

New species and generic delimitation of the Afrotropical genera *Bugilliesia* Lugo-Ortiz & McCafferty, 1996; *Cheleocloeon* Wuillot & Gillies, 1993 and *Delouardus* Lugo-Ortiz & McCafferty, 1999 (Ephemeroptera: Baetidae)

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The larval stage of the genera *Bugilliesia* Lugo-Ortiz & McCafferty 1996; *Cheleocloeon* Wuillot & Gillies, 1993 and *Delouardus* Lugo-Ortiz & McCafferty, 1999 are remarkably similar. In order to avoid inaccuracy in generic placement, we propose new generic diagnoses with new discriminating characters. The setation of the labrum, details of the right and left prosthema, the shape of the maxillary palp and the shape of the legs are the most reliable characters for separating the different genera. Based on this, the generic attribution of *Cheleocloeon mirandei* Lugo-Ortiz & McCafferty, 1997 is incorrect and the species must be transferred to *Bugilliesia* as *B. mirandei* n. comb. A new species of *Bugilliesia* is described from South Africa. This greatly increases the distribution of *Bugilliesia* to include the whole of the Afrotropical region including Madagascar. A new species of *Cheleocloeon* is also described, confirming the presence of this genus in Madagascar.

Keywords: Baetidae; systematics; Afrotropical; *Bugilliesia*; *Cheleocloeon*

Introduction

Baetidae are the most diverse and abundant family of Ephemeroptera in the Afrotropical region, contributing more than half of the generic and specific diversity (Barber-James and Lugo-Ortiz 2003; Barber-James, Gattolliat, Sartori and Hubbard 2008; Gattolliat et al. 2008). Since 1990, more than 30 new genera have been established in this family, partly to accommodate species that were previously attributed to polyphyletic Palearctic genera (Gillies 1990; Lugo-Ortiz and McCafferty 1997b; Lugo-Ortiz 1999). During this period, about 100 new species were described, and about half of these were from Madagascar. As a result, the Afrotropical Baetidae currently encompass just under 200 species and 40 genera (Barber-James and Lugo-Ortiz 2003; Barber-James et al. 2008; Gattolliat et al.

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2008). Nonetheless, recent molecular reconstructions (Monaghan et al. 2005; Gattolliat et al. 2008) have highlighted a number of polyphyletic genera. These results suggest that the Afrotropical Baetidae are still in need of more detailed faunistic and systematic studies.

The larvae of *Bugilliesia* Lugo-Ortiz & McCafferty, 1996; *Cheleocloeon* Wuillot & Gillies, 1993 and *Delouardus* Lugo-Ortiz & McCafferty, 1999 share several morphological similarities; thus the generic attribution can be confused when only the larval stage is known. In contrast, the male imago of *Bugilliesia* and *Cheleocloeon* can be easily diagnosed by the shape and number of segments of the genital forceps. Imagines of *Delouardus* remain unknown. A molecular phylogeny that included 58 species of Afrotropical Baetidae found the three genera to belong to different clades, each of which contained Malagasy and African species (Monaghan et al. 2005; Gattolliat et al. 2008). This suggests that the larval similarities are due to convergence and that new generic diagnoses are required.

Cheleocloeon was originally established for two West African species that have the disto-medial projection of the second segment of the labial palp strongly produced and pointed (Wuillot and Gillies 1993). The generic concept was later expanded and new species were included (Lugo-Ortiz and McCafferty 1997a,c, 1998). *Cheleocloeon* is presently characterised in the larval stage by the anteriorly convex distomedial projection of the second segment of the labial palp and the long and poorly denticulate tarsal claws; and in the imaginal stage by the basally bulbous three-segmented genital forceps and the forewing with a single intercalary vein. In addition to five species in continental Africa, *Cheleocloeon mirandei* Lugo-Ortiz & McCafferty, 1997 was described from Madagascar (Lugo-Ortiz and McCafferty 1997c) and *Cheleocloeon soldani* Gattolliat & Sartori, 2008 was described from the Arabian Peninsula (Gattolliat and Sartori 2008). Morphological examination of larvae of *C. mirandei* indicates that it clearly differs from African *Cheleocloeon*, but presents affinities with the African genus *Bugilliesia* (see below). The molecular phylogenetic reconstruction recovered another Malagasy species as sister to the South African species *Cheleocloeon excisum* (Barnard, 1932); this species was labelled as *Cheleocloeon sp1* in the phylogeny of Monaghan et al. (2005) and Gattolliat et al. (2008). Other larvae matching the African concept of *Cheleocloeon* and notably different morphologically from *C. mirandei* have since been found in other localities of Madagascar (J.-L. Gattolliat, unpublished). Consequently, the generic attribution of *Cheleocloeon mirandei* needs to be solved and the putative new species of *Cheleocloeon* needs to be examined morphologically to establish its status.

The genus *Bugilliesia* was established to include five species that previously constituted the *sudanense* species group of *Afroptilum* (Gillies 1990; Lugo-Ortiz and McCafferty 1996). The two-segmented, blade-shaped genital forceps, the mouthparts, and the denticulation of the tarsal claws were considered to be characters that separate them from the type species of *Afroptilum* (Lugo-Ortiz and McCafferty 1996). Its distribution includes the northern parts of sub-Saharan Africa, and a recent study of imagines from West Africa concluded that the species diversity is much higher than previously thought (Gattolliat 2006). To date, no species have been reported from Madagascar or Southern Africa; however, the recent phylogeny (Monaghan et al. 2005; Gattolliat et al. 2008) recovered one South African species and one Malagasy species to be well-supported sister taxa. Because they were morphologically similar to African *Bugilliesia*, they were labelled as *Bugilliesia sp1* and *Bugilliesia sp2* in the tree, but like *Cheleocloeon*, further analysis of morphological characters are required to confirm the generic placement.

The genus *Delouardus* Lugo-Ortiz & McCafferty, 1999 was established for a single Malagasy species, *D. djabala* Lugo-Ortiz & McCafferty, 1999. *Delouardus* larvae are morphologically very similar to *Cheleocloeon*. They share characters such as the narrow elongated first pair of gills, elongated tarsal claws, and labial palp segment II with a disto-medial projection (Lugo-Ortiz and McCafferty 1999). They differ in the shape of the disto-medial projection of the labial palp segment II, the shape of the labial palp segment III, the relative length of the tarsal claws and particularly in the shape of the legs (Lugo-Ortiz and McCafferty 1999).

We examined specimens of *Cheleocloeon* from West Africa (*C. yolandae* Wuillot, 1993 (type species); *C. carinatum* Wuillot, 1993); from South Africa (*C. excisum* (Barnard, 1932)), from the Arabian Peninsula (*C. soldani*) and from Madagascar (*Cheleocloeon mirandei*; *Cheleocloeon sp1*); specimens of *Bugilliesia* from West Africa (*B. cf sudanense*), from South Africa (*Bugilliesia sp1*) and from Madagascar (*Bugilliesia sp2*); specimens of *Delouardus* from Madagascar (*D. djabala* (type species)). The holotypes of the new species and some of the paratypes are housed in the Museum of Zoology, Lausanne, Switzerland [MZL] or in the Albany Museum, Grahamstown, South Africa [AMGS]. Other paratypes are deposited in the Museum National d'Histoire Naturelle, Paris, France [MNHM].

Taxonomy

Generic delimitation

Eight characters were used to separate the three genera in the larval stage (Table 1). The characters were not only examined in the species illustrated in the different plates but have also been checked against other species using either direct observations or by comparison with illustrations in the literature. The characters indicated are constant among the different genera. In the larval stage, the setation of the labrum (Figures 1–6) and the excavation at the apex of the maxillary palp (Figure 29) are the best characters for separating *Bugilliesia* from *Cheleocloeon* and *Delouardus*. The shape of the legs allows *Delouardus* to be distinguished from *Bugilliesia* and *Cheleocloeon* (figure 7 in Lugo-Ortiz and McCafferty 1999). The shape and setation of the paraglossae (Figures 19–24) and the shape of the right and left prosthecae (Figures 7–18) are also useful characters to separate the three genera. The shape of the disto-medial projection of the second segment of the labial palp is highly variable within each genus. The teeth of the tarsal claws are generally less developed or even vestigial in *Cheleocloeon* (Figure 43), whereas there are always two rows of abundant teeth in *Bugilliesia* (Figure 32) and *Delouardus* (figure 8 in Lugo-Ortiz and McCafferty 1999). Based mainly on the characters presented in Table 1, a complete diagnosis is proposed below for each genus.

Bugilliesia Lugo-Ortiz & McCafferty, 1996

Diagnosis

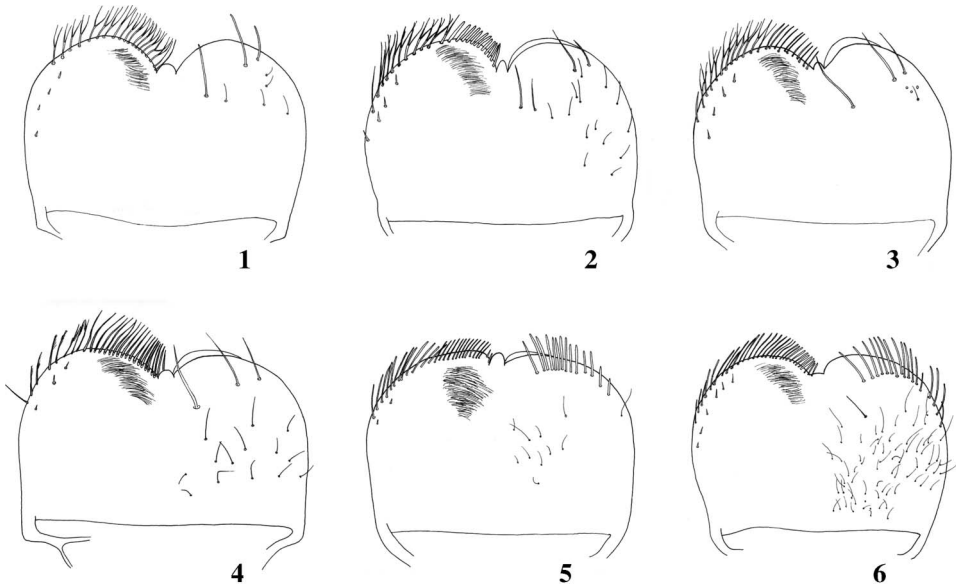
Larva

Labrum (Figures 5, 6 and 25) rounded; dorsal surface with an arc of 10–15 stout setae; distal margin with setae generally simple, sometimes feathered but never bifid. Right mandible (Figures 11, 12 and 27) with one set of incisors or two sets almost fused; prostheca slender, setae between prostheca and mola present. Left mandible

Table 1. Larval characters to separate the genera *Bugilliesia*, *Cheleocloeon* and *Delouardus*.

Characteristic	<i>Bugilliesia</i>	<i>Cheleocloeon</i>	<i>Delouardus</i>
Distribution	Afrotropics	Afrotropics, North Africa and Arabian Peninsula	Madagascar
Dorsal face of labrum: subdistal arc of setae	Arc of about 15 stout setae without submedian seta	Restricted to two setae and submedian seta	Restricted to two setae and submedian seta
Distal margin of labrum	Row of simple setae	Row of bifid setae	Row of mainly simple setae
Paraglossa	Broad and clavate Outer margin with two or three rows of setae apically	Falcate and tapered Outer margin with a single row of setae	Falcate and tapered Outer margin with two rows of setae
Excavation at the apex of maxillary palp	Present	Absent	Absent
Left canine	1 set of incisors or 2 sets almost fused	2 sets of incisors partially fused	2 sets of incisors partially fused
Left prosthema	Slender with slender teeth apically and in some species laterally	Slender with slender teeth apically	Broad with broad teeth apically
Right prosthema	Broad with all denticles of almost same length	Medium to slender with 3 to 4 broad denticles and a comb-shape structure	Medium with three broad denticles and a comb-shape structure
Legs	Elongate and slender; femora with parallel sides	Elongate and slender; femora with parallel sides	Short and stout; femora ovoid

(Figures 17, 18 and 28) with a broad prosthema without a clear comb-shaped structure, setae between prosthema and mola present. Maxilla (Figure 29) with elongated teeth, two stout dentisetae; maxillary palp two-segmented, clearly longer than galea-lacinia, segment II with distal excavation. Labium (Figures 23, 24 and 30) with paraglossae apically tapered with two or three rows of setae; labial palp segment II with disto-medial projection triangular (figure 67 in Gillies 1990; figure 6 in Lugo-Ortiz and McCafferty 1997a) or rounded (Figure 30; figure 74 in Gillies 1990). Hind wing pads present in both sexes. Legs (Figure 31) elongated; femora with a reduced number of short setae on the dorsal margin, tibio-patellar suture absent; tibia with sub-proximal arc of setae absent; tarsal claw (Figure 32) elongated with two rows of abundant teeth generally increasing in length apically, apical setae absent on tarsal claws. Distal margin of terga with triangular spines. Gills (Figure 33) present on segments I–VII, elongated and slender, distal margin serrated.



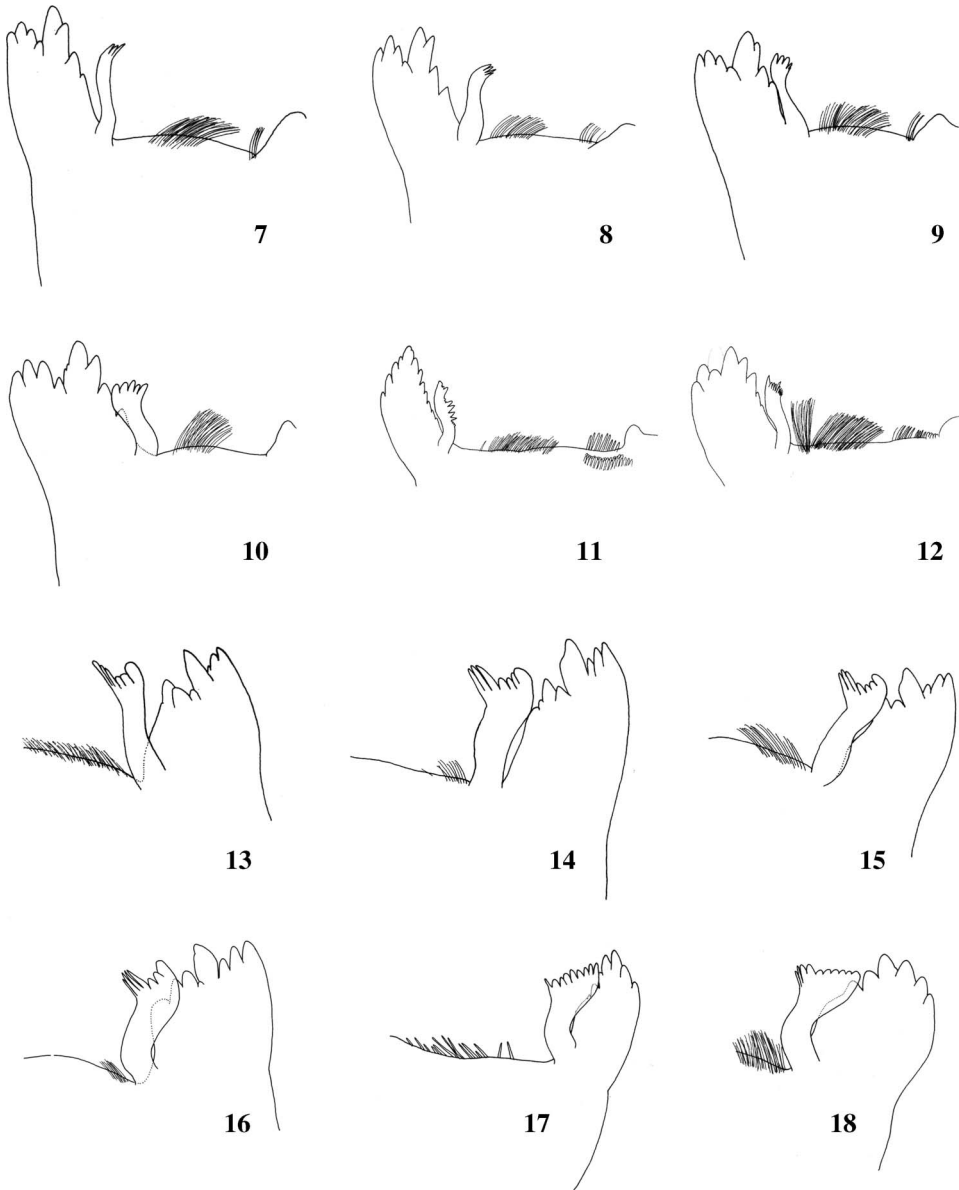
Figures 1–6. Labrum (left half: ventral view; right half: dorsal view). (1) *Cheleocloeon carinatum*, (2) *Cheleocloeon yolandae*, (3) *Cheleocloeon excisum*, (4) *Delouardus djabala*, (5) *Bugilliesia cf. sudanense*, (6) *Bugilliesia mirandei*.

Imago

Forewing hyaline, some species with part of the cross-veins with fuscous margination. Hind wing present, with two or three longitudinal veins; a single well-developed costal spur. Gonopods two-segmented, moderately elongated, and apically rounded; segment I with bulbous projection.

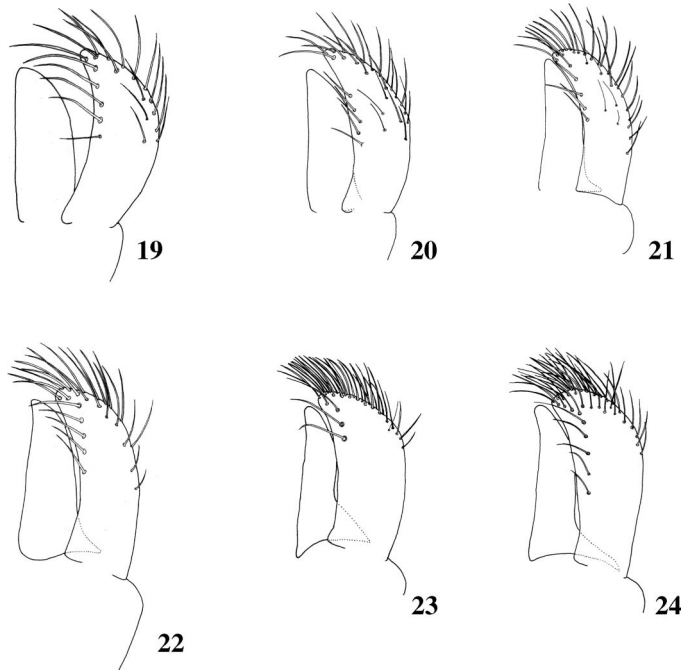
Discussion

The unusual two-segmented gonopods allow *Bugilliesia* to be distinguished from all other African genera (Gattolliat 2006). In the larval stage, the generic identification is more difficult because it is based on a restricted number of reliable characters. The labrum provides important characters: the arc of setae is composed of 10 to 15 setae (Figures 5, 6 and 25) while the same arc is only composed of two lateral and one submedian setae in *Cheleocloeon* (Figures 1, 2, 3 and 35) and *Delouardus* (Figure 4); the setae of the disto-lateral margin of the labrum are simple in *Bugilliesia* (Figures 5, 6 and 25) and bifid in *Cheleocloeon* (Figures 1, 2, 3 and 35). The maxillary palp (Figure 29) presents a unique distal excavation visible even at low magnification. Other characters are summarised in Table 1. The general body shape is a useful, although more subjective, character: elongated and slender in *Bugilliesia* and more compact in *Cheleocloeon* and *Delouardus*. Based on these different characters, it is obvious that *Cheleocloeon mirandei* does not belong to *Cheleocloeon* but must be attributed to *Bugilliesia*. We therefore propose the new combination *Bugilliesia mirandei*. This new combination is also supported by its position in the molecular reconstruction of



Figures 7–18. (7–12) Right mandible. (7) *Cheleocloeon carinatum*, (8) *Cheleocloeon yolandae*, (9) *Cheleocloeon excisum*, (10) *Delouardus djabala*, (11) *Bugilliesia cf. sudanense*, (12) *Bugilliesia mirandei*. (13–18) Left mandible. (13) *Cheleocloeon carinatum*, (14) *Cheleocloeon yolandae*, (15) *Cheleocloeon excisum*, (16) *Delouardus djabala*, (17) *Bugilliesia cf. sudanense*, (18) *Bugilliesia mirandei*.

the Afrotropical Baetidae (Monaghan et al. 2005; Gattolliat et al. 2008). With this new generic attribution and the description of a new species from South Africa, the distribution of *Bugilliesia* is greatly expanded and encompasses West Africa, East Africa, South Africa and Madagascar (Gillies 1990; Lugo-Ortiz and McCafferty 1996, 1997c; Gattolliat 2006).



Figures 19–24. Paraglossa. (19) *Cheleocloeon carinatum*, (20) *Cheleocloeon yolandae*, (21) *Cheleocloeon excisum*, (22) *Delouardus djabala*, (23) *Bugilliesia cf sudanense*, (24) *Bugilliesia mirandei*.

***Bugilliesia mirandei* (Lugo-Ortiz & McCafferty, 1997) n. comb.**

Material examined. 2 larvae; P0044; Madagascar; Betsiboka Bas.; Loc. Andranofeno Sud; 47°10'46"E/18°05'00"S; Alt. 1425m.; 17.04.1991; ORSTOM, Antananarivo [MZL].

2 larvae; P0380; Madagascar; Mangoro Bas.; Loc. 1 km from Sahafitahana; Trib. of Mangoro Riv.; 48°13'39"E/18°59'42"S; Alt. 880m.; 26.04.1995; Sartori M. and Ruffieux L. [MZL].

1 larva; P0485; Madagascar; Betsiboka Bas.; Loc. Ampibasy; unnamed Riv.; 47°57'30"E/18°27'10"S; Alt. 1375m.; 18.10.1995; Gibon F.-M. [MZL].

1♀ larva 621a (on slide) and 1 larva; P0621; Madagascar; Lokoho Bas.; Loc. Marojejy Camp II; unnamed Riv.; 49°45'33"E/14°26'05"S; Alt. 750m.; 15.10.1996; Legrand J. and Randriamasimanana D. [MZL].

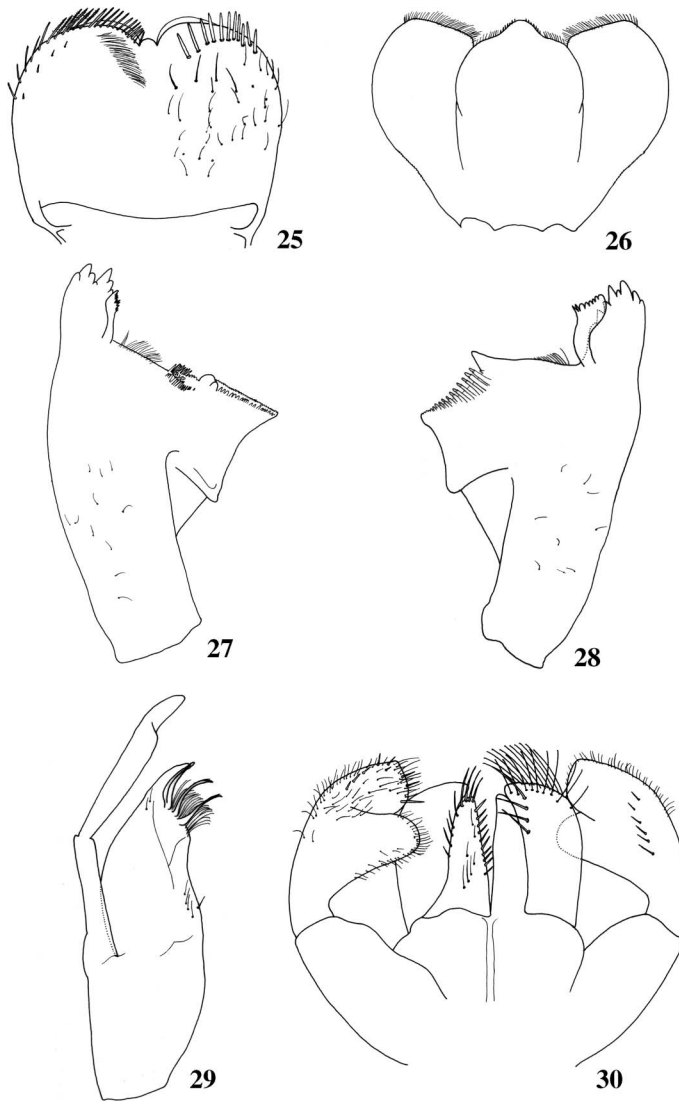
1♀ larva 814c (on slide) and 3 larvae; P0814; Madagascar; Antongombato Bas.; Loc. 100m downstream of Great Cascade; Makis Riv.; 49°10'14"E/12°29'17"S; Alt. 675m.; 22.3.1999; Gattolliat J.-L. and Rabeantoandro, Z. [MZL].

5 larvae; P0822; same locality as P0814, 24.03.1999. Gattolliat, J.-L. and Rabeantoandro, Z. [MZL].

1 larva; MD165; same locality as P0814; 22.11.2001; Gerecke R. and Goldschmidt T. [MZL].

2 larvae; P0867; Madagascar; Mangoro Bas.; Loc. PK 21 from Moramanga; unnamed Riv.; 48°14'13"E/19°05'57"S; 11.04.1999; Gattolliat J.-L. [MZL].

1♀ larva; P2001; Madagascar; Rianila Bas.; Loc. Camp: road to Lakato; unnamed Riv.; 48°21'50"E/19°03'30"S; 25.04.2003; mission MZL and Monaghan [MZL].



Figures 25–30. Larval mouthparts of *Bugilliesia margaretae*. (25) Labrum (left half: ventral view; right half: dorsal view), (26) hypopharynx, (27) right mandible, (28) left mandible, (29) right maxilla, (30) labium.

2 larvae; P2005; Madagascar; Mangoro Bas.; Loc. PK 20,4 road to Anosibe an'ala; unnamed Riv.; 48°14'00"E/19°05'53"S; Alt. 970m.; 03.04.2003; mission MZL and Monaghan [MZL].

Larva

For original description see Lugo-Ortiz and McCafferty (1997), additional features as follows:

Antenna reaching at least the base of abdominal segment V.

Setation of the labrum as in Figure 6; dorsal surface with an arc of 15 medium stout setae.

Colouration. Completely light amber brown or well contrasted yellow and brown. Head amber brown; turbinate eyes light honey brown. Pronotum amber brown, darker medially; mesonotum amber brown with 3 yellow symmetric oblique stripes; metanotum amber brown. Legs uniformly yellow cream. Tergum I yellow except medially and distally brown; terga II and III brown with a pair of symmetric submedian large yellow spots; terga IV and V yellow except medially and distally brown; terga VI and VII brown with a pair of symmetric submedian small yellow spots; terga VIII and IX yellow except medially and proximally faded brown; tergum X yellow. Sterna I to V light brown; sterna VI and VII medium brown; sterna VIII and IX yellow. Cerci and median caudal filament 2/3 basal dark brown and 1/3 apical yellow.

Imago

Unknown.

Distribution

B. mirandei was collected in the northern and eastern regions of Madagascar; it was apparently not particularly abundant anywhere. All the localities where it was collected occur within the remaining areas of tropical rainforest, suggesting that the species may be sensitive to deforestation.

Discussion

B. sudanense (Ulmer, 1916) was originally described from southern Sudan from the imaginal stage; the larval stage was subsequently described rather briefly based on reared material from Gambia (Gillies 1990). Since then, three new species have been described as adults from West Africa (Gattolliat 2006), bringing the total number of species of *Bugilliesia* to eight. Gillies (1990) noted that it was impossible to be certain whether the specimens from Gambia and Uganda were conspecific. The specific diversity of *Bugilliesia* is higher now than at the time of Gillies' study. It is therefore possible that the larval exuvia used for the description of *Bugilliesia sudanense* belongs to one of the species recently described from West Africa.

As mentioned above, *Bugilliesia mirandei* n. comb. perfectly matches the generic diagnosis of *Bugilliesia*. After morphological examination, it appears that the specimens labelled as *Bugilliesia sp2* in the molecular reconstruction (Monaghan et al. 2005; Gattolliat et al. 2008) belong, in fact, to *B. mirandei*. *B. mirandei* can be easily distinguished from the new species of *Bugilliesia* from South Africa by the shape of the disto-medial projection of segment II of the labial palp (Figure 30; figure 6 in Lugo-Ortiz and McCafferty 1997). The shape of this projection is similar between *B. mirandei* and *B. sudanense* (figure 67 in Gillies 1990). The two species can be separated by the shape of the right prosthema and the shape and size of the right canine: *B. sudanense* possesses a slender right prosthema with teeth all along the lateral margin and a slender right

canine with small denticles (Figure 11; figure 71 in Gillies 1990), *B. mirandei* possesses a slender right prosthema with teeth only present apically and a broad right canine with medium denticles (Figure 12).

***Bugilliesia margaretae* Gattolliat & Barber-James sp. n.**

Material examined. *Holotype* 1♂ larva; S2113; South Africa; Incomati Bas.; Loc. Kruger NP- near Skukuza Camp; Sabie Riv.; 31°26'16"E/24°59'16"S; Alt. 290m.; 19.05.2003; Mission MZL and AMGS [AMGS].

Paratypes. 1 larva 2104a (on slide) and 6 larvae; S2104 and LIM 82G; South Africa; Incomati Bas.; Loc. Kruger NP- near Malelane; Crocodile Riv.; 31°37'04"E/25°23'57"S; Alt. 245m.; 17.05.2003; Mission MZL and AMGS [MZL], [AMGS] and [MNHM].

1 larva; S2106; South Africa; Incomati Bas.; Loc. Kruger NP- near Malelane; Crocodile Riv.; 31°36'54"E/25°23'58"S; Alt. 255m.; 17.05.2003; Mission MZL and AMGS [MZL].

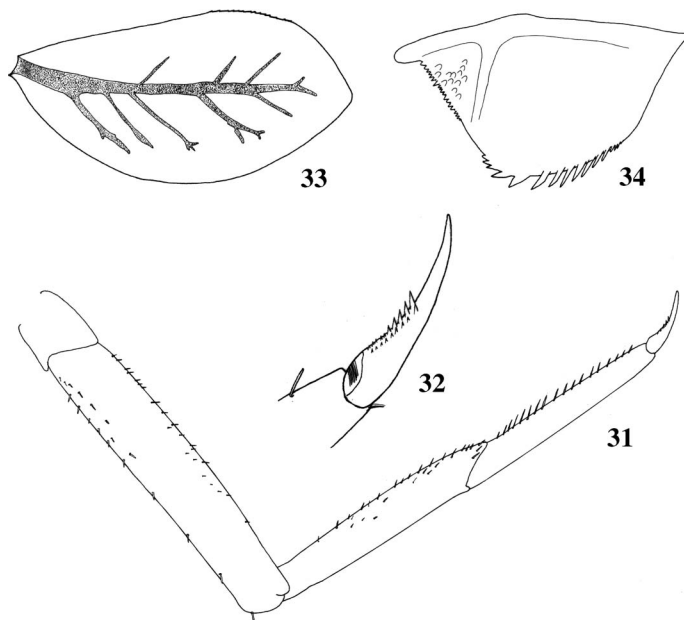
1♂ larva 2109a (on slide) and 1 larva; S2109; South Africa; Incomati Bas.; Loc. Kruger NP- near Skukuza Camp; Sabie Riv.; 31°59'58"E/25°09'43"S; Alt. 135m.; 18.05.2003; Mission MZL and AMGS [MZL].

1 larva; S2120; South Africa; Limpopo Bas.; Loc. Kruger NP- near Pafuri gate; Luvuvhu Riv.; 31°13'10"E/22°25'32"S; Alt. 200m.; 22.05.2003; Mission MZL and AMGS [MZL].

Larva

Maximum length. Body 5.3 mm. Cerci 2.2 mm. Median caudal filament 2.1 mm.

Colouration. General colouration honey brown. Head honey brown with turbinate eyes medium brown. Thorax honey brown with a median longitudinal ecru stripe. Legs ecru without visible marks. Terga honey brown except tergum I



Figures 31–34. Larva of *Bugilliesia margaretae*. (31) Foreleg, (32) tarsal claw, (33) gill IV, (34) paraprot.

ecru and tergum IV proximally honey brown and distally ecru; tergum VII and VIII with two ecru longitudinal marks, maybe present but less visible on other terga. Cerci and median caudal filament ecru with a broad dark brown stripe in middle of length of cerci. Some specimens are uniformly honey brown without any pattern.

Head

Labrum (Figure 25). Dorsal surface of the labrum with approximately 10 apically blunt median setae, thin setae scattered over the surface; distal margin bordered with slightly feathered setae; ventral surface with four small pointed setae apico-laterally.

Hypopharynx (Figure 26). Lingua trilobate with minute setae; lingua as long as superlingua, apically with short thin setae.

Right mandible (Figure 27). Two partially fused sets of incisors; prostheca slender, with minute teeth apically and laterally; tuft of short setae between prostheca and mola; basal half with setae dorsally.

Left mandible (Figure 28) Stout prostheca with about eight teeth; tuft of short setae between prostheca and mola absent; basal half with setae dorsally.

Maxilla (Figure 29) Crown with one row of setae slightly shorter in length than teeth; two setae at the base of the crown; row of four thin setae at base of galea; one short seta perpendicular to margin of galea; maxillary palp segment I approximately 0.8x length of segment II, segment II with a straight excavation looking like a third segment.

Labium (Figure 30) Margin of glossae with short stout setae, longer apically; paraglossae margin with two rows of long, stout setae; labial palp stout, segment I subequal in length to segments II and III combined; segment II with a broad triangular apically rounded disto-medial projection, with an oblique row of six setae dorsally; segment III broad and subconical, covered with abundant medium pointed stout setae and small thin setae.

Thorax

Forelegs (Figure 31). Femora with dorsal margin with a row of approximately 10 short pointed setae, with a row of short pointed setae subparallel to dorsal margin; dorso-apical setal patch formed by one or two blunt setae; anterior face without setae; ventral margin with short pointed setae.

Tibiae without setae dorsally; subproximal arc of setae absent; ventral margin with short pointed setae.

Tarsi without setae dorsally; ventral margin with a row of about 20 pointed simple setae, increasing in length distally; tarsal claws (Figure 32) about 0.3 x length of tarsi, with two rows of teeth, well-developed towards apex.

Abdomen

Tergal posterior margin with irregular spines.

Gills (Figure 33) with a well-marked central tracheation, margin slightly serrated disto-laterally without setae.

Paraproct (Figure 34). Margin with about 15 pointed spines, much larger apically; scale bases limited to posterolateral extension, margin with about 20 minute spines.

Imago

Unknown.

Distribution

At present, this species is known only from northeastern South Africa. All the localities are in the Kruger National Park.

Etymology

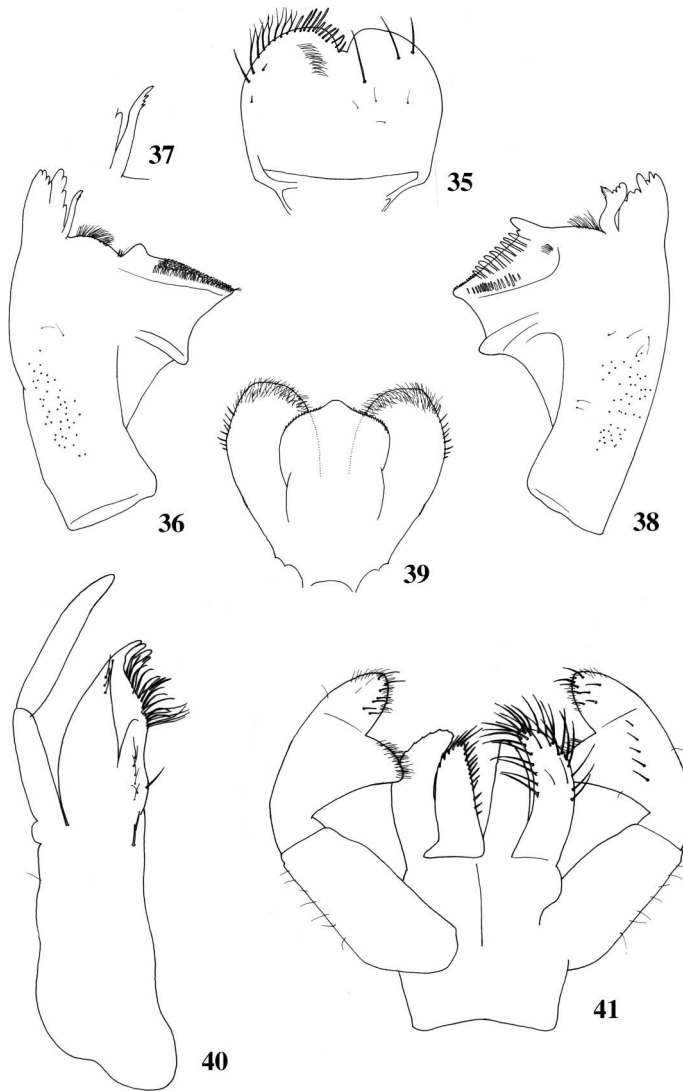
This species is dedicated to Margaret Barber, mother of one of the co-authors, in acknowledgement of her contribution to caring for three granddaughters, thus indirectly contributing to the furthering of knowledge of mayflies.

Discussion

Bugilliesia margaretae perfectly matches the present concept of *Bugilliesia*. It can be easily distinguished from other known *Bugilliesia* species in the larval stage by the segment II of the labial palp having a well-developed apically rounded disto-medial projection (Figure 30), and the setal arc on the dorsal side of the labrum being composed of only about 10 stout setae (Figure 25). It can not be excluded *a priori* that *Bugilliesia margaretae* represents the larval stage of one of the species from West Africa known only at the imaginal stage. Moreover, if the larva described by Gillies from Gambia does not belong to *Bugilliesia sudanense*, it is possible that *B. margaretae* is the larval stage of *B. sudanense*. However, comparisons with larvae of the three morphospecies from West Africa held in our collections shows that they all differ notably from the South African larvae in the shape of the right prosthema, the setation of the labrum and the shape of segment II of the labial palp (unpublished data).

Cheleocloeon Wuillot & Gillies, 1993**Diagnosis***Larva*

Labrum (Figures 1, 2, 3 and 35) rounded; dorsal surface with an arc of setae restricted to two stout lateral setae and 1 long submedian seta; distal margin apico-laterally with bifid setae. Right mandible (Figures 7, 8, 9 and 36) with two partially fused sets of incisors; prosthema slender, setae between prosthema and mola present. Left mandible (Figures 13, 14, 15 and 38) with a medium to broad prosthema with a well differentiated comb-shaped structure, setae between prosthema and mola present. Maxilla (Figure 40) with elongated teeth; maxillary palp two-segmented, clearly longer than galea-lacinia, segment II without excavation. Labium (Figures 19, 20, 21 and 41) with paraglossae apically falcate and tapered, distal margin with one row of setae; labial palp segment II with a disto-medial projection triangular more or less developed depending on the species. Hind wing pads present in both sexes, absent in female only, or absent in both sexes depending on species. Legs (Figure 42) elongated; femora with only a reduced number of short setae on the dorsal margin, tibio-patellar suture absent; tibia with subproximal arc of setae

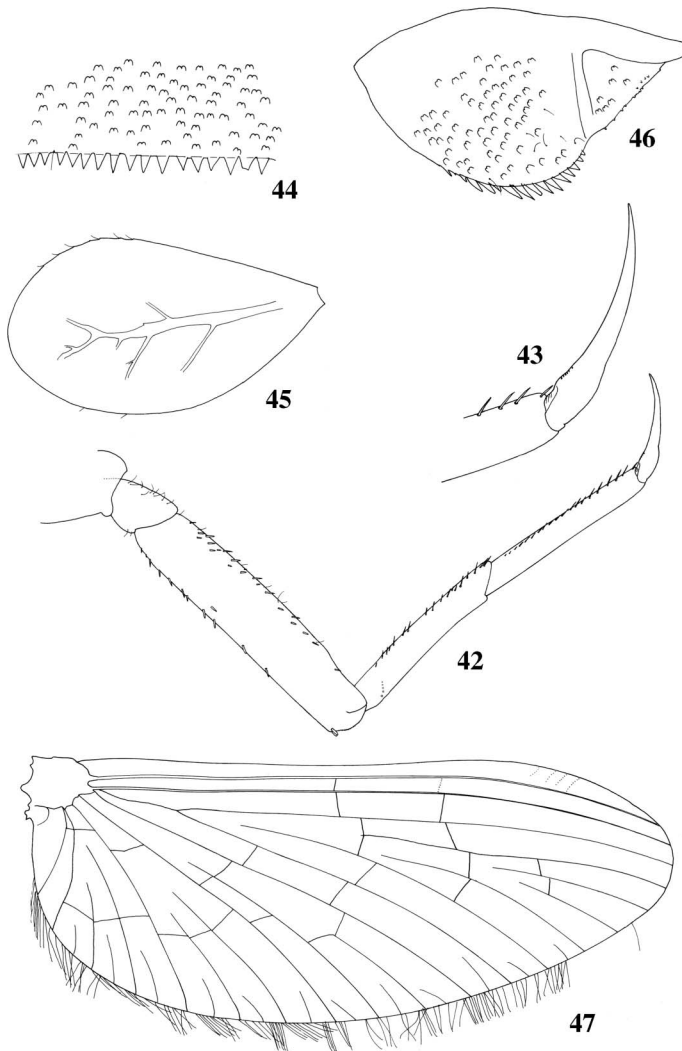


Figures 35–41. Larval mouthparts of *Cheleocloeon madagascariense*. (35) Labrum (left half: ventral view; right half: dorsal view), (36) right mandible, (37) right prosthema, (38) left mandible, (39) hypopharynx, (40) right maxilla, (41) labium.

present; tarsal claw (Figure 43) elongated with two rows of teeth reduced in size, vestigial or even absent in some species, apical setae absent on tarsal claws. Distal margin of terga (Figure 44) with triangular spines. Gills (Figure 45) present on segments I–VII, elongated and slender, distal margin serrated.

Imago

Forewing hyaline without any colouration. Hind wings present in both sexes, absent in female only or absent in both sexes depending on species; hind wings with two longitudinal veins and a single well-developed costal spur. Gonopods three-segmented; segment I enlarged, segment III ovoid.



Figures 42–47. Larva (42–46) and subimago (47) of *Cheleocloeon madagascariense*. (42) Foreleg, (43) tarsal claw, (44) distal margin of tergum IV, (45) gill IV, (46) paraproct, (47) forewing.

Discussion

Except for the shape of segment I of the gonopod (figure 2 in Wuillot and Gillies 1993), imagines of *Cheleocloeon* do not possess unique characters that allow it to be distinguished from among the Afrotropical Baetidae that have single intercalary veins in the forewing. The presence of hind wings in the male and the absence in the female of the same species can be a very useful character but is not constant within the genus; the shape of the hind wing may be of some help, but is only known for a few species (Barnard 1932; Gattolliat and Sartori 2008). In the larval stage, the setation of the labrum (Figures 1, 2, 3 and 35) is the best character for separating *Cheleocloeon* from *Bugilliesia*. The

slender legs with elongated tarsal claws in *Cheleocloeon* (figures 42 and 43) clearly differ from the stout and compact legs of *Delouardus* (figure 7 in Lugo-Ortiz and McCafferty 1999). *Cheleocloeon* is the only genus of Baetidae that it distributed across the whole of Africa and the Arabian Peninsula, but nowhere else.

Cheleocloeon madagascariense Gattolliat & Monaghan sp. n.

Material examined. Holotype 1♂ larva; P0477; Madagascar; Tsiribihina Bas.; Loc. Amparaky RN1; Mazy Trib. of Sakay Riv.; 46°38'07"E/18°56'03"S; Alt. 975m.; 11.10.1995; Ralaiteferana A [MZL].

Paratypes. 2♀ larvae 477a and 477b (on slides) and 17 larvae, same data as holotype [MZL], [MNHM] and [AMGS].

Other material. 2♂ larvae 28b and 28c (on slides) and 8 larvae; P0028; Madagascar; Onilahy Bas.; Imaloto Riv.; 45°23'43"E/22°35'45"S; Alt. 780m.; 7.4.1991; ORSTOM, Antananarivo [MZL].

1♀ subimago 350-2 (on slides) with corresponding larval exuvia; Madagascar; Mandrare bas.; Sakamamba Riv.; Loc. Imanombo; 45°45'59"E, 24°28'32"S; Alt. 340 m; 09.06.1994; ORSTOM, Antananarivo [MZL].

1♀ larva 836d (on slide) and 1 larva; P0836; Madagascar; Antongombato Bas.; Loc. Mt Ambre; Antongombato Riv.; 49°14'37"E/12°19'32"S; 30.3.1999; Gattolliat J.-L. and Rabeantoandro Z. [MZL].

1 larva; P0865; Madagascar; Rianila Bas.; trib. of Sahatandra Riv.; Loc. Andasibe; 48°24'54"E/18°55'53"S; Alt. 975 m.; 10.04.1999. Gattolliat J.-L. and Raberiaka N. [MZL].

1 larva (on slide); P2020; Madagascar; Mandrare Bas.; Loc. Imanombo; Sakamamba Riv.; 45°45'59"E/24°28'32"S; 06.05.2003; mission MZL and Monaghan [MZL].

1♂ larva; MD053; Madagascar; Loc. Ifotaka (upstream village); Mandrare Riv.; Alt. 60m.; 31.08.2001; Gerecke R. and Goldschmidt T. [MZL].

1 larva; MD070; Madagascar; Loc. Andohahela, Isaka; Riv. South National Park.; Alt. 200m.; 09.09.2001; Gerecke R. and Goldschmidt T. [MZL].

1♂ larva; MD086; Madagascar; Loc. Fort Dauphin, Pic St Louis; Alt. 70m.; 17.09.2001; Gerecke R. and Goldschmidt T. [MZL].

1♀ larva; MD171; Madagascar; Loc. Analavory, near Aragonite geyser Carriere de Monloup; Mazy Riv.; Alt. 900m.; 01.12.2001; Gerecke R. and Goldschmidt T. [MZL].

Larva

Maximum length. Body 4.4 mm. Cerci 2.1 mm. Median caudal filament 2.0 mm.

Colouration. The material examined is uniformly yellow cream, but this faded colouration is probably due to the long stay in alcohol.

Head

Labrum (Figure 35). Dorsal surface of labrum with two long setae, a long submedian seta and a few thin setae scattered over the surface; distal margin bordered with long bifid setae apico-laterally and simple broad blunt setae apico-medially; ventral surface with two small pointed setae apico-laterally.

Hypopharynx (Figure 39) Lingua trilobate, covered only with minute setae apico-laterally; lingua shorter than superlingua, apically with long thin setae.

Right mandible (Figure 36). Two partially fused sets of incisors, outer and inner sets with four denticles; prostheca (Figure 37) slender, with four minute teeth apically; tuft of short setae between prostheca and mola; tuft of setae at the apex of the mola present; basal half with traces of insertion of setae dorsally.

Left mandible (Figure 38). One set of incisors, with seven denticles; stout prostheca with three teeth and a comb-shaped structure; tuft of short setae between prostheca and mola; tuft of setae at the apex of mola absent; basal half with traces of insertion of setae and a few setae dorsally.

Maxilla (Figure 40). Four teeth, none of them opposed to the others; one row of setae subequal in length to teeth; three setae at the base of the crown; row of two long stout setae and six thin setae at base of galea; one long stout seta perpendicular to margin of galea; palp two-segmented; longer than galealacinia, segment I approximately 0.8x length of segment II.

Labium (Figure 41). Glossae as broad as paraglossae; margin of glossae with short stout setae, longer apically; margin of paraglossae with long stout setae; labial palp stout; segment I with a few thin setae laterally, segment I subequal in length to segments II and III combined; segment II with a pointed disto-medial projection, with numerous small thin setae ventrally; with an oblique row of five setae dorsally; segment III subconical, slightly longer than broad, with medium pointed stout setae and numerous small thin setae.

Thorax

Hind wing pads absent in female and present in male.

Forelegs (Figure 42). Coxae with thin medium setae.

Femora slender, with dorsal and ventral margins parallel; dorsal margin with a row of about 11 short pointed setae, absent in the distal third; without row of setae subparallel to dorsal margin; dorso-apical setal patch formed by two small blunt setae; anterior face without setae; ventral margin with short pointed setae.

Tibiae without setae dorsally; ventral margin with short pointed setae.

Tarsi without setae dorsally; ventral margin with a row of about 20 pointed simple setae, increasing in length distally; tarsal claws (Figure 43) hooked and elongated, about 0.6 x length of tarsi, with vestigial teeth proximally.

Abdomen

Terga (Figure 44) with W-shaped scale bases, without setae; posterior margin with irregular spines.

Gills (Figure 45). Poorly tracheated, slightly serrated disto-laterally with a few short thin setae.

Paraproct (Figure 46) with about 65 W-shaped scale bases, margin with about 15 pointed spines; posterolateral extension with about 7 W-shaped scale bases, margin with a few minute spines.

Cerci with abundant extremely thin setae on the inner margin; median caudal filament similar to cerci except extremely thin setae on both margins.

Female subimago

Length. Body 4.2 mm; forewings 4.3 mm; cerci broken.

Colouration. Head, thorax, abdomen and legs uniformly light yellowish grey without any pattern.

Forewings (Figure 47). Hyaline without markings; pterostigma with at least four cross-veins. Hind wings absent.

Distribution

C. madagascariense has a wide distribution, encompassing the northern, eastern and southern regions of Madagascar. It can be locally abundant in the slow-flowing and stagnant parts of the stream.

Etymology

This species is named after Madagascar from where the species was collected.

Discussion

Cheleocloeon madagascariense can be separated from the African species *C. carinatum* and *C. yolandae* by the degree of development of the disto-medial projection of the segment II of the labial palp of the larva (Figure 41; figures 6, 15 in Wuillot and Gillies 1993) and by the presence/absence of the hind wing in the male (Wuillot and Gillies 1993). The larva of *Cheleocloeon madagascariense* possesses long tarsal claws with vestigial teeth (Figure 43), and differs in this respect to *C. excisum*, *C. littorale* McCafferty 2001 and *C. soldani* (Lugo-Ortiz and McCafferty 1997a; McCafferty 2001; Gattolliat and Sartori 2008). *C. falcatum* remains unknown at the larval stage but this is the only species of *Cheleocloeon* with female imagines possessing hind wings, differing at least on this point from *C. madagascariense* (McCafferty, 2001). Morphological studies of *C. madagascariense* and *Cheleocloeon spl* used for the molecular reconstruction (Monaghan et al. 2005; Gattolliat et al. 2008) clearly indicate that the two species are conspecific; consequently *C. madagascariense* is, to date, the only true species of *Cheleocloeon* found to occur in Madagascar.

Delouardus* Lugo-Ortiz & McCafferty, 1999*Diagnosis****Larva**

Labrum rounded (Figure 4); dorsal surface with an arc restricted to two stout lateral setae and one long submedian seta; distal margin with mainly simple setae. Right mandible (Figure 10) with two partially fused sets of incisors; prostheca broad with stout teeth, setae between prostheca and mola present. Left mandible (Figure 16) with a broad prostheca with a well differentiated comb-shaped structure, setae between prostheca and mola reduced. Maxilla (figure 5 in Lugo-Ortiz and McCafferty 1999) with elongated teeth; maxillary palp two-segmented, clearly longer than galea-laciania, segment II without excavation. Labium, paraglossae (Figure 22) apically falcate and tapered with one row of setae; labial palp segment II with a disto-medial projection rounded. Hind wing pads present in both sexes. Legs (figure 7 in Lugo-Ortiz and McCafferty 1999) stout; femora with only a reduced number of medium to long setae on the dorsal margin, tibio-patellar suture absent; tibia with subproximal arc of setae present; tarsal claw (figure 8 in Lugo-Ortiz and McCafferty 1999) elongated with two rows of small teeth, apical setae absent on tarsal claws. Distal margin of terga (figure 9 in Lugo-Ortiz and

McCafferty 1999) with triangular spines. Gills present on segment I–VII, elongated and slender.

Imago

Unknown.

Discussion

Delouardus shares several characters with *Cheleocloeon*, including similar mouthparts, slender gills and elongated and weakly hooked tarsal claws. *Delouardus* differs from *Cheleocloeon* by having stout and compact legs (figure 7 in Lugo-Ortiz and McCafferty 1999) and two rows of bluntly pointed teeth on the tarsal claw. Both morphological and molecular evidence suggests that *Delouardus* is the sister-group of *Cheleocloeon* (Gattolliat and Monaghan, in prep.). They are not closely related to *Bugilliesia* and they do not belong to the *Centroptiloides* complex as assumed by Lugo-Ortiz and McCafferty (1999). Future investigations of the imaginal stage of *Delouardus* might challenge the validity of the genus, and it is possible that *Delouardus djabala* is a plesiotypic species of *Cheleocloeon*. Within our present state of knowledge, *Delouardus* is a monospecific genus and is endemic to Madagascar.

***Delouardus djabala* Lugo-Ortiz & McCafferty, 1999**

Material examined. 1 larva 373a (on slide); Madagascar; Rianila Bas.; Loc. Andasibe; Trib. of Sahatandra Riv.; 48°24'54"E/18°55'53"S; Alt. 975m.; 12.4.1995; Sartori M. and Ruffieux L. [MZL].

1 larva; P0762; Madagascar; Rianila Bas.; Loc. 200 m upstream of the bridge; Sahatandra Riv.; 48°21'43"E/19°02'40"S; Alt. 1050m.; 16.10.1998; Legrand J. and Raberiaka N. [MZL].

1♀ larva 834b; Madagascar; Antongombato Bas.; Loc. between Diégo-Suarez and Namakia; unnamed Riv.; 49°16'50"E/12°19'40"S; Alt. 40m.; 30.3.1999; Gattolliat J.-L. and Rabeantoandro Z. [MZL].

1 larva; P2005; Madagascar; Mangoro Bas.; Loc. PK 20,4 road Anosibe an'Ala; unnamed Riv.; 48°14'00"E/19°05'53"S; Alt. 970m.; 03.04.2003; mission MZL and Monaghan [MZL].

Larva

For the original description see Lugo-Ortiz & McCafferty 1999, except:

Labial palp three-segmented with segment II and III almost fused; segment II with a round disto-medial projection; segment III subconical, broader than long.

Hind wing pads present.

Imago

Unknown.

Distribution

Delouardus djabala appears to be an extremely rare species, as only five specimens have been collected. To date, the species has been recorded from north and north-east Madagascar.

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References

- Barber-James, H.M., Gattolliat, J.L., Sartori, M., and Hubbard, M.D. (2008), 'Global diversity of mayflies (Ephemeroptera, Insecta) in freshwater', *Hydrobiologia*, 595, 339–350.
- Barber-James, H.M., and Lugo-Ortiz, C.R. (2003), 'Ephemeroptera' in *Guides to the Freshwater Invertebrates of Southern Africa Volume 7: Insecta 1*, eds. I.J. de Moor, J.A. Day and F.C. de Moor, Pretoria: Water Resource Commission, pp. 16–159.
- Barnard, K.H. (1932), 'South African may-flies (Ephemeroptera)', *Transactions of the Royal Society of South Africa*, 20, 201–259.
- Gattolliat, J.L. (2006), '*Bugilliesia* Lugo-Ortiz and McCafferty and allied genera (Baetidae, Ephemeroptera), with emphasis on West African fauna', *Mitteilungen der Schweizerischen Entomologischen Gesellschaft*, 79, 281–298.
- Gattolliat, J.L., Monaghan, M.T., Sartori, M., Elouard, J.M., James, H., Derleth, P., Glaizot, O., de Moor, F., and Vogler, A.P. (2008), 'A molecular analysis of the Afrotropical Baetidae', in *International Advances in the Ecology, Zoogeography and Systematics of Mayflies and Stoneflies*, eds. F.R. Hauer, J.A. Stanford and R.L. Newell, Berkeley: University of California Press, pp. 219–232.
- Gattolliat, J.L., and Sartori, M. (2008), 'Order Ephemeroptera', in *Arthropod Fauna of the UAE*, ed. A. van Harten, Abu Dhabi: Dar Al Ummah, pp. 47–83.
- Gillies, M.T. (1990), 'A revision of the African species of *Centroptilum* Eaton (Baetidae, Ephemeroptera)', *Aquatic Insects*, 12, 97–128.
- Lugo-Ortiz, C.R. (1999), 'Systematic studies of Baetidae (Insecta: Ephemeroptera), with emphasis on biodiversity in the Southern Hemisphere', unpublished Ph.D. dissertation, Purdue University, Dept. of Entomology.
- Lugo-Ortiz, C.R., and McCafferty, W.P. (1996), 'The *Bugilliesia* complex of African Baetidae (Ephemeroptera)', *Transactions of the American Entomological Society*, 122, 175–197.
- Lugo-Ortiz, C.R., and McCafferty, W.P. (1997a), 'Contribution to the systematics of the genus *Cheleocloeon* (Ephemeroptera: Baetidae)', *Entomological News*, 108, 283–289.
- Lugo-Ortiz, C.R., and McCafferty, W.P. (1997b), 'A new genus and redescription for African species previously placed in *Acentrella* (Ephemeroptera: Baetidae)', *Proceedings of the Entomological Society of Washington*, 99, 429–439.
- Lugo-Ortiz, C.R., and McCafferty, W.P. (1997c), 'New species and first reports of the genera *Cheleocloeon*, *Dabulamanzia*, and *Mutelocloeon* (Insecta: Ephemeroptera: Baetidae) from Madagascar', *Bulletin de la Société d'Histoire Naturelle de Toulouse*, 133, 47–53.
- Lugo-Ortiz, C.R., and McCafferty, W.P. (1998), '*Cheleocloeon falcatum* (Crass), a new combination for a southern African species previously assigned to *Afropitulum* Gillies (Ephemeroptera: Baetidae)', *African Entomology*, 6, 379–380.
- Lugo-Ortiz, C.R., and McCafferty, W.P. (1999), '*Delouardus*, a new *Centroptiloides* complex genus from Madagascar and its relationship with *Cheleocloeon* Wuillot & Gillies (Ephemeroptera: Baetidae)', *African Entomology*, 7, 63–66.

- McCafferty, W.P. (2001), 'New Baetidae (Insecta: Ephemeroptera) from Lake Malawi', *Bulletin de la Société d'Histoire Naturelle de Toulouse*, 136, 65–72.
- Monaghan, M.T., Gattolliat, J.L., Sartori, M., Elouard, J.M., James, H., Derleth, P., Glaizot, O., de Moor, F., and Vogler, A.P. (2005), 'Trans-oceanic and endemic origins of the small minnow mayflies (Ephemeroptera, Baetidae) of Madagascar', *Proceedings of The Royal Society, Series B - Biological Sciences*, 272, 1829–1836.
- Wuillot, J., and Gillies, M.T. (1993), '*Cheleocloeon*, a new genus of Baetidae (Ephemeroptera) from West Africa', *Revue d'Hydrobiologie Tropicale*, 26, 213–217.