

The identification of African Simuliidae (Diptera) living in phoresis with nymphal Ephemeroptera, with special reference to *Simulium bernerii* Freeman

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SYNOPSIS

Keys are given for the identification of the African species of *Simulium* Latreille which live in phoretic association with mayfly nymphs. *Simulium bernerii*, one of the least known of such species, is recorded for the first time from East Africa and the previously unknown adult male is described and figured. The attachment sites of larvae of *S. bernerii* to nymphs of the mayfly *Elassoneuria* collected in Uganda are recorded.

THE African Simuliidae which, as larvae and pupae, live in a state of obligatory phoresis with mayfly nymphs are still very poorly known, and *Simulium bernerii* Freeman, which forms the main subject of the present contribution, has until now been known only from the larval and pupal type material collected by Berner (1954) in Togoland and described by Freeman (1954) and from a mature male pupa collected by Dr. M. T. Gillies in the Cameroun Republic¹.

S. bernerii was described after the appearance of the monograph by Freeman & de Meillon (1953) on the Simuliidae of the Ethiopian Region, and has not until now been placed in any identification keys to pupae and adults; it has however been placed in a key to the larvae of West African Simuliidae (Crosskey, 1960). The increasing interest now being shown in the freshwater ecology of African rivers and streams makes it expedient to have available keys for the recognition of all the black-fly species, including *S. bernerii*, which are known to occur on nymphal mayflies, and the keys here presented have been drawn up to assist ecologists wanting to identify these forms when found in field samples; the keys have been constructed after examination of all available material in the British Museum and my own collection. A simple key is also given by which the black-fly specialist can recognise the genera of mayfly nymphs occurring in phoretic associations. The term nymph is here used in preference to larva for the immature stages of mayflies to avoid any possible confusion between members of the immature partnership.

Larvae and pupae of *S. bernerii* were recently collected on *Elassoneuria* mayflies from a river on the Congo border of western Uganda, two infested nymphs being obtained by myself in November, 1964, and one having been found in 1960 by Dr. M. T. Gillies; these specimens represent the first finding of *S. bernerii* in East Africa or anywhere east of the Cameroun Republic. So little has been published on the incidence and attachment sites of the larvae of phoretic *Simulium* on their mayfly partners, that I have thought it useful to record this information for those *S. bernerii* found on the Uganda specimens of *Elassoneuria* in a later section. A further study is being made of these larvae of *S. bernerii* in an attempt to determine their respective instars, and the present paper is limited only to recording the occurrence of larvae without discussion of their probable age and its significance in the phenomenon of phoresy.

¹ This pupa is the basis of the record of *S. bernerii* from Cameroun published by Grenier & Mouchet (1958) and by Grenier *et al.* (1961).

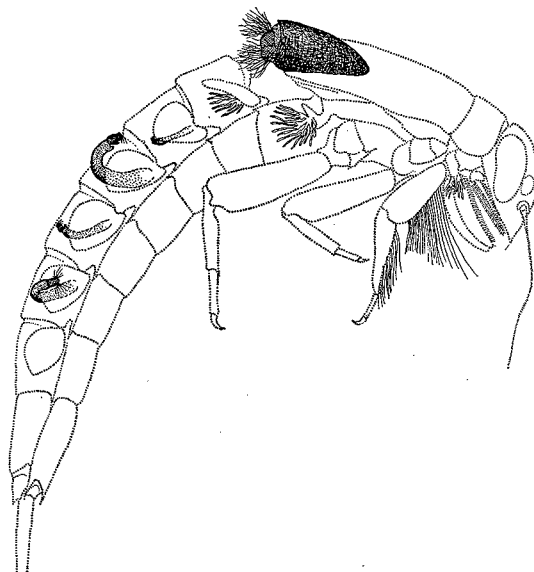


FIG. 1.—Outline of nymph of *Elassoneuria* showing pupa of *Simulium berneri* attached to wing-case and larvae attached to abdominal gills; drawn from Specimen B shown in accompanying table. The ventral position of the first abdominal gill and the brushes of long hair on the fore leg characteristic of the genus *Elassoneuria* are shown.

KEYS TO THE AFRICAN *SIMULIUM* OCCURRING IN PHORESIS WITH MAYFLIES

S. berneri and the other known African species of *Simulium* living on mayflies may be identified as larvae, pupae and adults by the following keys. The larval key is based on older larvae only, since younger larvae (under about fourth instar) are still insufficiently known. Scarcely any adult material of *S. berneri* and *S. dicerus* is yet available, and the female of the former is still unknown, so that it is impossible to distinguish these species in the key to adult flies; in practice they will normally be reared from identifiable pupae.

(a) Larvae

- 1 Cephalic fan when open forming a short flat brush. Head unusually convex, cephalic apotome broadest near the middle and tapering thence towards hind margin of head. Cuticle bare. (Attached to *Afromurus*, possibly also *Baetis*) *S. copleyi* Gibbins
- Cephalic fan when open forming a normal hemispherical type of *Simulium* mouth-brush. Head shape normal, cephalic apotome more or less parallel-sided or broadest near hind margin of head. Cuticle usually with colourless clubbed hairs or papilliform outgrowths at least postero-dorsally on abdomen 2

- 2 Hypostomium with a very large deeply cut off median tooth flanked by a group of five bluntly truncate and outwardly curved teeth on either side (fig. 68 in Crosskey, 1960). Cuticle entirely covered with small colourless slightly clubbed hairs. (Attached to *Elassoneuria*) *S. berneri* Freeman
- Hypostomium not of this form, with usual row of nine apical teeth of which corner teeth and median tooth are prominent. Cuticle appearing bare but posterodorsally at least with some blunt colourless papilliform prominences (character uncertain for *dicerus*) 3
- 3 Hypostomium with median tooth very large and prominent like the corner teeth. (Attached to *Afroneurus*) *S. lumbwanus* de Meillon
- Hypostomium with median tooth weakly developed, only a little more prominent than intermediate teeth and very much shorter than the strongly projecting corner teeth (not seen; figure 11 in Marlier, 1950). (Attached to unidentified Baetid) *S. dicerus* Freeman & de Meillon

(b) Pupae

- 1 Cocoon normal, covering abdomen and thorax. Abdominal armature of normal *Simulium* type (figs. 7 and 10), without supernumerary hooks. Gill with about 38-53 filaments. (Attached to *Elassoneuria*)
S. berneri Freeman 1a
- 1a Gill with 38 filaments typical form, Ghana
- Gill with more than 38 filaments 1b
- 1b Gill with about 47 filaments Cameroun form
- Gill with about 53 filaments western Uganda form
- Cocoon reduced, covering abdomen only. Abdominal armature unusual, with numerous supernumerary hooks (figs. 8-12). Gill almost always with fewer than 38 filaments. (Not attached to *Elassoneuria*) 2
- 2 Abdominal armature as in figures 9 and 12, segments 5-7 each girdled with about 22-24 hooks, and segment 8 with from 4-7 hooks irregularly on each side. Gill with 25-41 filaments. (Attached to *Afroneurus*)
S. lumbwanus de Meillon
- Abdominal armature as in figures 8 and 11, segments 5-7 bare dorsally (except for two or three small spiny hooks each side laterodorsally on 5) and with normal complement ventrally, segment 8 without hooks (occasional specimens with one pair of minute hooklets ventrally). Gill usually with 10 or 16-18 filaments, sometimes 28-32 terminal branches due to further bifurcation. (Attached to *Afroneurus*, *Baetis* or unidentified Baetid) 3
- 3 Gill with 10 filaments *S. dicerus* Freeman & de Meillon
- Gill with more than 10 filaments *S. copleyi* Gibbins 3a
- 3a Gill with 16-18, usually 17, filaments typical form
- Gill with 28-32 filaments, some branchings in apical half of gill
form *marlieri* Grenier

(c) Adult flies, male and female

- 1 Fore tarsi conspicuously dilated, the basitarsus four or four and a half times as long as its greatest breadth 2
- Fore tarsi not dilated, the basitarsus six and a half times as long as its greatest breadth or more
- S. berneri* Freeman, *S. dicerus* Freeman & de Meillon
- 2 Postnotum with two patches of yellow or golden scales. Scutum entirely yellow-scaled. Parameral hook of male genitalia absent or rudimentary
S. copleyi Gibbins

- Postnotum bare. Scutum with black-brown scales on a broad median area, with yellow scales only laterally and around margins. Male genitalia with very long strong parameral hook *S. lumbwanus* de Meillon

KEY TO THE GENERA OF AFRICAN MAYFLY NYMPHS OCCURRING IN PHORESTS
WITH *SIMULIUM*

- 1 Fore legs with conspicuous brushes of long hair (fig. 1). First pair of abdominal gills on ventral surface (fig. 1) *Elassoneuria* Eaton (Oligoneuridae)
- Fore legs without such brushes. All abdominal gills on dorsal surface 2
- 2 Eyes dorsal. Body strongly dorsoventrally flattened, head the widest part of body *Afronurus* Lestage (Heptageniidae)
- Eyes lateral. Body not very strongly dorsoventrally flattened, head narrower than thorax *Baetis* Leach and unidentified genus (Baetidae)

Simulium bernerii Freeman

Simulium bernerii Freeman, 1954, *Ann. Mag. nat. Hist.* (12) 7 : 113. Berner, 1954, *Ann. Mag. nat. Hist.* (12) 7 : 116, 120. Grenier & Mouchet, 1958, *Bull. Soc. Path. exot.* 51 : 968, 970, 973-5. Corbet, 1960, *Proc. R. ent. Soc. Lond.* (B) 29 : 71. Crosskey, 1960, *Bull. Brit. Mus. nat. Hist. (Ent.)*, 10 : 5, 25, 30, 55. Grenier, Mouchet, Rageau & Adam, 1961, *Bull. Soc. Path. exot.* 54 : 1131, 1135. Crosskey, 1962, *Bull. Wld Hlth Org.* 27 : 483, 486.

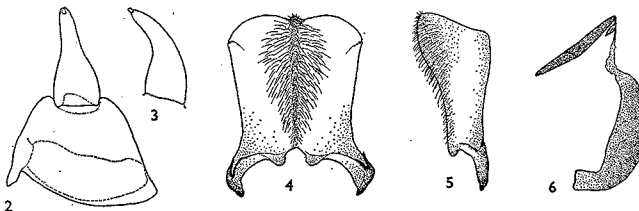
Description of pupa by Freeman (1954) and description of larva by Crosskey (1960). Male described below from specimen dissected from mature pupa: generic characters of *Simulium* Latreille s.l. (costa with black spinules as well as hairs, radial sector not forked, calcipala and pedisulcus well developed, and antennae with 11 segments) all confirmed.

Male

Head normal, blackish, eyes and mouthparts as in typical *Simulium*. Thorax blackish, scutum velvety-black with yellow scaling; pleural membrane and katepisternum bare; postnotum apparently bare. Basal section of radius haired. Legs entirely black; fore tarsi not enlarged or dilated, fore basitarsus slender and about 6-7.5 times as long as its greatest breadth; hind basitarsus not enlarged conspicuously. Abdomen velvety-black with very thick brilliant golden-yellow scales on first two segments. Male genitalia as in figures 2-6; style subconical and about 2.2 times as long as its basal width (fig. 2), slightly curved in ventral view (fig. 3) and with a single apical spinule; coxite normal, not prolonged beyond base of style; ventral plate (fig. 4) longer than broad and with short basal arms, slightly excavate apicomedia and with a pair of bluntly rounded projections between basal arms, with haired median ridge which is not strongly prominent in profile (fig. 5); paramere with one very long strong parameral hook and a small inconspicuous second hook near base of main one (fig. 6).

Pupa

The following descriptive notes, based on further material available since the original description, draw attention to minor differences in the pupal gill of specimens from different localities. In the type specimen the gill has 38 filaments, in a pupa



FIGS. 2-6.—Male genitalia of *Simulium bernerii*: (2) coxite and style; (3) style in profile; (4) ventral plate in ventral view; (5) ventral plate in profile; (6) paramere and parameral hook.

from Cameroun it has about 47 filaments, and in the pupa recently collected in Uganda it has about 53 filaments (as nearly as can be counted without removing the pupa from its *Elassoneuria* partner). In the Uganda specimen about 40 filaments arise individually from the base of the gill and about 12 from bifurcations, there being five or six forks in the basal two-fifths of the gill; in the Cameroun specimen many of the terminal filaments arise from common bases and some of the bifurcations occur at about half way along the length of the gill. No useful purpose is served by giving form names (which now have no status in nomenclature) to these different segregates, and in the preceding key I have therefore referred to them simply as the Cameroun and the Uganda form. It is of interest to note that the number of filaments, on present evidence, increases from west to east across the distribution range of *S. berneri*.

Material examined

Holotype pupa (gill only, slide mounted), GHANA: Togoland, near Huime, Dayi River, Kpandu-Hohoe road, 17.viii.1950 (*L. Berner*). *Paratypes*: 4 larvae, data as for holotype (one larva in spirit, two small larvae on slides, one large larva with structures individually slide-mounted). In British Museum (Natural History), London. (Other paratype larvae with the same data, in the Florida State Museum, have not been seen.)

One ♂ pupa with cocoon and extracted ♂ adult, CAMEROUN REPUBLIC: East Cameroon, Haut-Nyong, Djaposten, Dja River, 13.ix.1956 (*M. T. Gillies & J. Mouchet*) (B.M. Nat. Hist.). Two larvae, UGANDA: N. Kigezi District, 9.viii.1960 (*M. T. Gillies*) (B.M. Nat. Hist.). One ♂ pupa with cocoon, 1 empty cocoon, 16 larvae, UGANDA: Kigezi District, near Kayonza, Munyaga River (Uganda-Congo border), 4.xi.1964 (*R. W. Crosskey*) (B.M. Nat. Hist.).

All above-listed material originally found attached to nymphs of *Elassoneuria* sp. (Ephemeroptera : Oligoneuridae).

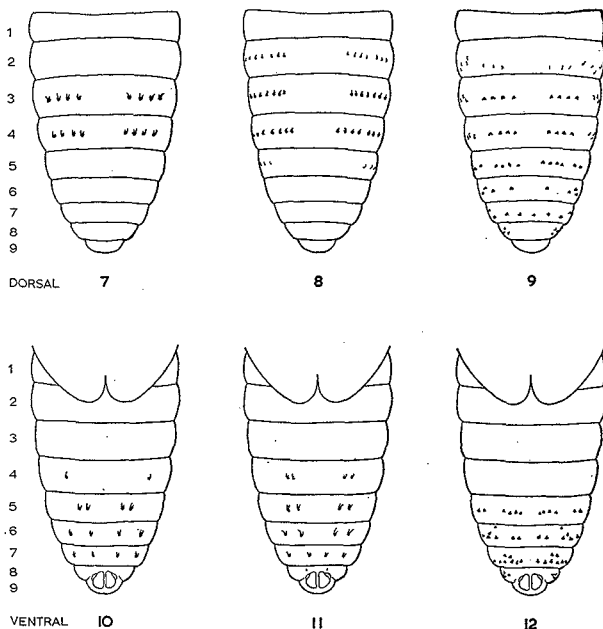
Affinities

The characters of the adult male of *S. berneri* confirm that this species is obviously related to the other forms which occur in association with African mayflies, although it differs from all of these in the pupa by having a normal *Simulium* complement of hooks on the abdomen (figs. 7 and 10) instead of the complex arrangement of supernumerary hooks such as occurs in *S. lumbwanus* de Meillon and *S. copleyi* Gibbins (figs. 8-12); however, the arrangement of abdominal hooks in the pupa is evidently an adaptive character associated with the size of cocoon, more hooks presumably ensuring that the pupa remains firmly fixed in a reduced cocoon which covers only the abdomen (as in *S. copleyi*).

S. berneri appears to be closest to the little-known *S. diceros* Freeman & de Meillon, as in both these species the fore tarsi are slender, whereas *S. copleyi* and *S. lumbwanus* both have enlarged and flattened fore tarsi; on the other hand the male genitalia of *S. berneri* are, at least in the ventral plate, rather more like those of *S. copleyi* than those of *S. diceros*. In the main it appears best to regard the abdominal characters of the pupa as obviously adaptive and to treat *S. berneri* as a species falling between *S. diceros* and *S. copleyi*, probably slightly closer to the former than the latter.

ATTACHMENT SITES OF LARVAE OF *S. BERNERI*

Pupation of *Simulium berneri* and of other phoretic *Simulium* occurring on mayflies appears always to take place on the wing-cases, and pupae and cocoons have never been found on any other sites on the mayfly body; larvae, on the other hand, occur in many different situations, and Berner (1954) recorded that the larvae of the type series of *S. berneri* were found just behind the labium, between the legs, and between the gills.



FIGS. 7-12.—Pupal abdomen and its armature of African species of *Simulium* occurring in phoretic association with mayflies: (7 and 10) *Simulium berneri* Freeman, dorsal and ventral; (8 and 11) *Simulium copleyi* Gibbins and *Simulium diceros* Freeman & de Meillon, dorsal and ventral; (9 and 12) *Simulium lumbwanus* de Meillon, dorsal and ventral.

The accompanying table shows the situations of all the larvae of *S. berneri* found on the three infested specimens of *Elassoneuria* now available from Uganda; figure 1 illustrates the *Elassoneuria* nymph with the heaviest incidence of larvae. Altogether this nymph bore eleven larvae and one pupa, together with an empty cocoon; so far as I know this is the highest number of *Simulium* larvae yet recorded from a mayfly phoretic partner.

Simulium larvae, particularly the small ones, very easily become detached from their mayfly partners, and it is possible that Specimen C (that collected by Gillies in 1960) may originally have had more larvae upon it than now remain; Specimens A and B are those collected by myself in November, 1964 and examined for *Simulium* larvae shortly after collection.

Specimens A and B are in the last nymphal instar and were collected from under loose stones in the Munyaga River, Kigezi District; they were obtained while I was trapping crabs in a search for the early stages of *Simulium neavei* Roubaud. *Elassoneuria* nymphs were evidently not common in the river at this time, as only these two were found in a half-hour spent searching. It is therefore impossible to say what infestation rate among *Elassoneuria* exists here, but Dr. Gillies (*personal com-*

TABLE I.—Attachment sites of larvae of *Simulium berner* to three nymphs of *Elassoneuria* sp. collected in Kigezi District, Uganda. A plus sign indicates the presence of a single larva

| <i>Elassoneuria</i> nymph Attachment site | Specimen A | | Specimen B | | Specimen C | |
|--|------------|------|------------|------|------------|------|
| | Right | Left | Right | Left | Right | Left |
| Maxillary gill . . . | — | — | + | + | — | — |
| First abdominal gill . . | + | — | — | — | — | — |
| Second abdominal gill . . | — | — | — | ++ | — | — |
| Third abdominal gill . . | — | — | + | — | — | — |
| Fourth abdominal gill . . | — | + | + | — | — | + |
| Fifth abdominal gill . . | — | + | + | + | — | — |
| Sixth abdominal gill . . | + | + | + | + | — | — |
| Seventh abdominal gill . . | — | — | — | + | — | — |
| Behind metacoxa . . . | — | — | — | — | — | + |

munication) tells me that 11 out of 15 *Elassoneuria* nymphs collected by him in the Dja River, Cameroun, carried larvae of *S. berner* (these larvae have unfortunately not been available for study); none of 19 *Elassoneuria* nymphs examined by Dr. Gillies from the Congo River at Brazzaville were infested.

I am most grateful to Dr. M. T. Gillies for advice on the key to mayflies and for information and material from his own collections of *Elassoneuria*, and to Mr. H. Oldroyd for taking the photographs accompanying this paper.

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FIG. 1.—Lateral view of nymph of *Elassoneuria* sp. from Kigezi District, Uganda, showing larvae of *Simulium berneri* attached to abdominal gills 3-6 and a pupa attached to wing-case.

FIG. 2.—Larva of *Simulium berneri*, probably in fourth instar, attached to underside of lamella of abdominal gill of *Elassoneuria* sp.