appears much more similar to those of *Bugilliesia* (Figs 3 and 4) or *Kivua* (Figs 21 and 22). Further analyses are necessary to know if *M. thomasorum* belongs to *Bugilliesia* or a related genus or to an undescribed genus. For this reason, I presently consider *M. thomasorum* as unassignable to any genus and therefore place it as *incertae sedis*.

4. Genus *Rhithrocloeon* Gillies, 1985

Diagnosis. Male imagos of *Rhithrocloeon* are characterized by the following characters: hindwings absent; gonopods elongated and apically pointed with a slender and acute projection on the lateral margin of segment 1.

Type species. *Rhithrocloeon permirum* (Kopelke, 1980)

Species included. *Rhithrocloeon indicator* Gillies, 1985, *Rhithrocloeon permirum* (Kopelke, 1980)

Comments. *Rhithrocloeon* notably differs from other genera of the *Bugilliesia* complex in that the second segment of the male genitalia has a straight inner margin. No imagos possessing such genitalia have been collected from West Africa. The length of this straight margin, as well as the degree of development of the internal projection, allow the identification of the two species (Gillies 1985).

4.1 *Rhithrocloeon indicator* Gillies, 1985

No material examined.

4.2 *Rhithrocloeon permirum* (Kopelke, 1980)

Cloeon permirum Kopelke, 1980

Rhithrocloeon permirum (Kopelke): Gillies 1985

No material examined.

4.3 *Rhithrocloeon* sp.

Material examined. 4 larvae, Guinea, Niger bas., Léléko riv. (Milo trib.), Loc. near de Konsankoro, 08.03.1988. 1 larva, Guinea (Fouta), trib. of Ouassélé riv., Loc. 11 km from Tanguel-Bori, 26.02.1987. 1 larva, Guinea (Fouta), Dalato, 24.01.1987. All specimens leg J.-M. Elouard, IRD.

Comments. *Rhithrocloeon* was previously only recorded from Tanzania and the Democratic Republic of Congo (Gillies 1985, 1988). The first *Rhithrocloeon* recorded from West Africa was *R. elouardi* (Gillies 1989), which was then transferred to *Kivua* (Lugo-Ortiz & McCafferty 1996). No imagos of *Rhithrocloeon* were found in the material examined from West Africa; however, larvae were found in samples from three localities. The larvae clearly belong to *Rhithrocloeon* but differ from the two described East African species, *R. indicator* and *R. permirum*, at least in the shapes of the paraglossae and right prostheca. This new species will be described elsewhere.

Key to the male adults from West Africa

1. Highly modified 2-segmented male genitalia (Figs 12–19). *Bugilliesia* and related genera 2
- Unmodified 3-segmented male genitalia. Other Baetidae
2. Hindwing with costal spur and longitudinal veins. *Bugilliesia* 3
- Hindwing absent, or extremely reduced. 8
3. Forewing with hyaline crossvein (Figs 6–8); hindwing relatively broad and apically rounded (Figs 9–11). 4

- Forewing with cross-veins fuscous margined with the same colour (Fig. 1); hindwing slender and acute (Figs 2, 5). 7
- 4. Apex of the male genitalia with a clear concavity in lateral view (Fig. 19)....
..... *Bugilliesia truncata* n.sp.
- Apex of the male genitalia rounded or pointed but without concavity in lateral view (Figs 14, 17). 5
- 5. Basal lobe of the male genitalia poorly developed (Fig. 12).....
..... *Bugilliesia cavalliensis* n.sp.
- Basal lobe of the male genitalia well developed (Fig. 15). 6
- 6. Forewing with short intercalary veins (less than a third of the intervein space) (Fig. 7); apical margin of the basal lobe clearly concave (Fig. 15).
..... *Bugilliesia guineensis* (Gillies, 1990)
- Forewing with relatively long intercalary veins (about half of the intervein space); apical margin of the basal lobe convex (Kimmings 1956, Fig. 2).
..... *Bugilliesia sudanensis* (Ulmer, 1916)
- 7. Fuscous margination of the crossveins mainly present in the basal half of the forewing (Fig. 1); basal lobe of male genitalia with ventral and dorsal expansions (Figs 3, 4); hindwing with costal spur erect and longitudinal veins reaching at most $\frac{3}{4}$ of the length of the hindwing (Fig. 2).
..... *Bugilliesia biloba* n.sp.
- Fuscous marking bordering all the crossveins of the forewing equally (Kimmings 1956, Fig. 3); basal lobe of male genitalia with a single broad expansion (Kimmings 1956, Fig. 5); hindwing with costal spur strongly curved and longitudinal veins almost reaching the apex of the hindwing (Fig. 5).
..... *Bugilliesia notabilis* (Kimmings, 1956)
- 8. Body of large size (more than 10 mm); male genitalia compact with first and second segment about 1.5 times longer than broad (Gillies & Elouard 1990, Fig. 3). *Mutelocloeon bihoumi* Gillies & Elouard, 1990
- Body of small to medium size (3 to 7 mm), male genitalia longer, first and second segment at least two times longer than broad (Figs 21, 22). 9
- 9. Male genitalia apically pointed, basal lobe slender and acute (Gillies 1985, Figs 25-26). *Rhithrocloeon* sp.
- Male genitalia apically rounded, basal lobe broad (Figs 21, 22).
..... *Kivua elouardi* (Gillies, 1989)

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