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## ***Rheoptilum*: A New Genus of Two-Tailed Baetidae (Ephemeroptera) from Madagascar**

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### **Abstract**

*Rheoptilum* gen. n. is established for *R. arni* sp. n. and *R. lokohensis* sp. n. from Madagascar. Imaginal and larval stages are both described. *Rheoptilum* nymphs have two important adaptations: mouthparts are highly modified for scraping and the habitus is adapted for fast flowing waters. The genus possesses an extremely broad labrum with distal margin almost straight, incisors almost fused, right protheca long and slender, caudal filament reduced to a single segment, legs long and slender, dorsally bordered with long and thin setae and the body dorsoventrally flattened. This combination of features distinguishes *Rheoptilum* from other Afro-Malagasy baetid genera. The phylogenetic position of this new genus is discussed.

**Keywords:** Ephemeroptera, Baetidae, *Rheoptilum*, new genus, new species, Madagascar.

### **Introduction**

New species of two-tailed Baetidae, belonging to the genera *Afrobaetodes* Demoulin and *Afroptiloides* Gillies, have been recently described from Madagascar (Gattolliat & Sartori, 1999a; Gattolliat, accepted-b). These discoveries have greatly extended the distributions of these two genera. Two new species of two-tailed Baetidae are described herein; they are also highly adapted to fast flowing waters. Moreover, they possess mouthparts highly modified for scraping. This modification has been noted in different baetid lineages in Madagascar (Lugo-Ortiz & McCafferty, 1997a; Gattolliat, accepted-a; Gattolliat & Sartori, accepted). This unusual combination of two adaptations clearly distinguishes these species from any known genus. Consequently, a new genus is established to accommodate them.

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

***Rheoptilum* Gattolliat gen. n.****Description***Larva*

General habitus dorsoventrally flattened (Fig. 7)

*Head.* Labrum (Fig. 1) extremely broad, with distal margin almost straight, arc of numerous long setae subparallel to distal margin. Hypopharynx (Fig. 2) covered only with numerous thin setae, lingua without tuft of stout setae. Right mandible (Figs. 3a, b) with two sets of incisors, outer formed only by one single well-developed and laterally reinforced tooth and inner one reduced to a single small tooth; prostheca long and thin, without apical teeth; tuft of setae between prostheca and mola present. Left mandible (Figs. 4a, b) with incisors fused into a single well-developed and laterally reinforced tooth; prostheca with apical teeth; tuft of setae between prostheca and mola present. Maxillae (Fig. 5) with 4 teeth, distal one opposite to three others; palpi 3-segmented, shorter than galea-lacinia, with a basal segment well distinguishable. Labium (Fig. 6) with glossae shorter than paraglossae; palpi 3-segmented, segment 1 stout, second segment expended distally, segment 3 conical, almost as broad basally as second apically.

*Thorax.* One single process on medio-distal margin of meso- and metathorax (Fig. 8). Hindwing pad present (Fig. 8). Legs (Fig. 13a) long and slender. Femora without villopore. Dorsal margin of femora with a row of long setae. Tibiae twisted, without tibio-patellar suture on any leg. Tibiae and tarsi without arc of setae. Dorsal margin of tibiae and tarsi with a dense row of numerous long and thin setae; ventral margin with only a few minute setae. Tarsal claws (Fig. 13b) with 2 subequal rows of teeth and two subapical setae.

*Abdomen.* Terga (Fig. 9) with scales and thin setae, distal margin with blunt spines. Sterna without scales or scale bases, distal margin smooth. Asymmetrical gills on segments 1 to 7; margin not serrated. Two extremely long cerci, caudal filament reduced to a single segment.

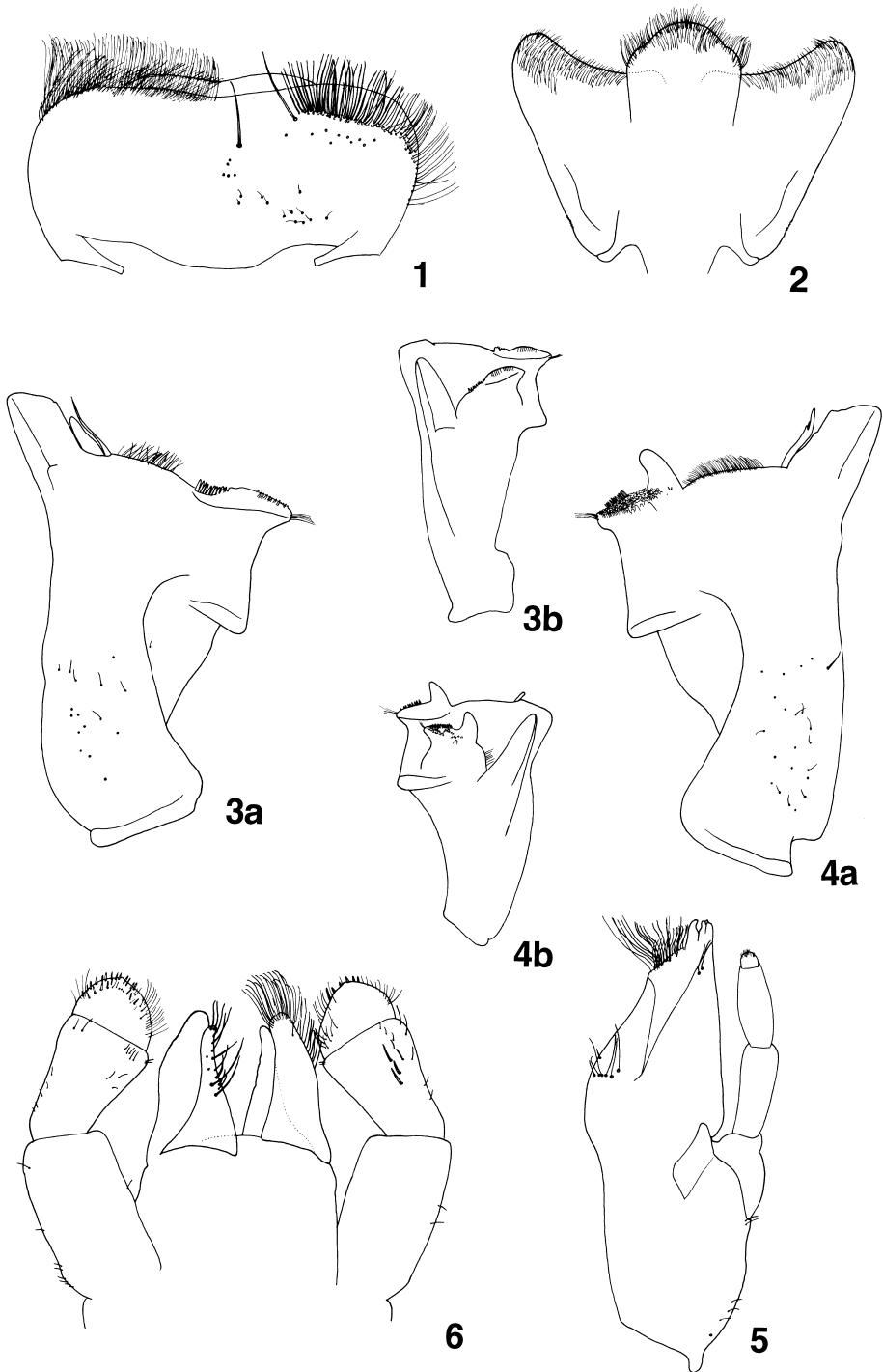
*Adult*

*Thorax.* Forewings (Fig. 14) hyaline with golden veins; a single intercalary vein between longitudinal veins, intercalaries extremely developed in proximal third; costal margin not serrated. Hindwings (Fig. 15) slender, with 2 well-developed longitudinal veins and a single well-developed spur on costal margin. Genitalia with 3-segmented gonopods, first segment without apophysis.

*Etymology.* The generic name is from the Greek *rheîn* which means to run fast (for a fluid) with an apposition of *-ptilum* in reference to the closely related genus *Dicentroptilum*.

*Type species:* *Rheoptilum arni* Gattolliat sp. n.

*Species included:* *Rheoptilum arni* Gattolliat sp. n.; *Rheoptilum lokohensis* Gattolliat sp. n.



Figures 1–6. Larval structures of *Rheoptilum arni*: (1) Labrum (left: ventral; right: dorsal); (2) Hypopharynx; (3a) Right mandible; (3b) Right worn mandible; (4a) Left mandible; (4b) Left worn mandible; (5) Left maxilla; (6) Labium.

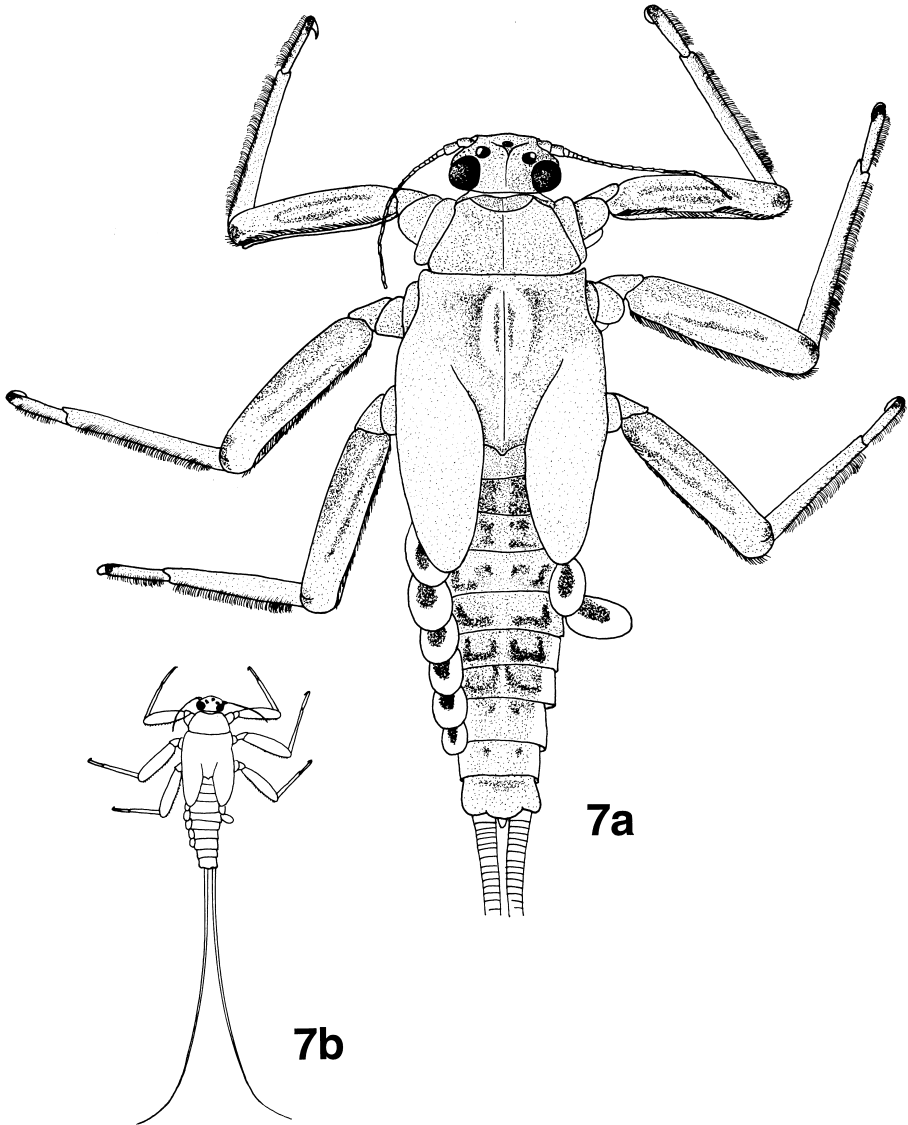


Figure 7. Larval structure of *Rheoptilum arni*: (7a and b) Dorsal view.

## Discussion

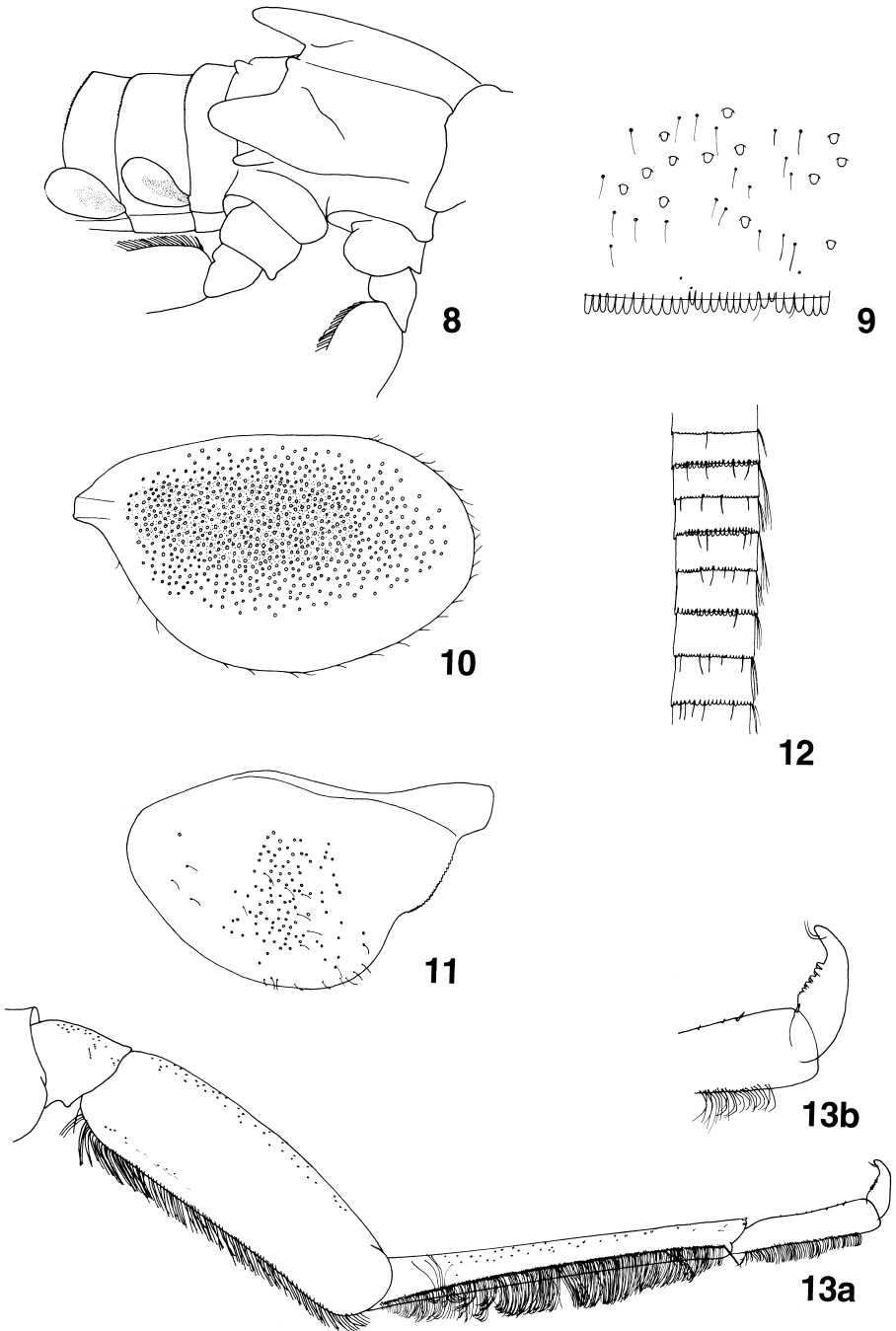
The larvae of *Rheoptilum* possess a high degree of specialization: mouthparts highly modified for scraping the top of stones and habitus adapted to fast flowing waters. These adaptations for scraping, such as incisors almost fused, one or both prosthecae generally reduced and slender, and labrum extremely broad with an almost straight

distal margin, are also found in three other genera present in Madagascar: *Xyrodromeus* Lugo-Ortiz & McCafferty, *Cloeodes* Traver (in part) and *Dabulamanzia* Lugo-Ortiz & McCafferty (in part) (Lugo-Ortiz & McCafferty, 1997a; Gattolliat, accepted-a; Gattolliat & Sartori, accepted). Nevertheless, *Rheoptilum* can be easily distinguished from *Cloeodes* and *Dabulamanzia* by the absence of a subproximal arc of setae on the tibiae and of tarsal claws with a double row of teeth (Waltz & McCafferty, 1987a; Lugo-Ortiz & McCafferty, 1996); the lack of these two features clearly indicates that *Rheoptilum* does not belong to the *Cloeodes* complex (Lugo-Ortiz & McCafferty, 1998b). *Rheoptilum* can be separated from *Xyrodromeus* by the following features: incisors of the right mandible fused to 2 teeth instead of a single as in *Xyrodromeus*, dorsal margin of tibiae and tarsi with a dense row of numerous long and thin setae, ventral margin of tibiae and tarsi with only few minute setae, and caudal filament reduced to a single segment.

With the caudal filament reduced to a single segment, long and slender legs with dense rows of long and thin setae on the dorsal margin of the tibiae and tarsi, *Rheoptilum* possesses similar adaptations as *Afroptiloides* Gillies, *Afrobaetodes* Demoulin, *Demoreptus* Lugo-Ortiz and McCafferty and *Tanzaniella* Gillies. *Rheoptilum* differs from all the Baetinae, and especially from the genera *Demoreptus* and *Tanzaniella*, by tarsal claws with a double row of teeth, absence of villopores (present at least in *Demoreptus*), presence of setae between prosthema and mola of both mandibles and, in the imaginal stage, forewings with a single intercalary vein (paired intercalary veins in *Demoreptus* and *Tanzaniella*) (Gillies, 1991a; Lugo-Ortiz & McCafferty, 1997b). *Afrobaetodes* possesses important apomorphic features which are not present in *Rheoptilum* such as: gills present on the apex of the first segment of the labial palpi, a pair of filamentous gills arising from the prosternum and the gill lamellae inserted on the ventral surface of the abdomen (Kimmins, 1955; Gillies, 1991b; Gattolliat & Sartori, 1999a). The highly developed medio-dorsal processes and well-developed tracheation of the abdominal gills are clearly apomorphic features that separate *Acanthiops* from *Rheoptilum* (Waltz & McCafferty, 1987b). *Rheoptilum* can be separated from *Afroptiloides* even if 2 of the 3 Malagasy species of *Afroptiloides* do not possess a medio-dorsal process on the terga. *Rheoptilum* does not possess important features of *Afroptiloides* such as ventral margin of the tarsi with a row of small and pointed setae ending with an extremely developed seta and pronotum strongly narrowed proximally and a process on the proximal area of the mesonotum (Gattolliat, accepted-b). On the other hand, *Rheoptilum* possesses highly adapted mouthparts which is not the case in *Afroptiloides*.

*Rheoptilum* clearly does not belong to the Baetinae nor to the *Cloeodes* complex. It also differs from other genera of the *Centroptiloides* complex (sensus Lugo-Ortiz and McCafferty, 1998) and the Cloeoninae (sensus Gillies, 1990). Consequently, the similarities between these genera appear to be due to convergent evolution in answer to a common life history (Gillies, 1991a).

Finally, *Dicentroptilum* Wuillot and Gillies appears to be the closest relative to *Rheoptilum*. This genus is not a classical two-tailed baetid (sensus Gillies, 1991a) nor is it specialized for scraping. Nevertheless, the presence of a row of thin setae on the dorsal margin of the tibiae and tarsi, the tarsal claws with two subequal rows of teeth,



Figures 8–13. Larval structures of *Rheoptilum arni*: (8) Meso- and metathorax with processes; (9) Distal margin of tergum; (10) Fourth gill; (11) Paraproct; (12) Left cercus; (13a) Left foreleg; (13b) Tarsal claw.

the shape of the labrum, the shape of the third segment of labial palpi, the left mandible with the incisors fused into a single tooth and the right one with incisors as two teeth (the inner one can be reduced in some species such as *D. merina* Lugo-Ortiz and McCafferty and additional undescribed Malagasy species), the terga with scales and setae and posterior margin with blunt spines are apomorphic features common to the two genera (Wuillot & Gillies, 1994; Lugo-Ortiz & McCafferty, 1998a).

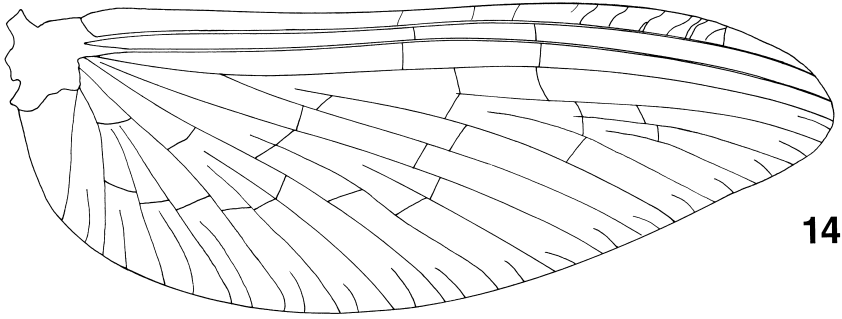
*Rheoptilum* has forewings with single intercalary veins. This feature distinguishes it from all the genera of the Baetinae, especially from *Demoreptus* and *Tanzaniella*. Moreover, these intercalary veins almost reach the transversal veins in the proximal third; this character is rather uncommon and generally considered plesiomorphic. The hindwings are characterized by a single spur on the costal margin and two longitudinal veins. In that, *Rheoptilum* differs from most of the genera of the *Centroptiloides* complex and the Cloeoninae and especially from *Afroptilum* (Lugo-Ortiz & McCafferty, 1998a; Gattolliat et al., 1999), *Dicentroptilum* (Wuillot & Gillies, 1994) and *Xyrodromeus* (Gattolliat, unpublished data). The only genus that has this combination of characters is the monospecific Malagasy genus *Nesoptiloides* Demoulin (Gattolliat & Sartori, 1999b). However, the shape of the genitalia clearly distinguishes the two genera. Moreover, *Nesoptiloides* possesses in the larval stage numerous apomorphies related to its carnivorous behaviour (Demoulin, 1973; Gattolliat & Sartori, in press).

*Rheoptilum arni* sp. n. (Figs. 1–19, 29–30)

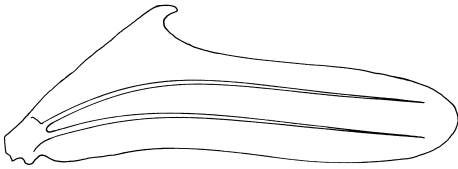
*Larva*

Maximal length: Male: Body 6.4 mm. Cerci 12.2 mm. Female: Body 6.9 mm. Cerci 14.5 mm.

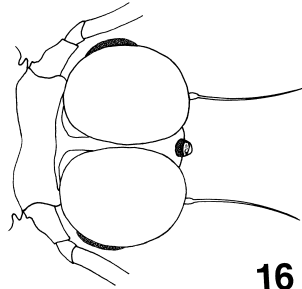
*Head.* Coloration almost uniformly light brown, vermiform marking slightly visible on vertex and frons. Antennae light yellow. Eyes and ocelli black. Labrum (Fig. 1) rectangular, ratio length-width relatively variable, but always greater than 1.8; distal margin with two rows of very abundant setae; dorsally with a continuous arc subparallel to margin composed of a triple row of numerous setae ending with a single submedian seta, few small setae in proximal half; without setae ventrally. Hypopharynx (Fig. 2) with distal margin of superlingua clearly incurved. Right mandible (Figs. 3a, b) with inner incisors reduced to a single small tooth; prosthema thin, unforked; tuft of subequal setae between prosthema and mola; tuft of setae at apex of mola well-developed; basal half with thin setae dorsally. Prosthema of left mandible (Fig. 4a) with apically a principal tooth and few poorly defined teeth; length of tuft of setae between prosthema and mola slightly reduced toward mola; tuft of setae at apex of mola well-developed; basal half with thin setae dorsally. Maxillae (Fig. 5), apex of galea with 2 rows of setae, one formed by abundant small setae and the other by longer and stouter setae, without pectinated or spine-like setae in middle of range; 6 setae at base of galea not arranged in a row; one single small seta perpendicularly



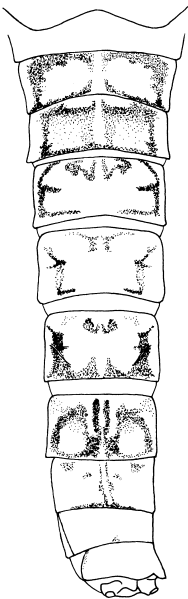
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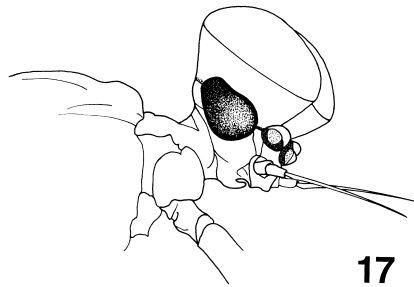
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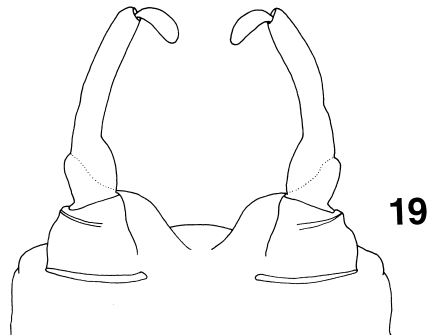
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Figures 14–19. Imaginal structures of *Rheoptilum arni*: (14) Forewing; (15) Hindwing; (16) Head (dorsal view); (17) Head (lateral view); (18) Abdomen (dorsal view); (19) Genitalia.



to margin of galea; palpi 3-segmented, first segment subequal to second and third combined; first and second segments almost bare; third segment rounded, as broad as long with numerous short setae at apex. Labium (Fig. 6), apical half of glossae slender with long setae on inner margin and apex; paraglossae rounded, with 2 rows of simple setae on second half of outer margin and apex; no seta on basal half of paraglossae. Labial palpi 3-segmented; first segment rectangular, subequal in length to second and third combined; second segment with a row of three stout setae and few thinner ones; third segment asymmetrical, with short and stout setae apically, long and thin setae laterally, especially numerous on inner margin.

*Thorax.* Coloration light brown, lighter medially (Fig. 7a). Legs light brown, except femora with a double brown band and apex dark brown. Forelegs with coxae with few minute setae (Fig. 13a). Femora dorsally with a row of numerous broad, blunt and slightly pectinate setae (Fig. 29); femoral patch formed by setae almost similar to those of dorsal margin (Fig. 30); submarginal row formed only by minute setae (Fig. 29), as on ventral margin (Fig. 13a). Tibiae dorsally with a double to triple row of long and thin setae; apex dorsally with a single straight seta; ventral margin with only minute setae (Fig. 13a). Tarsi dorsally with a single row of long and thin setae; ventral margin with only a row of minute setae, slightly longer apically; tarsal claws (Fig. 13b) with two rows of 5 to 6 teeth increasing in length toward apex. Second and third legs similar to forelegs.

*Abdomen.* Coloration of terga light brown, with darker pattern especially on terga 2 to 7 (Fig. 7a). Terga smooth (Fig. 9), with numerous scales and thin setae; distal margin with relatively regular, blunt spination. Sterna uniformly yellow; with few setae. Gills (Fig. 10) without visible tracheation, margin with only few thin setae apically and posteriorly; lamella dark brown. Paraproct (Fig. 11) with smooth margin without spines; surface covered with a few thin setae and without scale bases; posterolateral extension not clearly differentiated from paraproct, margin with very minute denticules; without scale bases or setae. Cerci more than twice length of body (Fig. 7b); very few swimming setae on inner margin; segments with distal margin alternatively with well-developed and poorly developed spination (Fig. 12).

#### *Male imago*

Maximal length: Body 6.2 mm. Cerci broken. Forewings 7.1 mm. Hindwings 0.7 mm.

*Head.* Almost uniformly light brown. Turbinate eyes yellowish-brown with a darker band at base (Figs. 16, 17). Antennae light brown; first segment of flagellum incurved ventrally.

*Thorax.* Pterostigma of forewings (Fig. 14) with about 10 cross veins, generally reaching subcostal vein, apical ones forked. Hindwings (Fig. 15) with 2 well-developed longitudinal veins, joined at base.

*Abdomen.* Terga light brown, with brown marking, especially terga 2, 3, 6 and 7 (Fig. 18). Sterna yellowish-brown. Genitalia (Fig. 19) with 3-segmented gonopods, limit between first and second barely visible. Basal segment stout involving first segment laterally. First segment broader than second, without setae on margin; second segment elongated, narrow especially at basis; third segment pear-shaped.

*Female imago*

Maximal length: Body 6.7 mm. Cerci broken. Forewings 7.9 mm. Hindwings 0.8 mm. Coloration and other characters similar to male, except sexual features.

*Material examined.* *Holotype*, one larva, P0212, Madagascar, Basin Namorona, River Ambatoharanana, Locality Ranomafana, 47°27'34"E, 21°15'15"S, altitude 800 m, 17.4.1994. J.-M. Elouard and M. Sartori. *Paratypes*, 117 larvae, same data as holotype. Ten larvae, P0214, Madagascar, Bas. Namorona, Riv. Ambatandrano, Loc. Ambatandrano, 47°26'32"E, 21°14'45"S, altitude 775 m, 17.4.1994. J.-M. Elouard and M. Sartori.

One male imago with larval and subimaginal corresponding exuviae, P0215, Madagascar, Bas. Namorona, Tributary riv. of Namorona, Loc. Ranomafana Reserve, 47°25'11"E, 21°15'40"S, altitude 1200 m, 18.4.1994. J.-M. Elouard and M. Sartori. One larva, same data.

*Other material.* 2 female imagines with larval and subimaginal corresponding exuviae, P0112, Madagascar, Bas. Mangoro, Riv. Mangoro, Loc. Mangoro (bridge), 48°06'32"E, 18°52'32"S, altitude 840 m, 15.11.1991. J.-M. Elouard. 7 larvae, P0508, same locality as P0112, 18.10.1995. J.-M. Elouard. 2 larvae, P0168, Madagascar, Bas. Manampatrana, Riv. Sahavatoy, Loc. Andringitra Camp 2, 47°00'50"E, 22°13'33"S, altitude 1390 m, 20.11.1993. J.-M. Elouard. 3 larvae, P0540, Madagascar, Bas. Manampanihy, tributary river to Andranohela, Loc. Camp I Andohahela, 46°45'31"E, 24°36'37"S, altitude 575 m, 24.11.1995. J.-M. Elouard. 1 larva, P0587, Madagascar, Bas. Mangoro, Riv. Tsaratanana, Loc. Ankirihitra, 47°17'37"E, 19°23'00"S, altitude 1700 m, 14.4.1996. J.-M. Elouard and R. Oliarinony.

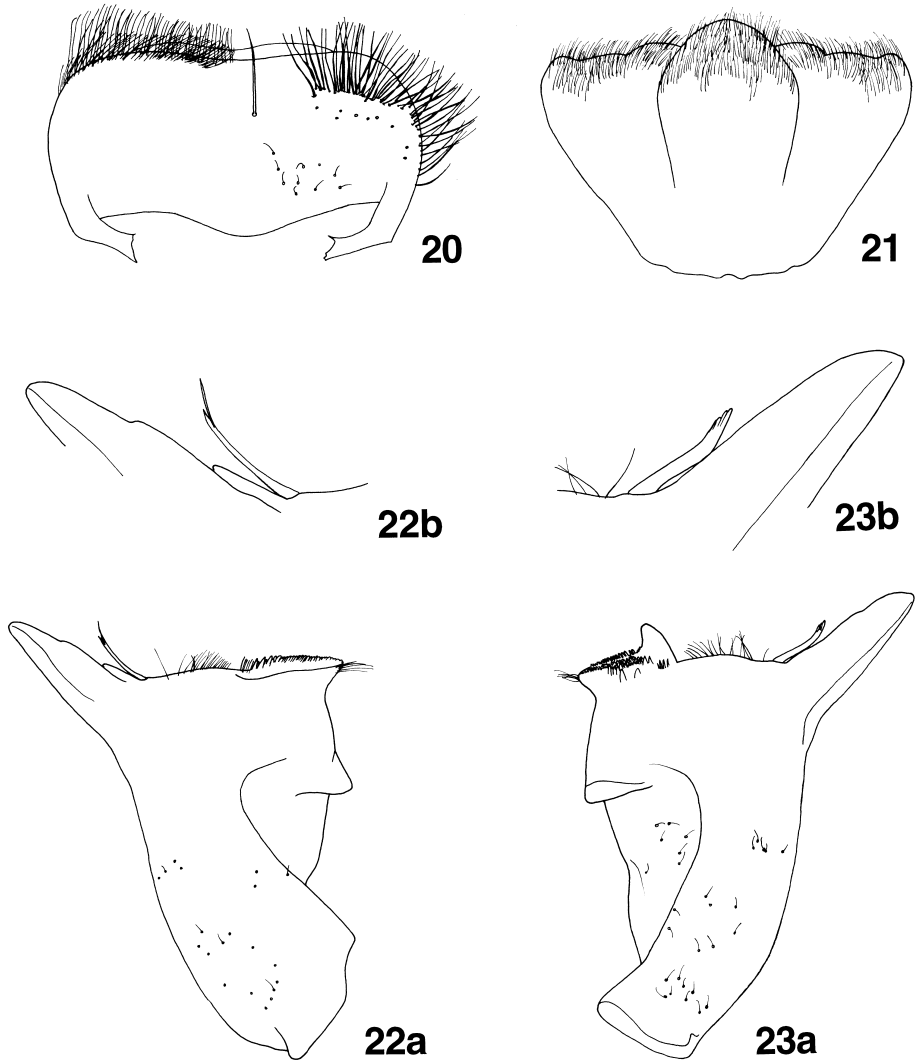
*Distribution and ecology.* This species appears to possess a wide distribution on the Eastern coast of Madagascar. It occurs in four different basins, which is unusual in comparison to *Afroptiloides* where each species is restricted to a single basin, and especially for *Afrobaetodes* which has been caught in a single locality. The larvae live in small to large rivers, with fast flow and little depth. They have been caught in primary forest as well as degraded area. Even if this species is present in areas intensely prospected, the imagines have never been caught by light traps, suggesting that this species has a diurnal activity.

*Etymology.* This species is dedicated to Arno Gattolliat.

*Rheoptilum lokohensis* sp. n. (Figs. 20–28)*Larva*

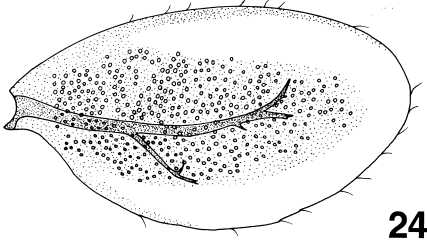
Maximal length: Body 4.0 mm. Cerci 9.5 mm.

*Head.* Coloration almost uniformly light brown, with vermiform marking on vertex and frons. Antennae light yellow. Eyes and ocelli black. Labrum (Fig. 20) rectangular, with two rows of very abundant setae; dorsally with a continuous arc composed of a single to double row of numerous setae ending with a submedian seta, few small

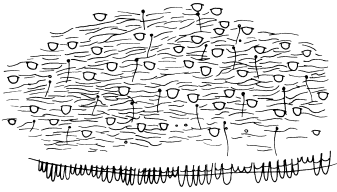


Figures 20–23. Larval structures of *Rheoptilum lokohensis*: (20) Labrum (left: ventral; right: dorsal); (21) Hypopharynx; (22a) Right mandible; (22b) Detail of right mandible; (23a) Left mandible; (23b) Detail of left mandible.

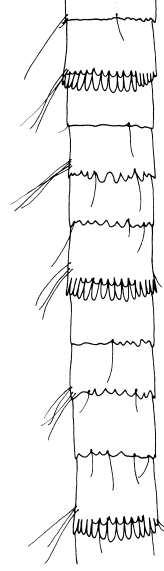
setae in proximal half; without setae ventrally. Hypopharynx (Fig. 21) with distal margin of superlingua relatively straight. Right mandible (Figs. 22a, b) with outer incisor turned backwards and inner one reduced to a single minute tooth; prostheca long and thin, forked; tuft of setae between prostheca and mola reduced in length toward the mola; tuft of setae at apex of mola well-developed; basal half with thin setae dorsally. Left mandible (Figs. 23a, b) with incisor turned backwards; prostheca with poorly defined teeth; length of tuft of setae between prostheca and mola slightly



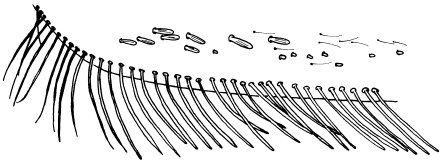
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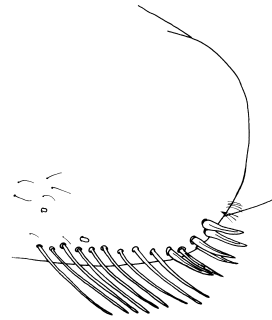
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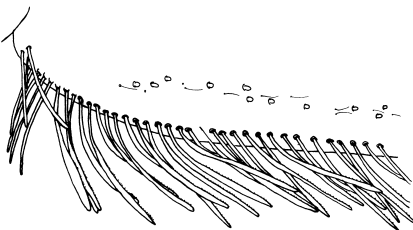
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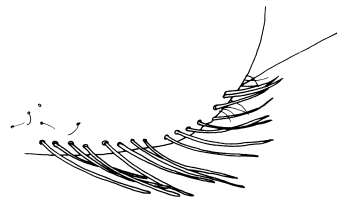
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Figures 24–30. Larval structures of *Rheoptilum* spp: (24–28) *R. lokohensis*. (24) Fourth gill; (25) Distal margin of tergum; (26) Right cercus; (27) Dorsal margin (third basal); (28) Dorsal margin (apex). (29–30) *R. arni*. (29) Dorsal margin (third basal); (30) dorsal margin (apex).

reducing toward mola; tuft of setae at apex of mola well-developed; basal half with thin setae dorsally. Maxillae and labium as in Figures 5 and 6, respectively.

*Thorax.* Coloration brown, medially darker with a light brown band. Legs brown, except femora with a light band and apex dark brown. Forelegs similar to Figure 13a except femora dorsally with a row of numerous broad, blunt setae which are not pectinate (Fig. 27); femoral patch formed by stout, dark brown setae, shorter than those on dorsal margin (Fig. 28); submarginal row formed by small setae and also minute ones (Fig. 27). Second and third legs similar to forelegs.

*Abdomen.* Coloration: terga 2 to 7 brown, with darker pattern, terga 8 to 10 light brown. Terga shagreened, with numerous scales and thin setae; distal margin with irregular, blunt spination (Fig. 25). Sterna uniformly yellow, with few setae. Gills (Fig. 24) with tracheation reduced but visible, margin with only few thin setae apically and posteriorly; lamella dark brown. Paraproct as in Figure 11. Cerci more than twice length of body; segments alternatively with and without very few swimming setae on inner margin; every fourth segment with well-developed distal marginal spines.

#### *Male and female imagines*

Unknown.

*Material examined.* *Holotype*, one larva, P0620, Madagascar, Bas. Lokoho, unnamed riv., Loc. Marojejy Camp II, 49°45'37"E, 14°26'10"S, altitude 750 m, 14.10.1996. J. Legrand and D. Randriamasimanana. *Paratypes*, 58 larvae, same data as holotype. One larva, P0606, Madagascar, Bas. Lokoho, Riv. Manantenina, Loc. Marojejy Camp I, 49°46'20"E, 14°26'02"S, altitude 420 m, 4.10.1996. One larva, P0621, Madagascar, Bas. Lokoho, unnamed riv., Loc. Marojejy Camp II, 49°45'33"E, 14°26'05"S, altitude 750 m, 15.10.1996. One larva, P0623, Madagascar, Bas. Lokoho, Riv. Manantenina, Loc. Marojejy Camp II, 49°45'37"E, 14°25'57"S, altitude 720 m, 17.10.1996. One larva, P0624, same locality as P0621, 18.10.1996. All coll. J. Legrand and D. Randriamasimanana.

*Distribution and ecology.* This species is restricted to a single basin on the Eastern coast. It occurs in very small streams less than 2 meters wide, with very fast flow (0.7 to 1 m/s) and little depth (less than 0.3 m). It has been caught only in intact humid forest at altitudes ranging from 450 to 750 m above sea level. Although, evening and morning light traps have been set during two weeks in the investigated area, no imagines were caught. Unfortunately, rearings were unsuccessful.

*Etymology.* This species is named after the basin Lokoho where all specimens were collected.

## Discussion

The two species can be easily distinguished at low magnification, by the dark brown venation of the gills in *R. lokohensis* (Fig. 24), while venation is absent in *R. arni*, and the dark brown, short and stout setae of the femoral patch in *R. lokohensis*

(Fig. 28). At higher magnification, they can be separated by the shape of the external incisors of the mandibles (Figs. 3a, 4a, 22a, 23a), the submarginal femoral row formed only by minute (*R. arni*, Fig. 29) or by small and minute setae (*R. lokohensis*, Fig. 27), and the terga smooth (*R. arni*, Fig. 9) or shagreened (*R. lokohensis*, Fig. 25).

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