

The mayflies of Ghana (Insecta: Ephemeroptera)

J.-L. GATTOLLIAT & M. SARTORI

Museum of Zoology, Palais de Rumine, Place Riponne 6, CH-1014 Lausanne, Switzerland
E-mail: jean-luc.gattolliat@vd.ch

Abstract – In the late 1960, S. ENDRÓDY-YOUNGA and B. ENTZ sampled insects of different orders from various areas of Ghana. Nearly 1000 imagoes of Ephemeroptera were collected. We were able to identify 26 taxa, mostly to the species level. With 9 species, Baetidae is by far the most diversified family. *Povilla adusta* NAVÀS, 1912 (Polymitarcyidae), *Procloeon cylindroculum* KIMMINS, 1955 (Baetidae) and *Tricorythus* sp. (Tricorythidae) are the most common and most abundant taxa. As the mayfly fauna of Ghana was poorly prospected, 21 of the 26 taxa constitute new reports for this country. Eight species are also new for West Africa, some of which have never been mentioned since the original description. We also illustrate three species that are possibly new to science. With 8 figures.

Key words – Ghana, Ephemeroptera, new records.

INTRODUCTION

The Ephemeroptera fauna of West Africa is still insufficiently known, although some genera have been studied in detail mainly by ELOUARD, WUILLOT and GILLIES (see references below). In this context, the mayflies of Ghana have been particularly underworked, due to several reasons, both historical and political. At the moment, the following Ephemeroptera are known to occur in Ghana (in chronological order):

Elassoneuria sp. (nymphs) (BERNER 1954); *Dicercomyzon femorale* DEMOULIN, 1954 (DEMOULIN 1970); *D. marginatum* KIMMINS, 1957 and *D. costale* KIMMINS, 1957 (KIMMINS 1957); *Adenophlebiodes* sp. (PETERS & EDMUNDS 1964) (nymphs); *Povilla adusta* NAVÀS, 1912 (PETR 1970); *Cloeon smaeleni* LESTAGE, 1924 and *C. perkinsi* BARNARD, 1932 (GILLIES 1980b); *Exeuthyplocia minima* (ULMER, 1916) (HIDEUX 1987); and *Adenophlebiodes massirius* ELOUARD-HIDEUX et ELOUARD, 1991 (ELOUARD-HIDEUX & ELOUARD 1991).

In the Hungarian Natural History Museum (HNHM) in Budapest there is a rather important collection of Ephemeroptera gathered mainly by Dr SEBASTIAN ENDRÓDY-YOUNGA in the late 1960's. The collector worked in Ghana as an ento-

mologist at the Crop Research Institute. In his survey of insects of economic importance, he used different methods, among them light trapping. This method has proven to be quite efficient to collect adult mayflies in the tropics.

Thanks to the courtesy of DÁVID MURÁNYI (HNHM), we had the opportunity to study this material. All specimens are kept in ethanol and are composed exclusively of imagoes and subimagoes; no nymphs were available for study. The material is not in perfect condition since specimens are often dried due to the collecting methods (chloroform instead of ethanol). Details of the localities are found in ENDRÓDY-YOUNGA (1970). The collection also includes a few specimens collected by Dr BÉLA ENTZ on the shores of Lake Volta during the same period.

LIST OF THE ENCOUNTERED SPECIES

BAETIDAE

Bugilliesia notabilis (KIMMINS, 1956)

Centroptilum notabile KIMMINS, 1956 (orig.)

Afroptilum notabile: GILLIES (1990) (comb.)

Bugilliesia notabilis: LUGO-ORTIZ & MCCAFFERTY (1996) (comb.)

Material examined – GHANA: Northern Region, Banda-Nkwanta, Volta, 2°09'W, 8°22'N, 122 m, 1 ♀, 13.09.1965 (G073); same locality, 1 ♀, 21.09.1965 (G081); 4 ♀♀, 27.09.1965 (G083); 1 ♀, 01.10.1965 (G088); 1 ♀, 07.10.1965 (G089). All collected by S. ENDRÓDY-YOUNGA.

Diagnostic features – Male imagoes of *Bugilliesia* LUGO-ORTIZ et MCCAFFERTY, 1998 possess highly transformed two segmented genital forceps, corresponding to the *Afroptilum sudanense* group in GILLIES (1990b). In this genus, *B. notabilis* and *B. nitida* (ULMER, 1916) as well as an undescribed species (see below *Bugilliesia* sp. A) can be easily separated from other congeneric species by the forewing markings: in both sexes, the forewings are hyaline with fuscous crossveins margined with the same colour. These three species can be distinguished by the shape of the peculiar gonopods, the degree of development of the fuscous marking (fig. 3 in KIMMINS 1956; fig. 2 in DEMOULIN 1957), the presence of an oval fuscous maculation at the apex of the costal, subcostal and radial areas in *B. nitida* (fig. 2 in DEMOULIN 1957), and the shape of the hindwing and especially of the costal spur (fig. 3 in KIMMINS 1956; fig. 2 in DEMOULIN 1957). In the examined material, only female imagoes were included. However, colouration as well as shape of the costal spur of the hindwings clearly fit *B. notabilis*.

Distribution – *Bugilliesia notabilis* was originally described from Uganda (KIMMINS 1956) and later mentioned from Tanzania (DEMOULIN 1965). Our data constitute the first record of this species for West Africa. Male and female imagoes were collected in other parts of West Africa (mainly Guinea, Mali and Ivory Coast) and are presently housed in our collections (Coll. ORSTOM, leg. J.-M. ELOUARD). A complete list of the localities will be published elsewhere (GATTOLLIAT in prep.).

Bugilliesia sp. A

Material examined – GHANA: Brong-Abafo Region, Bui camp, Volta, Black Volta, 2°15'W, 8°17'N, 106 m, 5 ♀♀, 01.11.1965 (G097); Central Region, Tafo, Volta, 0°22'W, 6°14'N 198 m, 3 ♀♀, 10.05.1969 (G350); Ashanti Region, Kumasi, Volta, 1°36'W, 6°43'N, 293 m, 2 ♀♀, 31.05.1969 (G364); same locality, 3 ♀♀, 31.05.1969 (G365). All collected by S. ENDRÓDY-YOUNGA.

Diagnostic features – During the revision of the *Bugilliesia* complex in West Africa (GATTOLLIAT in prep.) an undescribed species closely related to *B. notabilis* was discovered. The two species differ mainly by the shape of the genital forceps. Moreover, female imagoes can be securely separated by the shape of the costal spur of the hindwings and the less well-developed fuscous maculation bordering the cross-veins of forewings.

Distribution – This species has been found in Guinea, Ivory Coast and Mali. It seems to have the same distribution in West Africa as *B. notabilis*. In some localities, both species were present.

Cloeodes dentatus (KIMMINS, 1956)

Cloeon dentatum KIMMINS, 1956 (orig.)

Potamocloeon dentatum: GILLIES (1990a) (pro parte) (comb.)

Afroptilum plumosum WUILLOT, 1995 (syn.)

Maliqia plumosa: LUGO-ORTIZ & MCCAFFERTY (1997) (syn.)

Maliqia abdallahi MCCAFFERTY, 2000 (syn.)

Cloeodes dentatus: JACOBUS *et al.* (2006) (comb.)

Material examined – GHANA: Brong-Abafo Region, Bui camp, Volta, Black Volta, 2°15'W, 8°17'N, 106 m, 1 ♂, 01.11.1965 (G097), S. ENDRÓDY-YOUNGA.

Diagnostic features – While *Cloeodes dentatus* is highly distinguishable in the larval and imaginal stages, its generic attribution was a source of misunderstanding until recently. This confusion is partially due to a tentative, but unfortunately incorrect, association between nymph and imago. A recent revision of the genera *Cloeodes* TRAVER, 1938, *Potamocloeon* GILLIES, 1990 and *Securiops*

JACOBUS, MCCAFFERTY et GATTOLLIAT, 2006 in the Afrotropics now allows a secure identification and attribution of the taxa (JACOBUS *et al.* 2006). The male imago can be identified by the following combination of characters: forewings with single intercalaries, absence of hindwings, first segment of the gonopods strongly constricted apically and third segment truncated (WUILLOT & GILLIES 1993, JACOBUS *et al.* 2006).

Distribution – This species has a wide distribution in the Afrotropics, including West (Mali and Guinea), Central (Uganda) and Southern Africa (South Africa) (GILLIES 1990a, KIMMINS 1956, MCCAFFERTY 2001, WUILLOT & GILLIES 1993, JACOBUS *et al.* 2006). This new record is therefore included in the previous geographical range of the species.

Cloeon smaeleni LESTAGE, 1924

Material examined – GHANA: Northern Region, Banda-Nkwanta, Volta, 2°09'W, 8°22'N, 122 m, 2 ♀♀, 05.09.1965 (G071); Ashanti Region, Kumasi, Volta, 1°36'W, 6°43'N, 293 m, 1 ♀, 10.12.1967 (G290). All collected by S. ENDRÓDY-YOUNGA.

Diagnostic features – *Cloeon* LEACH, 1815 is one of the few genera of Baetidae for which the colouration of the abdomen and wings allows species-level determination of female imagoes. The wings of *C. smaeleni* females have the costal and subcostal area uniformly tinted brown with small hyaline windows bordering the cross-veins (fig. 2 in GILLIES 1980b; fig. 11 in GATTOLLIAT & RABEANTOANDRO 2002). The terga are light brown with specific dark brown markings (fig. 13 in GILLIES 1980b).

Distribution – *Cloeon smaeleni* is one of the most widespread and common species in the Afrotropics (DEMOULIN 1970). Its distribution also includes Madagascar and is the only species of Ephemeroptera which is not considered endemic of this island (GATTOLLIAT & RABEANTOANDRO 2002, MONAGHAN *et al.* 2005). GILLIES (1985) even mentioned four females from South Yemen. *Cloeon smaeleni* abounds in temporary ponds, rice fields, dams, slow moving streams and the margins of lakes (GILLIES 1980b).

Cloeon sp.

Material examined – GHANA: Ashanti Region, Kumasi, Volta, 1°36'W, 6°43'N, 293 m, 1 ♂, 28.09.1967 (G275), S. ENDRÓDY-YOUNGA.

Diagnostic features – Although a key exists for the male imagoes of *Cloeon* (GILLIES 1980b), specimens faded in alcohol cannot be determined with certainty.

This male imago could belong to *Cloeon smaeleni*, but no reliable character allows the confirmation of this hypothesis.

Labiobaetis sp.

Material examined – GHANA: Northern Region, Banda-Nkwanta, Volta, 2°09'W, 8°22'N, 122 m, 1 ♀, 05.09.1965 (G071); same locality, 1 ♀, 13.09.1965 (G073); 1 ♀, 21.09.1965 (G081); 4 ♀♀, 27.09.1965 (G083); 1 ♀, 01.10.1965 (G088); Ashanti Region, Kumasi, Volta, 1°36'W, 6°43'N, 293 m, 5 ♀, 06.07.1967 (G232); 1 ♀, 25.06.1969 (G377). All collected by S. ENDRÓDY-YOUNGA.

Diagnostic features – In order to avoid confusion with the old concept of *Pseudocloeon* KLAPÁLEK, 1905 (paired intercalary veins in forewing and no hindwing), these female imagoes are provisionally included in *Labiobaetis* NOVIKOVA et KLUGE, 1987, although they could be conspecific with the male imagoes of *Pseudocloeon cf. mtone* (see general comments under that species). Because of the lack of specific characters in *Labiobaetis* female imagoes and poor knowledge of Ghana's fauna, their specific identification remains unknown.

Procloeon cylindroculum KIMMINS, 1955

Cloeon cylindroculum: DEMOULIN (1970) (comb.)

Procloeon cylindroculum: GILLIES (1997) (comb.)

Material examined – GHANA: Northern Region, Banda-Nkwanta, Volta, 2°09'W, 8°22'N, 122 m, 1 ♀, 01.09.1965 (G070); same locality, 1 ♀, 27.09.1965 (G083); 2 ♀♀, 27.10.1965 (G087); 2 ♀♀, 01.10.1965 (G088); Ashanti Region, Kumasi, Volta, 1°36'W, 6°43'N, 293 m, 3 ♀♀, 06.07.1967 (G232); same locality, 1 ♂, 1 ♀, 03.02.1968 (G296), S. ENDRÓDY-YOUNGA. Kete Krachi, Volta, Lake Volta, 0°05'W, 7°50'N, 100 m, 1 ♀, 03.01.1969 (G991); Drija, sziklák [= boulders], Volta, Lake Volta, 4 ♀♀, 09.01.1969 (G992); Bagjamse, kanyar [= bend], Volta, Lake Volta, 18 ♂♂, 34 ♀♀, 08.01.1969 (G993); Western Region, Mpoho, Pra, 1°47'W, 5°25'N, 7 ♂♂, 16 ♀♀, 06.01.1969 (G994); Brong Ahafo Region, Yeji, Volta, Lake Volta, 0°0'W, 9°27'N, 1 ♂, 1 ♀, 08.01.1969 (G997); same locality, 4 ♂♂, 1 ♀, 07.01.1969 (G998); 8 ♂♂, 14 ♀♀, 04.01.1969 (G999). All collected by B. ENTZ.

Diagnostic features – Both sexes of *Procloeon cylindroculum* can be easily recognized by the forewing with a single veinlet in the pterostigma area and the single intercalaries, which are reduced both in length and in number (fig. 7 in GILLIES 1980b). In the original description, KIMMINS (1955) mentioned the highly characteristic cylindrical eyes of the male. GILLIES (1979, 1980b) noticed that a dimorphism existed in this character: a few specimens from East Africa have eyes broader at the apex than at the basis (ratio of height to width 1:1 rather than 1.5:1 in typical specimens). Specimens examined by GILLIES (1980b) from Gambia are of

the broader type. All specimens listed above also fit the broader morph concept, although the poor preservation of part of this material makes the estimation of the ratio of the turbinate eyes difficult. The generic attribution of the species to *Procloeon* BENGTTSSON, 1915 or to *Cloeon* is unclear; the species was originally described in the genus *Procloeon* (KIMMINS 1955) then moved to *Cloeon* (DEMOULIN 1970) and finally put back in *Procloeon* (GILLIES 1997). The situation will remain unclear until a complete revision of the genera *Cloeon* and *Procloeon* is undertaken.

Distribution – *Procloeon cylindroculum* is widely distributed in Africa from Malawi (Nyasaland) in the south, to Tanzania in the east and Senegal in the west (GILLIES 1980b, KIMMINS 1955). In West Africa, it is reported from Gambia, Senegal and Ivory Coast (GILLIES 1980b). These first citations from Ghana are consequently included in the previously known distribution.

Pseudocloeon cf. mtone GILLIES, 1994

Baetis mtonis GILLIES, 1994 (orig.)

Labiobaetis mtonis: LUGO-ORTIZ & MCCAFFERTY (1997) (comb.)

Pseudocloeon mtone: LUGO-ORTIZ, MCCAFFERTY & WALTZ (1999) (comb.)

Material examined – GHANA: Ashanti Region, Kumasi, Volta, 1°36'W, 6°43'N, 293 m, 6 ♂♂, 03.06.1967 (G224); same locality, 6 ♂♂, 02.07.1967 (G230). All collected by S. ENDRÓDY-YOUNGA.

Further material – IVORY COAST: Cavally, Road Tiboto-Grabo, 3 ♂♂, 11.02.1988, (A0263), J.-M. ELOUARD (ORSTOM) coll. and leg.

Diagnostic features – *Labiobaetis* NOVIKOVA et KLUGE, 1987 was raised to the generic rank and included most species of the *Baetis propinquus* (WALSH, 1863), *B. atrebatinus* EATON, 1870 and *B. molawinensis* MÜLLER-LIEBENAU, 1982 species group by MCCAFFERTY & WALTZ (1995). Several African species previously assigned to *Baetis* were transferred to this genus (LUGO-ORTIZ & MCCAFFERTY 1997). Despite the dubious status of the genus *Pseudocloeon* KLAPÁLEK, 1905, all the species previously included in *Labiobaetis* and some species placed in *Baetis* LEACH, 1815 were subsequently assigned to *Pseudocloeon* (LUGO-ORTIZ *et al.* 1999). Because of the controversial status of the genus *Pseudocloeon* and the lack of clearly shared diagnostic characters, GATTOLLIAT (2001) refuted the placement of the Malagasy species of *Labiobaetis* in *Pseudocloeon*. Recent molecular analysis show that the concept of *Labiobaetis/Pseudocloeon* is polyphyletic and that several lineages occur in the Afrotropical Realm (MONAGHAN *et al.* 2005). The examined material possesses the following characters: hindwings present with two longitudinal veins and without costal spur; sclerotized plate be-

tween forceps with distal margin straight, paraproct of the 10th segment with a rounded subapical spur (as in fig. 3 in GILLIES 1994), gonopod 3-segmented with the third segment as long as broad, continuous brown line along the lateral margin of the abdomen. These specimens appear closely related to *Pseudocloeon mtone*; mainly by sharing the peculiar spur on paraprocts (GILLIES 1994). This attribution remains tentative because it is based only on the imaginal stage.

Distribution – *Pseudocloeon mtone* was previously only known from Tanzania (GILLIES 1994). It has not been collected again since the original description.

Pseudopannota muganinani ELOUARD et GILLIES, 1990

Material examined – GHANA: Central Region, Tafo, Volta, 0°22'W, 6°14'N, 198 m, 3 ♂♂, 10.05.1969 (G350), S. ENDRÓDY-YOUNGA.

Diagnostic features – The male imagoes of *Pseudopannota muganinani* can be easily separated from other species of *Pseudopannota* WALTZ et MCCAFFERTY, 1987 by the peculiar turbinate eyes; they look mushroom-shaped with the upper face overlapping the base of the turbinate eyes as well as the upper portion of the compound eyes. The third segment of the gonopods is truncated (fig. 12 in ELOUARD *et al.* 1990) rather than rounded in other species of *Pseudopannota* (fig. 5 in ELOUARD *et al.* 1990; figs 1d and 2d in ELOUARD & HIDEUX 1991). The male imago of *P. muganinani* is also quite similar to the one of *Ophelmatostoma camerunense* (ULMER, 1920). However, *O. camerunense* differs from all species of *Pseudopannota* by having the inner margin of the basal segment of the gonopods expanded apically, and from *P. muganinani* also by the shape and colour of the turbinate eyes (GILLIES *et al.* 1990).

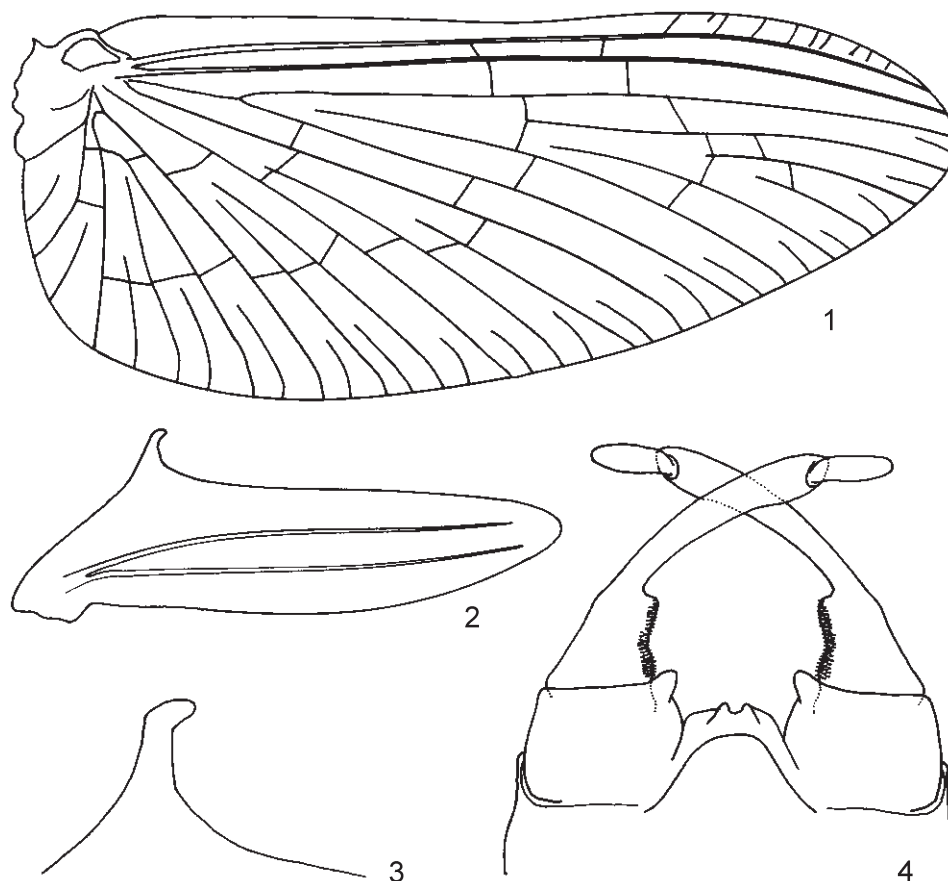
Distribution – This species is restricted to West Africa, where it possesses a wide distribution, but is less abundant than other species of *Pseudopannota* (ELOUARD *et al.* 1990). It was collected mainly in streams in the savannas as well as large rivers in the forest zone. This first report from Ghana extends the distribution of the species to the East.

Baetidae Genus 1 (Figs 1–4)

Material examined – GHANA: Northern Region, Banda-Nkwanta, Volta, 2°09'W, 8°22'N, 122 m, 1 ♂, 1 ♀, 27.10.1965 (G087); same locality, 1 ♀, 01.05.1965 (G020); 2 ♀♀, 01.10.1965 (G088); 1 ♂, 07.10.1965 (G089); Ashanti Region, Kumasi, Volta, 1°36'W, 6°43'N, 293 m, 1 ♂,

15.09.1967 (G274); same locality 1 ♀, 31.05.1969 (G364); 1 ♂, 31.05.1969 (G365). All collected by S. ENDRÓDY-YOUNGA.

Diagnostic features – Both male and female imagoes can be easily recognized by the forewing with very long single intercalary veins (reaching or almost reaching the crossveins in the cubital field) (Fig. 1) and a broad hindwing with two longitudinal veins and a single well developed and erected costal spur (Figs 2–3). The male gonopods have a basal segment with an apico-internal process, the first and second segments almost fused, but with the first segment apically constricted, the third segment oval and elongated, and a peculiar bifid sclerotized process between the gonopods (Fig. 4).



Figs 1–4. Baetidae Genus 1: 1 = forewing, 2 = hindwing, 3 = detail of hindwing (costal spur), 4 = male genitalia

About 20 genera of Baetidae are presently known to occur in the Afrotropical area; 19 of them are known from West Africa (BARBER-JAMES & LUGO-ORTIZ 2003). Baetidae Genus 1 possesses single intercalary veins; therefore it does not belong to subfamily Baetinae (sensu GILLIES 1991). The single costal spur of the hindwings also excludes Genus 1 from *Afroptilum* GILLIES, 1990, *Centroptiloides* LESTAGE, 1918, *Dicentropilum* WUILLOT et GILLIES, 1994 and *Mickiops* MCCAFFERTY, LUGO-ORTIZ et BARBER-JAMES, 1997. The shape of the gonopods also indicates that Genus 1 differs from *Dabulamanzia* LUGO-ORTIZ et MCCAFFERTY, 1996 and genera with highly transformed gonopods [*Bugilliesia* complex sensu LUGO-ORTIZ & MCCAFFERTY (1996)]. The shape of hindwing, in peculiar the costal spur (Fig. 3), differs from *Cheleocloeon* WUILLOT et GILLIES, 1993 and *Peuhlella*, but presents high similarity with *Crassabwa* LUGO-ORTIZ et MCCAFFERTY, 1996 (fig. 20f in CRASS 1947). The gonopods of Genus 1 also seem similar to those of *Crassabwa* (fig. 20e in CRASS 1947). The basal segment of the type species *C. flava* (CRASS, 1947) apparently does not have any process, but this structure is present in other species of the genus (fig. 21b in KOPELKE 1980). The forewing appears different between the two genera: *Crassabwa* possesses relatively long single intercalary veins in the radial area, but reduced ones in the cubital fields (fig. 20d in CRASS 1947). The genus *Crassabwa* has never been reported from West Africa and no specimens from this area have been found in our collections. According to the present state of knowledge, Genus 1 should be either a new genus, the imaginal stage of a genus previously known only in the larval stage, or an atypical new species of *Crassabwa*.

Baetidae (unidentified)

Material examined – GHANA: Northern Region, Banda-Nkwanta, Volta, 2°09'W, 8°22'N, 122 m, 2 ♀♀, 13.09.1965 (G073); same locality, 1 ♀, 01.10.1965 (G088); 1 ♀, 07.10.1965 (G089); Brong-Arafo Region, Bui camp, Volta, Black Volta, 2°15'W, 8°17'N, 106 m, 1 ♂, 1 ♀, 27.10.1965 (G087); same locality, 1 ♀, 16.11.1965 (G100); Central Region, Tafo, Volta, 0°22'W, 6°14'N, 198 m, 5 ♀♀, 10.05.1969 (G350). All collected by S. ENDRÓDY-YOUNGA. Western Region, Mpoho, Pra, 1°47' W, 5°25' N, 3 ♀♀, 05.01.1969 (G996), ENTZ, B.

Diagnostic features – The poor condition of the material makes any attempt of identification even at a generic level fruitless.

HEPTAGENIIDAE

Afronurus cf. collarti (NAVÀS, 1930)

Adenophlebia collarti NAVÀS, 1930 (orig.)

Afronurus collarti: DEMOULIN (1956) (comb.)

Material examined – GHANA: Ashanti Region, Kumasi, 1°36'W, 6°43'N, 293 m, 1 ♂, 02.07.1967 (G230), S. ENDRÓDY-YOUNGA.

Diagnostic features – We consider here *A. collarti* as *species propria* and, as already stated by PUTHZ (1971), we do not follow the synonymy proposed by DEMOULIN (1956) with *A. pulcher* ULMER, 1930. Because of the different shape of the female genital plate [compare fig. 4d in DEMOULIN (1956) and fig. 28 in ULMER (1930)] the Abyssinian and Congo specimens cannot belong to the same species.

Fifteen species of *Afronurus* LESTAGE, 1924 are known from continental Africa. According to SCHOONBEE (1968), the single specimen from Ghana belongs to the *A. peringueyi* (ESBEN-PETERSEN, 1913) group, based on the inner sclerite of the penis longer than the outer one. It is very close to the redescription of *A. collarti* proposed by DEMOULIN (1956), in both the shape of the genitalia as well as general colouration and marking. Some uncertainty remains due to the scarcity of the available material.

Distribution – *Afronurus collarti* was described based on one male and two females from Stanleyville, Congo (nowadays Kisangani, Democratic Republic of the Congo), and as far as we are aware of, has never been mentioned since that time. If our identification is correct, the Ghana material extends its distribution far to the West. This species is new for Ghana.

Componeuria njalensis (KIMMINS, 1937)

Afronurus njalensis KIMMINS, 1937 (orig.)

Notonurus njalensis: DEMOULIN (1956) (comb.)

Componeuriella njalensis: GILLIES (1963) (comb.)

Componeuria njalensis: BRAASCH & SOLDÀN (1986) (comb.)

Thalerosphyrus njalensis: MCCAFFERTY (2003) (comb.)

Componeuria njalensis: WEBB *et al.* (2006) (comb.)

Material examined – GHANA: Brong-Abafo Region, Volta, Black Volta river at Bui camp, 2°15'W, 8°17'N, 106 m, 1 ♂, 16.11.1965 (G100); Ashanti Region, Kumasi, 1°36'W, 6°43'N, 293 m, 1 ♀, 25.06.1969 (G376); Northern Region, Banda-Nkwanta, 2°09'W, 8°22'N, 122 m, 1 ♂, 07.10.1965 (G089); same locality, 1 ♂, 05.09.1965 (G071); 1 ♀, 21.09.1965 (G081). All collected by S. ENDRÓDY-YOUNGA.

Further material – GUINEA: Niger basin; Niandan river at Bambaya; 2 ♂♂; 25.10.1984 (AO066), ELOUARD J.-M. (ORSTOM) coll. and leg.

Diagnostic features – The generic placement of this and other related species has been controversial, as illustrated by the numerous generic placements over the years. Basically the synonymy of *Notonurus* CRASS, 1947 with *Compsoeuriella* ULMER, 1939 as proposed by GILLIES (1984) is well established. In a recent paper WANG & MCCAFFERTY (2004) rejected the synonymy between *Compsoeuriella* and *Compsoeuria* EATON, 1881 proposed by BRAASCH & SOLDÁN (1986) and put *Compsoeuriella* in synonymy with *Thalerosphyrus* EATON, 1881. We follow the last development in this controversial issue as proposed by WEBB *et al.* (2006) and consider *Compsoeuria* as a valid genus and a senior synonym for both *Compsoeuriella* and *Notonurus*.

The genus *Compsoeuria* encompasses five species in continental Africa. The examined material perfectly fits the diagnosis of *C. njalensis*. The closest species is *C. bequaerti*, but the Ghana specimens differ in the shape of the genitalia and the colour patterns on the forewing [see DEMOULIN (1956) for comparison].

Distribution – *Compsoeuria njalensis* is recorded from Sierra Leone and Uganda (DEMOULIN 1970) up to South Africa (SCHOONBEE 1967). The Ghana material was compared to some males from Guinea and proved to be conspecific. The species is new for Ghana and Guinea.

OLIGONEURIIDAE

All of the oligoneuriid material presented here belongs to the genus *Elassoneuria* EATON, 1881. The systematics of the family is in great need of a revision, and specific attributes are only tentative. Oligoneuriidae adults are well known to exhibit marked intraspecific variation. At the moment, 6 species are recognized from continental Africa (GILLIES 1974).

Elassoneuria cf. candida EATON, 1913 (Figs 5–6)

Material examined – GHANA: Brong-Arafo Region, Volta basin, Black Volta river at Bui camp, 2°15'W, 8°17'N, 106 m, 24 ♂♂, 1 ♀, 27.10.1965 (G087); same locality, 3 ♂♂, 06.11.1965 (G098). All collected by S. ENDRÓDY-YOUNGA.

Diagnostic features – According to GILLIES (1974) the studied specimens share the following characters with *E. candida*: gonopods four-segmented and first segment with an inner spur (Figs 5–6). Our uncertainty comes from the fact that the

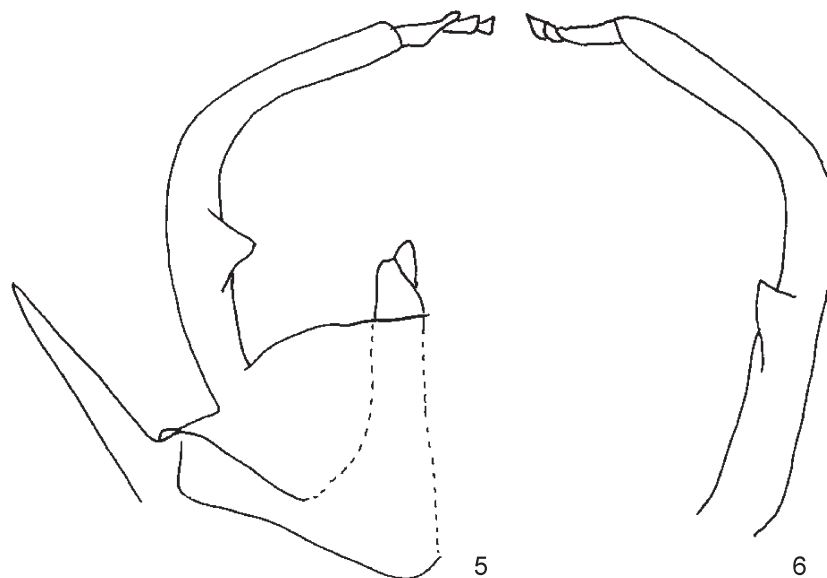
genitalia of the Ghana specimens resemble less those illustrated by KIMMINS (1960) under the name *E. candida*, than those drawn by GILLIES (1974) under the name *Elassoneuria* sp., the latter being possibly the enigmatic *E. trimeniana* (MCLACHLAN, 1868).

Distribution – *Elassoneuria candida* was described from Nigeria, and mentioned since then only from Uganda.

Elassoneuria cf. congolana NAVÀS, 1911

Material examined – GHANA: Northern Region, BANDA-NKWANTA, 2°09'W, 8°22'N, 122 m, 1 ♂, 09.09.1965; (G072); same locality, 2 ♀♀, 21.09.1965 (G081). All collected by S. ENDRŐDY-YOUNGA.

Diagnostic features – We follow the explanation given by GILLIES (1974) and recognize *E. congolana* as *species propria* and not as a synonym of *E. trimeniana* (MCLACHLAN, 1868) as suggested by DEMOULIN (1970). The single male available shares with *E. congolana* three-segmented gonopods with the first segment lacking an inner spur, as well as a small size compared to others. The two females have spines on the subanal plate more than half the length of the lateral



Figs 5–6. *Elassoneuria cf. candida*: 5 = half right genitalia of a male imago, 6 = left gonopod of another specimen

processes of the 9th segment. Wing venation also fits what GILLIES (1974) reports for this species.

Distribution – *E. congolana* was described from the Congo basin and has never been reported from any other country since then. If our identification is correct, this is the first report of this species for West Africa.

Elassoneuria cf. disneyi GILLIES, 1974

Material examined – GHANA: Ashanti Region, Kumasi, 1°36'W, 6°43'N, 293 m, 3 ♀♀, 03.06.1967 (G224), S. ENDRÓDY-YOUNGA.

Diagnostic features – Only females are available, but they differ greatly from those of the two previous species by their size, colouration and the length of the lateral processes of the 9th abdominal segment. They fit the diagnosis proposed by GILLIES (1974) for *E. disneyi*, but the lack of male imagoes refrains us to identify them with certainty.

Distribution – *Elassoneuria disneyi* was described from Cameroon on the basis of male and female adults. Nymphs referred to that species are also mentioned from Liberia and Togo (GILLIES 1974), making this species restricted to this area at the moment.

Elassoneuria sp.

Material examined – GHANA: Ashanti Region, Kumasi, 1°36'W, 6°43'N, 293 m, 8 ♀♀, 06.07.1967 (G232), S. ENDRÓDY-YOUNGA.

Diagnostic features – This material is represented only by damaged females. Any attempt to identify them would be preposterous.

TRICORYTHIDAE

Dicercomyzon cf. femorale DEMOULIN, 1954

Material examined –GHANA: Ashanti Region, Kwadaso/Kumasi, 1°39'W, 6°42'N, 259 m, 1 ♀, 04.08.1969 (G224), S. ENDRÓDY-YOUNGA.

Diagnostic features – The proposed identification is very speculative since it is much more based on the absence of characters than proper features. Among the

four species known, only two, *D. costale* KIMMINS, 1957 and *D. sjosterdti* ULMER, 1910 (= *D. marginatum* KIMMINS, 1957 syn. fide PUTHZ 1972) are sufficiently known in the adult stage. Both of them have the subcostal field of the forewing tinted with brown, the latter also having some crossveins bordered with brown (KIMMINS 1957, PUTHZ 1972). *D. femorale* is almost unknown in the winged stage. Some characters of the female subimago have been given by DEMOULIN (1954). The imagoes of both sexes are unknown. We provisionally assign our material to this species, based on the absence of a tinted subcostal field, as well as geographical data (see below).

Distribution – *D. femorale* was described from Congo and since then has also been recorded from Ghana (DEMOULIN, 1970).

Tricorythus latus ULMER, 1916

Material examined – GHANA: Northern Region, Banda-Nkwanta, 2°09'W, 8°22'N, 122 m, 1 ♂, 01.09.1965 (G070), ENDRÓDY-YOUNGA, S.

Diagnostic features – The single specimen available fits the description by ULMER (1916), as well as the redescription by DEMOULIN (1954). It differs from *T. lanceolatus* KIMMINS, 1960 by the shape of the second segment of the forceps (KIMMINS 1960).

Distribution – *T. latus* is known with certainty only from the Congo River at Kinshasa. ULMER (1916) mentioned the presence of the species in the source of the Nile River (Bahr-el-Djebel, Sudan), but KIMMINS (1960) hypothesized it could rather belong to *T. lanceolatus*. This species is new for Ghana.

Tricorythus longus ULMER, 1916

Caenis regia NAVÀS, 1932 (syn.)
Caenis collarti NAVÀS, 1933 (syn.)

Material examined – GHANA: Northern Region, Banda-Nkwanta, 2°09'W, 8°22'N, 122 m, 4 ♂♂, 01.09.1965 (G070), S. ENDRÓDY-YOUNGA.

Diagnostic features – As for the previous species, these specimens are in accordance with the description by ULMER (1916) and DEMOULIN (1954). *T. longus* is related to *T. tinctus* KIMMINS, 1956, but differs in the coloration of the wing and in some details of the genitalia (KIMMINS 1956).

Distribution – *T. longus* is known from Congo and Sudan. This is the first report of this species from West Africa and is new for Ghana.

Tricorythus sp.

Material examined – GHANA: Northern Region, Banda-Nkwanta, Volta, 2°09'W, 8°22'N, 122 m, 6 ♀♀, 07.10.1965 (G089); same locality, 56 ♀♀, 01.09.1965 (G070); 8 ♀♀, 27.09.1965 (G083); 28 ♀♀, 01.10.1965 (G088); Brong-Abafo Region, Bui camp, Volta, Black Volta, 2°15'W, 8°17'N, 106 m, 10 ♀♀, 27.10.1965 (G087); same locality, 6 ♀♀, 01.11.1965 (G097); Ashanti Region, Kumasi, Volta, 1°36'W, 6°43'N, 293 m, 21 ♀♀, 06.07.1967 (G232); same locality, 72 ♀♀, 02.07.1967 (G230); 1 ♀, 24.06.1965 (G016); 2 ♀♀, 25.07.1967 (G220); Kwadaso/Kumasi, Volta, 1°39'W, 6°42'N, 259 m, 16 ♀♀, 30.06.1969 (G379); same locality, 7 ♀♀, 28.07.1969 (G383). All collected by S. ENDRÓDY-YOUNGA.

Diagnostic features – Material constituted by female imagoes and subimagoes. At the moment, no reliable identification can be provided.

CAENIDAE

Caenis elouardi MALZACHER, 1990

Material examined – GHANA: Northern Region, Banda-Nkwanta, Volta, 2°09'W, 8°22'N, 122 m, 2 ♀♀, 14.10.1965 (G090); same locality, 2 ♀♀, 07.10.1965 (G089); 7 ♀♀, 27.09.1965 (G083); 8 ♀♀, 01.10.1965 (G088); 2 ♀♀, 21.09.1965 (G081); 6 ♀♀, 13.09.1965 (G073); Brong-Abafo Region, Bui camp, Volta, Black Volta, 2°15'W, 8°17'N, 106 m, 3 ♂♂, 06.11.1965 (G098); same locality, 85 ♂♂, 1 ♀, 27.10.1965 (G087); 5 ♂♂, 1 ♀, 01.11.1965 (G097); 5 ♂♂, 16.11.1965 (G100); Ashanti Region, Kumasi, Volta, 1°36'W, 6°43'N, 293 m, 1 ♀, 25.06.1969 (G377). All collected by S. ENDRÓDY-YOUNGA.

Diagnostic features – The specimens listed above shares with *C. elouardi* some unique features such as rounded tip in the male forceps and forecoxae more widely separated than in other species. Compared to the original description by MALZACHER (1990), our specimens slightly differ by the shape of the penis lobes and the forceps, but according to MALZACHER (pers. comm.), these small differences must be regarded as intraspecific variations. *C. elouardi* belongs to a group of *Caenis* species mainly diversified in South America (MALZACHER 1990, 2001).

Distribution – *Caenis elouardi* was described from Guinea and has never been mentioned since that time. In the ORSTOM collection deposited in our museum, we found several other populations from Guinea and Ivory Coast (MALZACHER & SARTORI, in prep.)

Caenis sp.

Material examined – GHANA: Northern Region, Banda-Nkwanta, Volta, 2°09'W, 8°22'N, 122 m, 2 ♀♀, 05.09.1965 (G071); Ashanti Region, Kumasi, Volta, 1°36'W, 6°43'N, 293 m, 10 ♀♀, 06.07.1967 (G232); same locality, 25 ♀♀, 04.02.1968 (G297); 2 ♀♀, 28.05.1967 (G221); 13 ♀♀, 10.12.1967 (G290); 1 ♀, 03.02.1968 (G296); 12 ♀♀, 25.07.1967 (G220). All collected by S. ENDRÓDY-YOUNGA.

Diagnostic features – This material is exclusively composed of females for which specific identification is impossible at the moment.

EPHEMERIDAE

Eatonica crassi MCCAFFERTY, 1971

Material examined – GHANA: Northern Region, Banda-Nkwanta; 2°09'W, 8°22'N, 122 m, 2 ♀♀, 01.10.1965 (G088); same locality, 1 ♀, 07.10.1965 (G089); 5 ♀♀, 14.10.1965 (G090). All collected by S. ENDRÓDY-YOUNGA.

Diagnostic features – Only females were available in the studied material. Nevertheless they were identified with confidence to this species based on the dorsal abdominal colour pattern, with paired stripes slightly concave instead of convex as in the closely related *E. schoutedeni* (MCCAFFERTY 1971, MCCAFFERTY & GILLIES 1979). As already observed by ELOUARD & FORGE (1978), only females of this species seem to be attracted to light.

Distribution – *Eatonica crassi* is known from Sudan, Tanzania, Malawi (MCCAFFERTY 1971), as well as Ivory Coast, Mali and Guinea (ELOUARD 1986). Its presence in Ghana is therefore not surprising.

Eatonica patriciae ELOUARD, 1986

Material examined – GHANA: Brong-Abafo Region, Volta basin, Black Volta river at Bui camp, 2°15'W, 8°17'N, 106 m, 1 ♀, 06.11.1965 (G98), S. ENDRÓDY-YOUNGA.

Diagnostic features – The single female specimen available fits the description given by ELOUARD (1986). This species is larger than *E. crassi* and the pattern of the abdominal stripes is identical to those described by him. This specimen has also been compared to a female paratype deposited in our collections.

Distribution – *Eatonica patriciae* is mentioned here for the first time since its description from Guinea.

POLYMITARCYIDAE

Povilla adusta NAVÀS, 1912

Material examined – GHANA: Northern Region, Banda-Nkwanta, Volta, 2°09'W, 8°22'N, 122 m, 1 ♂, 5 ♀♀, 14.10.1965 (G090); same locality, 1 ♂, 27.09.1965 (G083); 2 ♂♂, 21.09.1965 (G081); 1 ♂, 13.09.1965 (G073). All collected by S. ENDRÓDY-YOUNGA. Lake Volta, Kete Krachi, 0°05'W, 7°50'N, 100 m, 119 ♂♂, 4 ♀♀, 03.01.1969 (G991); same locality, 3 ♂♂, 3 ♀♀, 09.01.1969 (G992); Eastern Region, Adawso, Volta, 0°27'W, 5°52'N, 31 ♂♂, 5 ♀♀, 28.02.1969 (G995); Western Region, Mpoho, Pra, 1°47'W, 5°25'N, 6 ♂♂, 05.01.1969 (G996); same locality, 1 ♀, 06.01.1969 (G994). All collected by B. ENTZ.

Diagnostic features – This burrowing mayfly is the only species of the genus found in Africa, the others inhabiting the Oriental realm (HUBBARD 1984). *Povilla adusta* is easy to recognize because of its large size. It is the most abundant species collected during this survey, as it is strongly attracted by light traps.

Distribution – *Povilla adusta* is widespread in equatorial Africa, being found from Sudan to South Africa as well as from West Africa to Tanzania (ULMER 1916, DEMOULIN 1970, HUBBARD 1984). In the Museum of Zoology (Lausanne) collections, we have numerous specimens collected in Mali, Guinea, Ivory Coast and Sierra Leone, coll. and leg. J.-M. ELOUARD (ORSTOM). Its presence in Ghana was recorded for the first time by PETR (1970, 1973) who studied this species in the newly built Lake Volta. *Povilla adusta* nymphs live in lakes and large rivers where they burrow in the sediment but also in wood, being one of the rare mayflies interfering with human beings by damaging boats and pilings below the waterline (KIMMINS 1949). The species is also well known for its synchronous and peculiar mass emergences [see for instance HARTLAND-ROWE (1984)] and is locally so numerous that they can serve as food for the people (BERGERON *et al.* 1988).

Exeuthyplocia minima (ULMER, 1916)

Euthyplocia minima ULMER, 1916 (orig.)

Exeuthyplocia minima: LESTAGE (1918) (comb.)

Material examined – GHANA: Brong-Abafo Region, Volta basin, Black Volta river at Bui camp, 2°15'W, 8°17'N, 106 m, 2 ♀♀, 06.11.1965 (G98); same locality, 4 ♀♀, 16.11.1965 (G100). All collected by S. ENDRÓDY-YOUNGA.

Diagnostic features – The genus *Exeuthyplocia* LESTAGE, 1918 is represented by the single species *E. minima*. Its status has been reviewed by HIDEUX (1987).

Distribution – *Exeuthyplocia minima* is mainly found in West Africa, where populations have been recorded in Guinea, Ivory Coast, Mali, Gambia, Togo and Ghana (HIDEUX, 1987). Its range extends eastwards to Uganda and southwards to Congo (GILLIES 1980a, KIMMINS 1960, DEMOULIN 1952).

LEPTOPHLEBIIDAE

Adenophlebiodes (Adenophlebiodes) massirius
ELOUARD-HIDEUX et ELOUARD, 1991

Material examined – GHANA: Northern Region, Banda-Nkwanta, Volta, 2°09'W, 8°22'N, 122 m, 2 ♀♀, 07.10.1965 (G089); same locality, 1 ♀, 01.09.1965 (G070); 1 ♀, 27.09.1965 (G083); 1 ♀, 09.09.1965 (G072); 3 ♀♀, 01.10.1965 (G088); 4 ♀♀, 13.09.1965 (G073); Ashanti Region, Kumasi, Volta, 1°36'W, 6°43'N, 293 m, 1 ♀, 31.05.1969 (G365); same locality, 1 ♀, 25.06.1969 (G377). All collected by S. ENDRÓDY-YOUNGA.

Diagnostic features – In the genus *Adenophlebiodes* ULMER, 1924, the male genitalia do not allow a species-level determination. The diagnosis of the different species is mainly based on the colour pattern on the forewings and abdomen. The different species were separated into two groups depending on the pigmentation of the basal half of the forewing. In the *A. ornatus* ULMER, 1916 group, the pigmentation is restricted to patches and margination of crossveins (ELOUARD-HIDEUX & ELOUARD 1991). *Adenophlebiodes massirius* can be separated from other species of the *A. ornatus* group by having brown fore femora with a central dark brown spot (fig. 4I in ELOUARD-HIDEUX & ELOUARD 1991), the relatively poorly developed markings on fore and hindwings (figs 18 to 25 in ELOUARD-HIDEUX & ELOUARD 1991) and the absence of a rounded brown marking on the apical half of the forewing (as in *A. adrieni* ELOUARD-HIDEUX et ELOUARD, 1991, figs 26 to 28 in ELOUARD-HIDEUX & ELOUARD 1991).

Distribution – *Adenophlebiodes massirius* is the most abundant and widespread species of *Adenophlebiodes* in West Africa. It has already been reported from Ghana as well as from Guinea, Ivory Coast, Mali, Senegal, Sierra Leone and Togo (ELOUARD-HIDEUX & ELOUARD 1991).

Adenophlebiodes (Adenophlebiodes) rubeus
ELOUARD-HIDEUX et ELOUARD, 1991

Material examined – GHANA: Ashanti Region, Kwadaso/Kumasi, 1°39'W, 6°42'N, 259 m, 1 ♂, 04.08.1969 (G224), ENDRÓDY-YOUNGA, S.

Diagnostic features – *A. rubeus* belongs to the *A. decoratus* (NAVÀS, 1931) species group. As in other species of the group, almost the whole basal half of the forewing is pigmented. The determination of the different species is rather difficult and based mainly on coloration of the thorax and fore femora as well as the number of crossveins in forewing (ELOUARD-HIDEUX & ELOUARD 1991). The problematic determination is amplified by a species only known at the subimaginal stage.

Nevertheless, the male imago collected in Ghana fits the original description of *A. rubeus* and is rather similar to the type-material we examined.

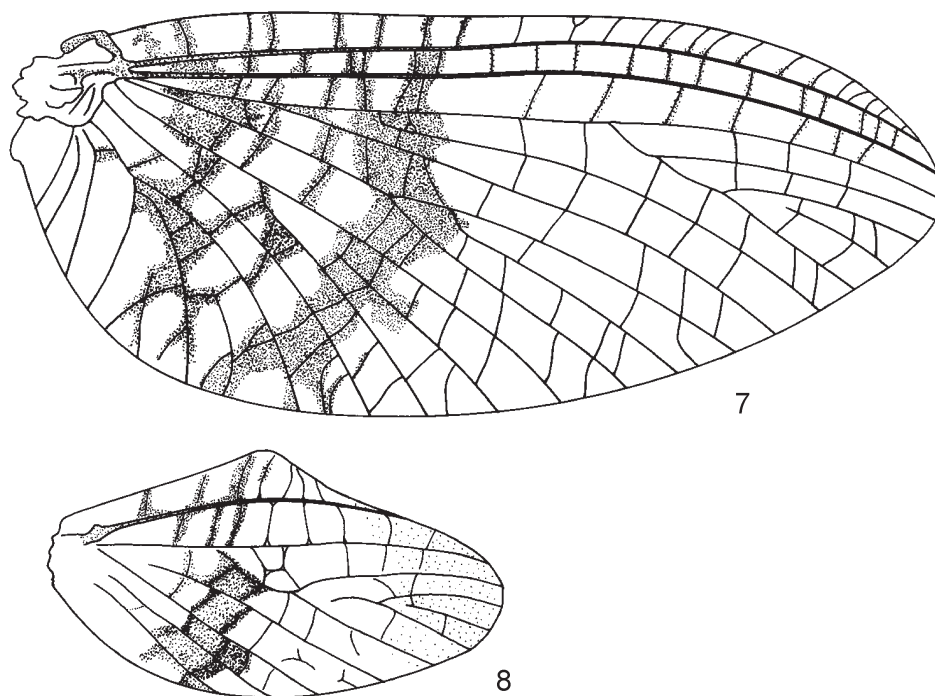
Distribution – *Adenophlebiodes rubeus* was originally reported from Ivory Coast, Guinea and Sierra Leone mainly in the moist savannah and forest zones. This new report slightly extends its distribution to the East.

Adenophlebiodes (Adenophlebiodes) sp. A
(Figs 7–8)

Material examined – GHANA: Ashanti Region, Kumasi, 1°36'W, 6°43'N, 293 m, 1 ♀, 28.05.1967 (G221), S. ENDRÓDY-YOUNGA.

Further material – GUINEA: Téliimélé Region, near Mahbé, 1 ♀, 01.02.1989, J.-M. ELOUARD (ORSTOM) coll. and leg.

Diagnostic features – The two hooked tarsal claws, the pigmented wings and the shape of the hind wing (Fig. 8) clearly support the assignment of these female imagoes to *Adenophlebiodes*. The pigmentation of the basal half of the forewing



Figs 7–8. *Adenophlebiodes (Adenophlebiodes) sp. A*: 1 = forewing, 2 = hindwing

(Fig. 7) indicates that it belongs to the *Adenophlebiodes ornatus* group of species. These two specimens differ from *A. massirius* by the greater size (body 8.5 mm, fore wing 9 to 10 mm) and the more extensive pigmentation of the hindwing, and from *A. adrieni* by the absence of a rounded brown marking on the apical half of the fore wing (figs 26 to 28 in ELOUARD-HIDEUX & ELOUARD 1991). *Adenophlebiodes* sp. A appears more similar to *A. ornatus* due to the body size. The pigmentation of the basal half is similar to the subimago of *A. ornatus* (fig. 8 in ELOUARD-HIDEUX & ELOUARD 1991), but is clearly much more developed than in the imago (fig. 10 in ELOUARD-HIDEUX & ELOUARD 1991). Consequently, we refrain to attribute these specimens to any species of the *ornatus* group.

Adenophlebiodes (Hyalophlebia) sp.

Material examined – GHANA: Northern Region, Banda-Nkwanta, Volta, 2°09'W, 8°22'N, 122 m, 1 ♀, 01.09.1965 (G070); same locality, 1 ♀, 07.10.1965 (G089); 1 ♀, 13.09.1965 (G073); Ashanti Region, Kumasi, Volta, 1°36'W, 6°43'N, 293 m, 2 ♀♀, 18.05.1967 (G217); Ashanti Region, Kwadaso/Kumasi, Volta, 1°39'W, 6°42'N, 259 m, 2 ♀♀, 21.07.1969 (G382). All collected by S. ENDRÓDY-YOUNGA.

Diagnostic features – *Hyalophlebia* DEMOULIN, 1955 was first recognized as a subgenus of *Adenophlebiodes* ULMER, 1924 (DEMOULIN 1955). Afterwards, most of the characters used for separating the two subgenera were shown to be unreliable except that the members of *Adenophlebiodes s.s.* have pigmented wings, whereas those of *Hyalophlebia* are hyaline (PETERS & EDMUNDS 1964). Some larval characters allow the separation of specimens belonging to *Adenophlebiodes* or *Hyalophlebia* into two groups (PETERS & EDMUNDS 1964). However, as in most cases the adult-nymph association remains unknown, the correspondence between each one of the two larval groups with either *Adenophlebiodes* or *Hyalophlebia* still needs to be established (PETERS & EDMUNDS 1964). More recently, *Hyalophlebia* was raised to the generic level without any justification or new arguments (MCCAFFERTY & DE MOOR 1995), therefore we continue to consider *Hyalophlebia* as a subgenus. The female imagoes studied here were attributed to *Hyalophlebia* because they possess hyaline wings and pretarsi with two similar hooked claws (as in fig. 45 in PETERS & EDMUNDS 1964). Four species of *Hyalophlebia* have been described (DEMOULIN 1970); for most of them only one stage and one sex is known, making any serious attempt of identification extremely uncertain. The recent study of the closely related subgenus *Adenophlebiodes* illustrated that West Africa possesses species with restricted distribution (ELOUARD-HIDEUX &

ELOUARD 1991). The lack of any other report from West Africa (see below) also justifies our choice of not attributing this material to any described species.

Distribution – This subgenus is reported from Central and South Africa (Uganda, Congo, Zimbabwe and South Africa) (DEMOULIN 1970). Consequently, this constitutes the first record of *Hyalophlebia* from West Africa.

*

Acknowledgements – We would like to thank DÁVID MURÁNYI (Hungarian Natural History Museum, Budapest, Hungary) for making this material available for the present study, JEAN-MARC ELOUARD (Montpellier) for his help with the literature, and JEFF WEBB (Purdue University, West Lafayette, Indiana, USA) for reviewing an early draft of the manuscript and providing valuable suggestions.

REFERENCES

- BARBER-JAMES, H. M. & LUGO-ORTIZ, C. R. 2003: Ephemeroptera. – In: DE MOOR, I. J., DAY, J. A. & DE MOOR, F. C. (eds): *Guides to the Freshwater Invertebrates of Southern Africa Volume 7: Insecta I*. Water Resource Commission, Pretoria, South Africa, pp. 16–159.
- BERGERON, D., BUSHWAY, R. J., ROBERTS, F. L., KORNFELD, I. & OKEDI, J. 1988: The nutrient composition of an insect flour sample from Lake Victoria, Uganda. – *Journal of Food composition and Analysis* **1**(4): 371–377.
- BERNER, L. 1954: Phoretic association between a species of Simulium and a mayfly nymph, with a description of the nymph. – *Annals and Magazine of Natural History* **7**(12): 116–121.
- BRAASCH, D. & SOLDÁN, T. 1986: Die Heptageniidae des Gombak River in Malaysia (Ephemeroptera). – *Reichenbachia, Staatliches Museum für Tierkunde in Dresden* **24**(3): 41–52.
- CRASS, R. S. 1947: The May-flies (Ephemeroptera) of Natal and the Eastern Cape. – *Annals of the Natal Museum* **11**(1): 37–110.
- DEMOULIN, G. 1952: Contribution à l'étude des Ephoronidae Euthyplociinae (Insectes Ephéméroptères). – *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique* **28**(45): 1–22.
- DEMOULIN, G. 1954: Recherches critiques sur les Ephéméroptères Tricorythidae d'Afrique et d'Asie. – *Bulletin et Annales de la Société Entomologique de Belgique* **90**(9–10): 264–277.
- DEMOULIN, G. 1955: Révision de quelques Ephéméroptères décrits du Congo belge par L. Navàs. I. – *Bulletin et Annales de la Société Entomologique de Belgique* **91**(11–12): 281–290.
- DEMOULIN, G. 1956: Révision de quelques Ephéméroptères décrits du Congo Belge par L. Navàs. II. – *Bulletin et Annales de la Société Entomologique de Belgique* **92**(1–2): 44–52.
- DEMOULIN, G. 1957: Révision de quelques Ephéméroptères décrits du Congo Belge par L. Navàs. III. – *Bulletin et Annales de la Société Entomologique de Belgique* **93**(9–10): 257–275.
- DEMOULIN, G. 1965: Ephemeroptera. – *Annales du Musée Royal d'Afrique Centrale* **138**(8): 91–114.
- DEMOULIN, G. 1970: Ephemeroptera des faunes éthiopienne et malgache. – *South African Animal Life* **14**: 24–170.
- ELOUARD, J.-M. 1986: Ephémères d'Afrique de l'Ouest: le genre Eatonica (Ephemeridae). – *Revue d'Hydrobiologie Tropicale* **19**(2): 87–92.

- ELOUARD, J.-M. & FORGE, P. 1978: Emergence et activité de vol nocturne de quelques espèces d'Ephéméroptères de Côte d'Ivoire. – *Cahiers de l'ORSTOM, série Hydrobiologie* **12**(3–4): 187–195.
- ELOUARD, J.-M., GILLIES, M. T. & WUILLOT, J. 1990: Ephemeroptera from West Africa: The genus *Pseudopannota* (Baetidae). – *Revue d'Hydrobiologie Tropicale* **23**(1): 27–39.
- ELOUARD, J.-M., & HIDEUX, P. 1991 : Ephémères d'Afrique de l'Ouest: deux nouvelles espèces du genre *Pseudopannota* (Baetidae). – *Bulletin de la Société Entomologique de France* **95**(7–8): 247–252.
- ELOUARD-HIDEUX, P. & ELOUARD, J.-M. 1991: Mayflies of West Africa: the adults of the subgenus *Adenophlebiodes* s.s. (Ephemeroptera: Leptophlebiidae). – *Aquatic Insects* **13**(1): 133–150.
- ENDRÓDY-YOUNGA, S. 1970: Entomological expeditions in Ghana by Dr. S. Endrődy-Younga. 1. A diary of entomological collection in Ghana 1965–1969. – *Folia Entomologica Hungarica* **23**(1): 5–91.
- GATTOLLIAT, J.-L. 2001: Six new species of *Labiobaetis* Novikova & Kluge (Ephemeroptera: Baetidae) from Madagascar with comments on the validity of the genus. – *Annales de Limnologie* **37**: 97–123.
- GATTOLLIAT, J.-L. & RABEANTOANDRO, S. Z. 2002: The genus *Cloeon* (Ephemeroptera, Baetidae) in Madagascar. – *Mitteilungen der Schweizerischen Entomologischen Gesellschaft* **74**(3/4) [2001]: 195–209.
- GILLIES, M. T. 1974: Three new species of *Elassoneuria* (Ephemeroptera: Oligoneuriidae) from tropical Africa. – *Journal of Entomology, Series B* **43**(1): 73–82.
- GILLIES, M. T. 1979: Polymorphism in the turbinate eyes of an African *Cloeon* (Ephemeroptera: Baetidae). – *Entomologist's Monthly Magazine* **114**: 155.
- GILLIES, M. T. 1980a: The African *Euthyplociidae* (Ephemeroptera) (*Exeuthyplociinae* subfam. n.). – *Aquatic Insects* **2**(4): 217–224.
- GILLIES, M. T. 1980b: An Introduction to the study of *Cloeon* Leach (Baetidae, Ephemeroptera) in West Africa. – *Bulletin de l'Institut Fondamental de l'Afrique Noire, série A* **42**(1): 135–156.
- GILLIES, M. T. 1984: On the synonymy of *Notonurus* Crass with *Compsoneriella* Ulmer (Heptageniidae). – In: LANDA, V., SOLDÁN, T. & TONNER, M. (eds): *Proceedings of the Fourth International Conference on Ephemeroptera*. Institute of Entomology, Czechoslovak Academy of Sciences, České Budějovice, pp. 21–25.
- GILLIES, M. T. 1985: A preliminary account of the East African species of *Cloeon* Leach and *Rhithrocloeon* gen. n. (Ephemeroptera). – *Aquatic Insects* **7**: 1–17.
- GILLIES, M. T. 1990a: A new genus for the Afrotropical mayfly, *Cloeon dentatum* Kimmins (Ephemeroptera, Baetidae). – *Entomologist's Monthly Magazine* **126**: 207–208.
- GILLIES, M. T. 1990b: A revision of the African species of *Centroptilum* Eaton (Baetidae, Ephemeroptera). – *Aquatic Insects* **12**: 97–128.
- GILLIES, M. T. 1991: A diphyletic origin for the two-tailed baetid nymphs occurring in East African stony streams with a description of the new genus and species *Tanzaniella spinosa* gen. sp. nov. – In: ALBA-TERCEDOR, J. & SANCHEZ-ORTEGA, A. (eds): *Overview and strategies of Ephemeroptera and Plecoptera*. Sandhill Crane Press, Inc., Gainesville, pp. 175–187.
- GILLIES, M. T. 1994: Descriptions of some Afrotropical Baetidae (Ephemeroptera) II. *Baetis* Leach, s.l., East African species. – *Aquatic Insects* **16**(2): 105–118.
- GILLIES, M. T. 1997: A new species of *Procloeon* Bengtsson from the forest zone of West Africa (Ephem., Baetidae). – *Entomologist's Monthly Magazine* **133**: 247–250.
- GILLIES, M. T., ELOUARD, J.-M. & WUILLOT, J. 1990: Ephemeroptera from West Africa: the genus *Ophelmatostoma* (Baetidae). – *Revue d'Hydrobiologie Tropicale* **23**(2): 115–120.

- HARTLAND-ROWE, R. 1984: The adaptive value of synchronous emergence in the tropical African mayfly *Povilla adusta*: a preliminary investigation. – In: LANDA, V., SOLDÁN, T. & TONNER, M. (eds): *Proceedings of the Fourth International Conference on Ephemeroptera*. Institute of Entomology, Czechoslovak Academy of Sciences, České Budějovice, pp. 283–289.
- HIDEUX, P. 1987: Ephémères d’Afrique de l’Ouest: le genre *Exeuthyplocia* (Euthyplociidae). – *Revue d’Hydrobiologie Tropicale* **20**(2): 113–119.
- HUBBARD, M. D. 1984: A revision of the genus *Povilla* (Ephemeroptera: Polymitarciidae). – *Aquatic Insects* **6**(1): 17–35.
- JACOBUS L. M., MCCAFFERTY W. P. & GATTOLLIAT, J.-L. 2006: Taxonomy of Afrotropical Securiops, new genus, and *Cloeodes Traver* (Ephemeroptera: Baetidae). – *African Entomology* **14**(1): 129–140.
- KIMMINS, D. E. 1949: Ephemeroptera from Nyasaland, with descriptions of new species. – *Annals and Magazine of Natural History* **12**(1): 825–836.
- KIMMINS, D. E. 1955: Ephemeroptera from Nyasaland with descriptions of three new species and some interesting nymphal forms. – *Annals and Magazine of Natural History* **12**(8): 859–880.
- KIMMINS, D. E. 1956: New species of Ephemeroptera from Uganda. – *Bulletin of the British Museum (Natural History) Entomology* **4**(2): 71–87.
- KIMMINS, D. E. 1957: New species of the genus *Dicercomyzon* Demoulin (Ephemeroptera, fam. Tricorythidae). – *Bulletin of the British Museum (Natural History) Entomology* **6**(5): 129–136.
- KIMMINS, D. E. 1960: Notes on East African Ephemeroptera, with descriptions of new species. – *Bulletin of the British Museum (Natural History) Entomology* **9**(6): 339–355.
- KOPELKE, J.-P. 1980: Ephemeroptera aus der Emergenz des zentralafrikanischen Bergbaches Kalengo (Zaire). I. Baëtidae. – *Entomologische Abhandlungen* **43**(6): 99–129.
- LUGO-ORTIZ, C. R. & MCCAFFERTY, W. P. 1996: The *Bugilliesia* complex of African Baetidae (Ephemeroptera). – *Transactions of the American Entomological Society* **122**(4): 175–197.
- LUGO-ORTIZ, C. R. & MCCAFFERTY, W. P. 1997: *Labiobaetis* *Novikova* & *Kluge* (Ephemeroptera: Baetidae) from the Afrotropical region. – *African Entomology* **5**(2): 241–260.
- LUGO-ORTIZ, C. R., MCCAFFERTY, W. P. & WALTZ, R. D. 1999: Definition and reorganization of the genus *Pseudocloeon* (Ephemeroptera: Baetidae) with new species descriptions and combinations. – *Transactions of the American Entomological Society* **125**: 1–37.
- MALZACHER, P. 1990: Caenidae der äthiopsichen Region (Insecta: Ephemeroptera). Teil 1. Beschreibung neuer Arten. – *Stuttgarter Beiträge zur Naturkunde Serie A (Biologie)* **454**: 1–28.
- MALZACHER, P. 2001: South and Central American *Caenis* species with rounded forceps tips (Insecta: Ephemeroptera: Caenidae). – *Stuttgarter Beiträge zur Naturkunde Serie A (Biologie)* **626**: 1–20.
- MCCAFFERTY, W. P. 1971: New burrowing mayflies from Africa (Ephemeroptera: Ephemeridae). – *Journal of the Entomological Society of South Africa* **34**(1): 57–62.
- MCCAFFERTY, W. P. 2001: New Baetidae (Insecta: Ephemeroptera) from Lake Malawi. – *Bulletin de la Société d’Histoire Naturelle de Toulouse* **136** [2000]: 65–72.
- MCCAFFERTY, W. P. 2003: New nomenclatural applications for certain African Heptageniidae (Ephemeroptera). – *Proceedings of the Entomological Society of Washington* **105**: 792–793.
- MCCAFFERTY, W. P. & GILLIES, M. T. 1979: The African Ephemeridae (Ephemeroptera). – *Aquatic Insects* **1**(3): 169–178.
- MCCAFFERTY, W. P. & DE MOOR, F. C. 1995: South African Ephemeroptera: problems and priorities. – In: CORKUM, L. D. & CIBOROWSKI, J. J. H. (eds): *Current Directions in Research on Ephemeroptera*. Canadian Scholars’ Press Inc., Toronto, pp. 463–476.
- MCCAFFERTY, W. P. & WALTZ, R. D. 1995: *Labiobaetis* (Ephemeroptera: Baetidae): new status, new North American species, and related new genus. – *Entomological News* **106**(1): 19–28.

- MONAGHAN, M. T., GATTOLLIAT, J. L., SARTORI, M., ELOUARD, J. M., JAMES, H., DERLETH, P., GLAIZOT, O., DE MOOR, F. & VOGLER, A. P. 2005: Trans-oceanic and endemic origins of the small minnow mayflies (Ephemeroptera, Baetidae) of Madagascar. – *Proceedings of The Royal Society, B-Biological Sciences* **272**(1574): 1829–1836.
- PETERS, W. L. & EDMUNDS, G. F. 1964: A revision of the generic classification of the Ethiopian Leptophlebiidae (Ephemeroptera). – *Transactions of the Royal Entomological Society of London* **116**(10): 225–253.
- PETR, T. 1970: Macroinvertebrates of flooded trees in the man-made Volta lake (Ghana) with special reference to the burrowing mayfly *Povilla adusta* Navas. – *Hydrobiologia* **36**(3–4): 373–398.
- PETR, T. 1973: Some factors limiting the distribution of *Povilla adusta* Navàs (Ephemeroptera, Polymitarcidae) in African lakes. – In: PETERS, W. L. & PETERS, J. G. (eds): *Proceedings of the First International Conference on Ephemeroptera*. Brill, E.J., Leiden, pp. 223–230.
- PUTHZ, V. 1971: Über einige Ephemeropteren von der Elfenbeinküste (Insecta, Ephemeroptera). – *Revue Zoologique et Botanique Africaine* **83**(3–4): 226–237.
- PUTHZ, V. 1972: Ueber *Diceromyzon sjostedti* (Ulmer) (Insecta, Ephemeroptera). – *Revue Zoologique et Botanique Africaine* **85**(1–2): 183–185.
- SCHOONBEE, H. J. 1967: A new record of *Compso-neuriella njalensis* (Kimmins) (Ephemeroptera: Heptageniidae) from South Africa. – *Journal of the Entomological Society of South Africa* **29**: 151–156.
- SCHOONBEE, H. J. 1968: A revision of the genus *Afronurus* Lestage (Ephemeroptera: Heptageniidae) in South Africa. – *Memoirs of the Entomological Society of South Africa* **10**: 1–60.
- ULMER, G. 1916: Ephemeropteren von Aequatorial-Afrika. – *Archiv für Naturgeschichte, Abteilung A* **81**(7): 1–19.
- ULMER, G. 1930: Entomological expedition to Abyssinia, 1926–27; Trichoptera and Ephemeroptera. – *Annals and Magazine of Natural History* **6**(10): 479–511.
- WANG, T. Q. & MCCAFFERTY, W. P. 2004: Heptageniidae (Ephemeroptera) of the world. Part I: Phylogenetic higher classification. – *Transactions of the American Entomological Society* **130**(1): 11–45.
- WEBB, J. M., BRAASCH, D. & MCCAFFERTY, W. P. 2006: Reevaluation of the Genera *Compso-neuria* Eaton and *Trichogenia* Braasch & Soldán (Ephemeroptera: Heptageniidae). – *Zootaxa*: in print.
- WUILLOT, J. & GILLIES, M. T. 1993: New species of *Afroptilum* (Baetidae, Ephemeroptera) from West Africa. – *Revue d'Hydrobiologie Tropicale* **26**(4): 269–277.