

# Contribution to the systematics of *Afrobaetodes* Demoulin (Ephemeroptera: Baetidae)

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Series of larval specimens of the genus *Afrobaetodes* Demoulin (Ephemeroptera: Baetidae) from Guinea, Ivory Coast, Kenya, Senegal, South Africa and Tanzania exhibit heretofore undocumented intraspecific variability. Specimens from Guinea, Ivory Coast and Senegal represent new distribution records. *Afrobaetodes pugio* Gillies and *A. intermedius* Lugo-Ortiz & McCafferty are shown to be synonyms of *A. bernerii* Demoulin, and *A. delicatissimum* (Barnard) is shown to be a synonym of *A. pusillus* (Navás). The larval stage of *Afrobaetodes* and the species *A. bernerii* are redescribed. A taxonomic synopsis summarizes the new revisions.

**Key words:** Ephemeroptera, Baetidae, *Afrobaetodes*, new synonyms, new records, redescriptions.

## INTRODUCTION

Recent global studies of the family Baetidae (Ephemeroptera) have emphasized the need for collecting and rearing African species (e.g. Lugo-Ortiz & McCafferty 1999). We inspected collections of African baetids in the Purdue Entomological Research Collection and discovered a significant amount of material of the genus *Afrobaetodes* Demoulin that have not been previously identified to species. Attempts to identify specimens to species were confounded by variability of the very characters historically used for species identification in the genus. A review of the published accounts of *Afrobaetodes* species confirmed inadequacies in species descriptions and that some species had been based on characters often subject to variability (e.g. slight colouration differences). It became apparent that a taxonomic revision of the genus was called for.

*Afrobaetodes*, which contains some of the smallest African mayflies (Gillies 1991b), was erected by Demoulin (1970) for *A. bernerii* Demoulin, a species from Malawi originally described by Kimmins (1955) as 'Baetidae nymph A, ? near *Centroptilum* Eaton'. Larvae of *Afrobaetodes* are defined by the following characters: the presence of a papilla on the first segment of the labial palp, a pair of papillae on the prosternum, ventrally orientated abdominal gills and a double row of denticles on the tarsal claws. Adults of *Afrobaetodes* have single marginal intercalaries in the forewings. The three-

segmented male genital forceps have segment 2 bowed and with a basomedial protuberance, and segment 3 is ellipsoidal and nearly one-third the length of segment 2.

It has been difficult to ascertain the precise phylogenetic relationship of the apparently highly adapted genus *Afrobaetodes* relative to other baetid genera. Demoulin (1970) noted that the genus was similar to the mainly Neotropical genus *Baetodes* Needham & Murphy with respect to the ventrally oriented abdominal gills and the general sprawling appearance of the larva, but the wing venation and larval mouthparts suggested that it was not related to *Baetodes*. Lugo-Ortiz & McCafferty (1996a) showed that *Baetodes* belongs to a distinct monophyletic, Western Hemisphere grouping unrelated to *Afrobaetodes*. The larvae of *Afrobaetodes* appear most similar to those of the also Afrotropical genus *Thraulobaetodes* Elouard & Hideux (Elouard & Hideux 1991: Figs 1–3). *Afrobaetodes* has the double row of tarsal claw denticles shared by *Thraulobaetodes* and other *Centroptiloides* complex genera (Lugo-Ortiz & McCafferty 1998), but *Afrobaetodes* has not been considered a part of this complex. Because the male adults have a basomedial protuberance on segment 2 of the genital forceps, Lugo-Ortiz & McCafferty (1996b) assigned *Afrobaetodes* to the *Bugilliesia* complex of Afrotropical Baetidae, which also contains the genera *Bugilliesia* Lugo-Ortiz & McCafferty, *Kivua* Lugo-Ortiz & McCafferty, *Mutelocloeon* Gillies & Elouard, *Potamocloeon* Gillies

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and *Rhithroclaeon* Gillies. The *Bugilliesia* complex was defined by male genitalia distinctive among Baetidae, including the presence of the large basomedial protuberance on forceps segment 2 (Lugo-Ortiz & McCafferty 1996b: Figs 19–24). Species in the *Bugilliesia* complex of genera also share characters not exclusive to the complex, such as single marginal intercalaries in the forewings and a distinctive projection between the bases of the male genital forceps (Lugo-Ortiz & McCafferty 1996b: Figs 19–24).

The genus *Afrobaetodes* has till now consisted of six species: *A. pusillus* (Navás), *A. delicatissimus* (Barnard), *A. bernerii* Demoulin (the genotype), *A. pugio* Gillies, *A. intermedius* Lugo-Ortiz & McCafferty and *A. lenae* Gattolliat & Sartori. Navás (1930) described *A. pusillus* (as *Cloeon pusillum*) from female adults collected from the Democratic Republic of Congo. Gillies (1979) subsequently described the male adults of *A. pusillus* based on material associated with female adults collected from the Congo and the Democratic Republic of Congo, and then transferred the species to *Afrobaetodes*. *Afrobaetodes delicatissimus* was described (as *Cloeon delicatissimum*) based on female adults collected in South Africa (Barnard 1932). Gillies (1979) transferred this species to *Afrobaetodes*, based on its similarity to *A. pusillus* in size, colour and wing venation. *Afrobaetodes bernerii* is known as larvae (Kimmins 1955; Demoulin 1970; Gillies 1991b) and female adults (Gillies 1991b). The species has been reported from Malawi (Kimmins 1955), South Africa (Agnew 1963) and Tanzania (Gillies 1991a,b). *Afrobaetodes intermedius* was described from larvae from South Africa by Lugo-Ortiz & McCafferty (1996b). *Afrobaetodes lenae* was recently described by Gattolliat & Sartori (1999) from larvae collected in Madagascar.

Historically, proper characterization of *Afrobaetodes* species has been hindered by a paucity of correlated life stages. For example, only *A. pugio* is known as larvae as well as male and female adults. In addition, most species are known from very few specimens collected from a very few localities. An extreme case is *Afrobaetodes intermedius*, which is known from two specimens collected at the same time and place. Because there have been so few specimens available to researchers for comparison, additional material preserved in research collections or museums are invaluable to further understanding the genus. Based on the comparative study of such material, we are able to make the

following contribution to the taxonomy of *Afrobaetodes*.

## SPECIES VARIABILITY AND REVISION

### *Afrobaetodes bernerii*

The most easily observed characters used to differentiate and identify *Afrobaetodes* species have been abdominal tuberculation and the placement of setal tufts on the thorax and abdomen. Our study shows that the armature of the abdominal terga in individuals from the same population may vary from very slight median protuberances, as have been associated with *A. bernerii* (Gillies 1991b: Fig. 2.6), to well-developed median tubercles, as have been associated with *A. pugio* (Gillies 1991b: Fig. 2.7). Thus, the relative development of median abdominal tubercles does not appear to be a consistent species-specific character.

Gillies (1991b) noted that the presence and distribution of mesonotal setal tufts differentiated *A. pugio* from *A. bernerii*. All larval specimens of *Afrobaetodes* we examined had tufts of mesonotal setae in locations corresponding to those figured by Gillies (1991b: Fig. 2.8) for *A. pugio*. The paratype of *A. bernerii* had small tufts of pale, translucent setae in this configuration, although they had not been mentioned in previous descriptions or discussions of the larvae of *A. bernerii* by Kimmins (1955), Demoulin (1970) or Gillies (1991b). All larvae we examined also had a pair of occipital tufts of setae, which were present on variously developed occipital tubercles. This observation was also missing from previous studies.

Each abdominal tergum of all mature larvae we examined had a median tuft of setae, as was associated with *A. intermedius* by Lugo-Ortiz & McCafferty (1996b). Sometimes, however, setal tufts were visible only when specimens were illuminated from the side and examined with high magnification. The tufts varied in their relative development, ranging from prominent to minute. Colour of the setae in the tufts also varied, ranging from pale and translucent to opaque and dark brown. These variations were found not only between specimens but often on the same specimen. Based on the published accounts of species, Lugo-Ortiz & McCafferty (1996b) inferred that *A. bernerii* and *A. pugio* lacked tufts of setae on their abdominal terga. Type material of *A. bernerii*, however, had small translucent setal tufts on all abdominal terga, although they were not

mentioned in descriptions and discussions of the larvae by Kimmins (1955), Demoulin (1970), or Gillies (1991b). The holotype of *A. intermedius*, a middle instar larva, also had median setal tufts on all terga, but Lugo-Ortiz & McCafferty (1996b) reported them on only terga 1–6. These terga had the most robust, dark-coloured setae. The small tufts of setae on terga 7–10 consisted of pale, translucent setae, and they were only visible when carefully examined, as described above.

Gill shape, setation of the cerci and denticulation of mandibular incisors have also been used to distinguish species of *Afrobaetodes*. Abdominal gills varied in shape only slightly, but the variation was enough to establish the presence of forms intermediate of those figured by Gillies (1991b: Figs 2.9, 2.10.). Long, thin, simple setae, such as those described by Lugo-Ortiz & McCafferty (1996b) for *A. intermedius*, were found interomedially on the cerci of all specimens examined. Lugo-Ortiz & McCafferty (1996b) noted that *A. intermedius* had more denticles on the mandibular incisors than *A. berneri* and *A. pugio*. Comparison of mandibles figured by Lugo-Ortiz & McCafferty (1996b: Figs 12, 13) for *A. intermedius* and mandibles figured by Gillies (1991b: Figs 3.12, 3.13, 3.16, 3.17) for *A. pugio* and *A. berneri*, indeed indicated that *A. intermedius* possesses more denticles on its mandibles. However, examination of specimens revealed that mandibles with only light wear closely resemble those figured by Lugo-Ortiz & McCafferty (1996b), while more heavily worn mandibles resemble those figured by Gillies (1991b). Morihara & McCafferty (1979) previously found that wear led to difficulties in accurately ascertaining the number of mandibular denticles in other baetid species.

Gillies (1991b) noted that the female adults of *A. pugio* and *A. berneri* differed only in the size of the minute hindwings (see Gillies 1991b: Figs 1.3, 1.4) and abdominal colouration. However, species discriminations based on colour and minor differences in hindwing size have been shown to be unreliable, especially in baetids (e.g. Waltz 1995, Waltz et al. 1998). This is further borne out by the fact that mature larvae we examined varied in size of the minute hindwing pads, with no correlation with any specific name.

Based on the above observations, *A. berneri*, *A. intermedius* and *A. pugio* are considered the same species. We therefore propose the following synonyms: *A. berneri* Demoulin [= *A. intermedius*

Lugo-Ortiz & McCafferty, **syn. n.**; = *A. pugio* Gillies, **syn. n.**]. The high degree of variability and widespread distribution of *A. berneri* (i.e. South Africa to Tanzania to Senegal) is not without precedent among species of African Baetidae. For an example, see Lugo-Ortiz et al. (2000) regarding the variable and widespread *Pseudocloeon glaucum* (Agnew).

### ***Afrobaetodes pusillus***

*Afrobaetodes delicatissimum* (Barnard) and *A. pusillus* (Navás) remain unknown in the larval stage. Demoulin (1957) noted the similarity of the adults, and Gattolliat & Sartori (1999) doubted the distinction between the two species. *Afrobaetodes pusillus* is well defined (Navás 1930, Demoulin 1957, Gillies 1979), but Barnard's (1932) description of *A. delicatissimum* was based on four damaged female adults and gave little detail. Demoulin (1957) noted that *A. pusillus* resembled *A. delicatissimum* in the absence of hindwings, but suggested that *A. pusillus* was slightly more coloured and had smaller caudal filaments, even though Barnard (1932) indicated the caudal filaments of the type material were lost. Examination of a specimen from the syntype series in The Natural History Museum, which we herein designate the lectotype (see Materials Examined), confirmed that the caudal filaments were lost. Since the only ostensible means of separating the species is a slight colouration difference, and colouration differences have been shown to be unreliable in baetid species differentiation (e.g. Bergman & Hilsenhoff 1978, McCafferty et al. 1994), we consider *A. delicatissimum* as a junior synonym of *A. pusillus*.

### **Additional remarks**

The possibility remains that *A. berneri* may be conspecific with *A. pusillus*. The only known means of differentiating between the two species is the presence or absence of hindwings, respectively. Gillies (1991b) considered that previous workers could simply have overlooked the hindwings in *A. pusillus*. Examination of a specimen of *A. pusillus* bearing a Navás 'Typus' label (see explanation by Alba-Tercedor & Peters 1985) and the lectotype of *A. delicatissimus* revealed that the hindwings are indeed absent. Therefore, we continue to recognize both *A. berneri* and *A. pusillus* at this time, because all larvae of *A. berneri sensu lato* possess hindwing pads and known

adults have hindwings. It is important to reiterate, however, that the relative development of hindwing pads varied among larvae, and hindwing pads were difficult to detect on some specimens. Furthermore, the presence of hindwing pads in the larva may not guarantee the presence of hindwings in the adult, as was shown by Soldán & Thomas (1985) to be the case for the African baetid species *Cheleocloeon dimorphicum* (Soldán & Thomas). Gillies (1991b) considered the vestigial nature of the hindwings in *A. bernerii* and suggested that some adults of the species may eventually be found that do not have developed hindwings.

*Afrobaetodes bernerii* and the Madagascar species *A. lenae* are clearly distinct as larvae. Those of *A. bernerii* have 4–6 denticles in the first row of denticles on the tarsal claw, whereas those of *A. lenae* have eight denticles in the first row. The two species also differ in the shape of the lingua of the hypopharynx (compare Lugo-Ortiz & McCafferty (1996b), Fig. 11, and Gattolliat & Sartori (1999), Fig. 6). Although a relatively large number of mayfly genera are known from both Africa and Madagascar (McCafferty 1999), there are no species known to be distributed in both regions.

## REDESCRIPTIONS

An emended description of the genus *Afrobaetodes* in the larval stage must be given to express the character states discovered in this research and associated with the recently described species *A. lenae* from Madagascar. We also include a redescription of *A. bernerii* in the larval stage that takes into consideration newly discovered variability.

### Genus *AFROBAETODES* Demoulin

*Mature larva.* Antennae 2.0–2.5 times length of head capsule. Mandibles with fused left incisors and cleft right incisors; left prosthema apically denticulate, right prosthema reduced to robust filament with minute apical denticles. Maxillary palps two-segmented; palp segment 1 with filamentous distolateral papilla. Labium with three-segmented palps; palp segment 1 longer than palp segments 2 or 3; segment 3 apically rounded; glossae and paraglossae subequal in length, relatively narrow and elongate. Thoracic prosternum with one sublateral filamentous papilla on either

side. Legs somewhat robust; femora with dorsal row of long, simple setae; tarsal claws with two subapical setae arising opposite each other, one row of 4–9 denticles and a second row of one or two lateral denticles. Abdominal terga with or without variously developed tubercles. Ventrally imbricated gills on abdominal segments 1–6, with smooth margins and no dorsal flap. Cerci 0.6–0.8 times length of body; median caudal filament reduced to one segment.

### *Afrobaetodes bernerii* Demoulin

*Mature larva.* Body length: 2.5–3.5 mm. Cerci length: 2.0–2.5 mm. Head: colouration yellow-brown, epicranial suture pale margined. Vertex with scattered stout spicules; ocellar tufts of setae present; ocellar tubercles variously produced. Antennae nearly 2.5 times head capsule length. Labrum with long submedian seta and 4–5 long lateral submarginal setae on either side of midline; anterior margin with branched setae. Hypopharynx with scattered setae on anterior margins of lingua and superlinguae; lingua with small, blunt, apical projection. Left mandible with 4–5 + 3 denticles; prosthema with four denticles; tuft of simple setae present between prosthema and mola. Right mandible with 3–4 + 3–4 denticles; prosthema reduced to robust filament with four minute denticles; tuft of simple setae present between prosthema and mola. Maxillae with 3–4 denticles on crown of galealaciniae; 3–4 setae present on medial hump; palps segment 1 nearly 0.85 times length of segment 2; distomedial filamentous papilla nearly 0.90 times length segment 2. Labium with long, simple setae present on outer margins and apices of paraglossae and on inner margins and apices of glossae; palp segment 3 broadly rounded and with scattered setae. Thorax: colouration yellow-brown; thoracic nota margined in brown anteriorly; pronotum with anteromedial brown spot; mesonotum with dark brown medial stripe and dark brown posteromedial spot; metanotum brown, pale mottled. Pronotum with tuft of setae on posteromedial tubercle; mesonotum with three tufts of setae, pair of tufts submedially in anterior half and one tuft of setae medially on posterior margin between wingpads; metanotum with tuft of setae on posteromedial tubercle; hindwing pads present, variably minute. Prosternum with pair of filamentous papillae. Legs with well-developed coxal spurs; femora yellowish, banded in brown at each

end, with single row of long, stout setae dorsally; tibiae pale with apical brown band, hairlike setae dorsally, short and stout setae ventrally and pair of apical spurs; tarsi with hairlike setae dorsally, 5–7 spurs ventrally; claws with one row of 4–6 denticles, increasing in length distally, second row of one or two lateral denticles and two apical setae, arising opposite each other. Abdomen: colouration yellow-brown to pale. Terga patterned with brown; sterna yellow-brown, unpatterned. Terga 1–10 each with small, median tuft of setae, sometimes minute, on variously developed posteromedian protuberance. Gills 1.2–2.2 times length of corresponding abdominal segment, with each gill relatively shorter than preceding gill. Paraprocts marginally smooth. Caudal filaments pale; cerci with long, fine, simple setae interomedially in midregion.

## MATERIAL

Material is deposited in the Purdue Entomological Research Collection, West Lafayette, Indiana, U.S.A., unless otherwise indicated as being housed in The Natural History Museum, London, England [BMNH] or in the Museo de Zoología, Barcelona, Spain [MZBS]. All map coordinates included with collecting data were obtained from gazetteers (United States Board on Geographic Names 1954a,b; 1964a,b; 1965a,b,c,d; 1970) and are only approximate.

*Material examined.* *Afrobaetodes berner*: PARATYPE, larva, Nyasaland, Tengadzi stream, between 16°27'S 35°08'E and 16°32'S 35°05'E, 22-VII-1952, Lewis Berner [BMNH]; two larvae, Guinea, Baoule River, between 8°37'N 8°17'W and 9°33'N 9°09'W; 50 larvae, Guinea, M'Boo River near Moeindougou, 8°33'N 8°25'W, 1992 (parts on slides); one larva, Guinea, tributary of Milo River, Konsankoro, 9°02'N 9°00'W, II-1979; three larvae, Ivory Coast, tributary of White Bandama River, 6°54'N 5°31'W; one larva, Kenya, Marira River near Meru, 0°03'N 37°39'E, 22-XI-1971, G.F. Edmunds, C.H. Edmunds; three larvae, Senegal, near Missira, 13°N 14°W, Surba, 1988; one larval exuviae, South Africa, East Transvaal, Kruger National Park, 23°50'S 31°30'E, Sabie River at Molondozi, dusk drift, 23-X-1990, W.P. McCafferty, N. McCafferty, F. de Moor, H. Barber; one larva, Tanzania, Amani, 5°06'S 38°38'E, Kwamkuyu Stream, 5-VI-1961; 12 larvae, Tanzania, Manyara National Park, 3°31'S 35°56'E, III-1979.

*A. delicatissimum*: LECTOTYPE, one female adult, South Africa, Wolvenhoek Kloof, French Hoek, 33°55'S 19°07'E, IV-1931, K. H. B. [BMNH]. *A. intermedius*: HOLOTYPE, larva, South Africa, Mpumalanga Province, Sabie River at Lisbon Estates, 24°58'S 31°26'E, 27-X-1990, W.P. McCafferty, N. McCafferty (parts on slide); one larva, same data. *A. pusillus*: 'TYPUS' (Musée du Congo), Zaire, Stanleyville, 0°30'N 25°12'E, 20-II-1928, A. Collart [MZBS]. *Afrobaetodes* sp.: one larva, Tanzania, M.T. Gillies (parts on slide).

## TAXONOMIC SYNOPSIS

***Afrobaetodes* Demoulin, 1970: 52**

Type species: *Afrobaetodes berner* Demoulin, 1970.

***Afrobaetodes berner* Demoulin**

Baetidae nymph A, ? near *Centropetulum* Kimmins 1955: 871 (larva).

*Afrobaetodes berner* Demoulin, 1970: 52 (larva);

Gillies 1991b: 106 (larva, female adult).

*Afrobaetodes pugio* Gillies, 1991b: 106 (larva; male, female adults). **Syn. n.**

*Afrobaetodes intermedius* Lugo-Ortiz & McCafferty, 1996b: 181 (larva). **Syn. n.**

***Afrobaetodes lenae* Gattolliat & Sartori**

*Afrobaetodes lenae* Gattolliat & Sartori, 1999: 179 (larva).

***Afrobaetodes pusillus* (Navás)**

*Cloeon pusillum* Navás, 1930: 321 (female adult); Demoulin 1957: 271 (female adult).

*Cloeon delicatissimum* Barnard, 1932: 216 (female adult). **Syn. n.**

*Afrobaetodes pusillus* (Navás): Gillies 1979: 153 (male adult, transferred from *Cloeon*).

*Afrobaetodes delicatissimus* (Barnard): Gillies 1979: 153 (transferred from *Cloeon*). **Syn. n.**

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