

The genus *Cloeodes* (Ephemeroptera: Baetidae) in Madagascar

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The genus *Cloeodes* (Ephemeroptera: Baetidae) in Madagascar. - The genus *Cloeodes* has been recently reported from Madagascar by a single species. In this paper, I describe three new species: *Cloeodes bicoloratus*, *C. freitagae* and *C. pseudoglodius*. Features on mouthparts, gills, paraproct as well as general pattern and coloration allow to distinguish them easily. The four Malagasy species constitute an homogenous lineage, that can be separated from all the other species of *Cloeodes* by the shape of the third segment of the labial palp, the general habitus, the shape of the legs and the presence of setae between prostheca and mola.

Key-words: Ephemeroptera - Baetidae - *Cloeodes* - new species - Madagascar

INTRODUCTION

The genus *Cloeodes* has been erected by Traver for specimens collected in Puerto-Rico. Waltz and McCafferty showed that this genus is also present in South and Middle America as well as in the Oriental region (Waltz & McCafferty, 1987a, 1987b). Additional species have recently been described from Africa (Waltz & McCafferty, 1994), Australia (Lugo-Ortiz & McCafferty, 1998) and Madagascar (Lugo-Ortiz *et al.*, 1999). Consequently *Cloeodes* presents an unusual pantropical distribution (Sartori *et al.*, 2000). I shall describe herein three new species. At the present time, the Malagasy fauna has four species; they present all the important apomorphies of the genus *Cloeodes*. However, they also possess different features such as a stocky general habitus, stocky legs and presence of setae between prostheca and mola that clearly indicate they form a distinguishable lineage among the genus.

One of the species presents high adaptation of the mouthparts for scrapping. These modifications are unique among the genus. Three other Malagasy genera exhibit similar adaptations. These similarities must be considered as strict convergences and in any case as synapomorphies (Lugo-Ortiz & McCafferty, 1997; Gattolliat, 2001; Gattolliat & Sartori, 2000).

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

Cloeodes bicoloratus sp. n.

Figs 1-12

Material examined

Holotype. One larva, P0199, Madagascar, Bas. Antongombato, Riv. Makis, Roussette station, Long. 49°10'21" E, Lat. 12°31'38" S, Alt. 1075m, 2.4.1994. J.-M. Elouard and M. Sartori.

Paratypes. 5 larvae 199a, 199b, 199c, 199d, 199e (on slides) and 52 other larvae, P0199, same data as holotype. One larva, P0196, same locality as holotype, 30.3.1994. J.-M. Elouard and M. Sartori. One larva, P0806, same locality as holotype, 20.3.1999. J.-L. Gattolliat and Z. Rabeantoandro.

Larva.

Maximal length (fully grown specimen): Body 5.0 mm. Cerci 2.2 mm. Terminal filament 2.0 mm.

Head. Middle brown with vermiform marking on vertex and front, lighter between antennae. Antennae pale yellowish brown. Eyes and ocelli black, turbinated eyes brown.

Labrum (Fig. 1) as broad as long; rounded with a narrow anteromedial emargination; distal margin bordered with bifid or trifid setae; dorsally with a single submedial pair of symmetrical long setae, short arc of about 7 long setae from the lateral margin to the first third of the labrum.

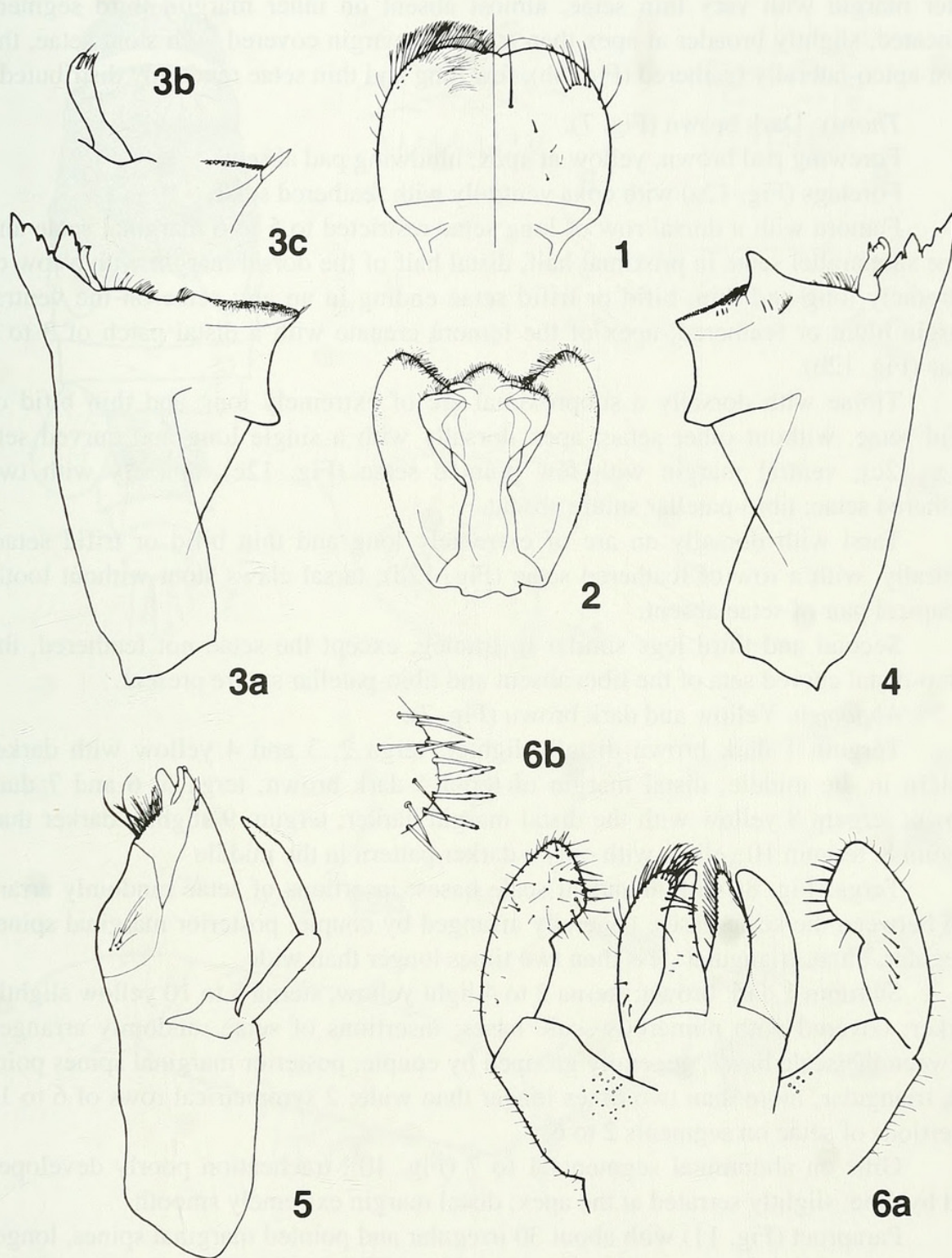
Hypopharynx as in figure 2; lingua covered with thin setae but without bristle tuft at the apex; superlingua poorly expanded.

Right mandible (Fig. 3a) with two sets of 4 and 3 incisors; prostheca short and stout (Fig. 3b); relatively scarce setae between prostheca and mola; small tuft of thinner setae beneath the mola; tuft of setae at the apex of the mola reduced to a spine-like seta and a thin seta (Fig. 3c); basal half without setae dorsally.

Left mandible (Fig. 4) with two sets of incisors almost fused to a group of 2 major and 4 smaller teeth; prostheca well-developed, with 3 teeth together with a comb-shaped structure; tuft of setae between prostheca and mola present; bases of the mola with a depression covered with thin setae; tuft of setae at the apex of mola absent; basal half without setae dorsally.

Maxillae (Fig. 5) with 4 teeth, inner one opposite to the three others; 2 rows of setae formed by abundant small setae and long stout setae ending with two setae twice as long as the others; in middle of range, no pectined or spine-like setae; 5 to 6 sometimes bifid setae at bases of galea not arranged in a row; 1 single very small seta perpendicularly to the margin of the galea; palp 2-segmented, first segment shorter than the second; second segment pointed and slightly constricted.

Labium (Fig. 6a) with glossae subegal to paraglossae; 2/3 apical of the inner margin of glossae with stout setae, outer margin with thinner setae, few small stout setae on the ventral side; paraglossae apically rounded, with 2 rows of simple setae, second row forming an arc subparallel to margin; 3 stout simple setae on outer bases of paraglossae. Labial palp 3-segmented; first segment stout, shorter than the second and third combined, inner margin partially covered with micropores, very thin setae on the outer margin; dorsal side of second segment with a row of about five setae,



FIGS 1-6

Larval structures of *Cloeodes bicoloratus*. 1: labrum (left: ventral; right: dorsal). 2: hypopharynx. 3a: right mandible. 3b: right prostheca. 3c: apex of the mola. 4: left mandible. 5: left maxilla. 6a: labium. 6b: apex of the third segment of the labial palp.

outer margin with very thin setae, almost absent on inner margin; third segment truncated, slightly broader at apex than at bases, margin covered with stout setae, the most apico-laterally feathered (Fig. 6b), few long and thin setae randomly distributed.

Thorax. Dark brown (Fig. 7).

Forewing pad brown, yellow at apex; hindwing pad absent.

Forelegs (Fig. 12a) with coxa ventrally with feathered setae.

Femora with a dorsal row of long setae restricted to 5 to 6 marginal setae and three subparallel setae in proximal half, distal half of the dorsal margin with a row of extremely long and thin, bifid or trifid setae ending in an arc; setae on the ventral margin blunt or feathered; apex of the femora crenate with a distal patch of 3 to 4 setae (Fig. 12b).

Tibiae with dorsally a subproximal arc of extremely long and thin bifid or trifid setae, without other setae; apex dorsally with a single long and curved seta (Fig. 12c); ventral margin with few pointed setae (Fig. 12c), apically with two feathered setae; tibio-patellar suture absent.

Tarsi with dorsally an arc of extremely long and thin bifid or trifid setae; ventrally, with a row of feathered setae (Fig. 12d); tarsal claws stout without tooth, subapical pair of setae absent.

Second and third legs similar to foreleg, except the setae not feathered, the dorso-distal curved seta of the tibia absent and tibio-patellar suture present.

Abdomen. Yellow and dark brown (Fig. 7).

Tergum 1 dark brown distally lighter; terga 2, 3 and 4 yellow with darker pattern in the middle; distal margin of terga 4 dark brown; terga 5, 6 and 7 dark brown; tergum 8 yellow with the distal margin darker; tergum 9 slightly darker than tergum 8; tergum 10 yellow with only a darker pattern in the middle

Terga (Fig. 8) with abundant scale bases; insertions of setae randomly arranged between the scale bases, generally arranged by couple; posterior marginal spines irregular, blunt, triangular, less than two times longer than wide.

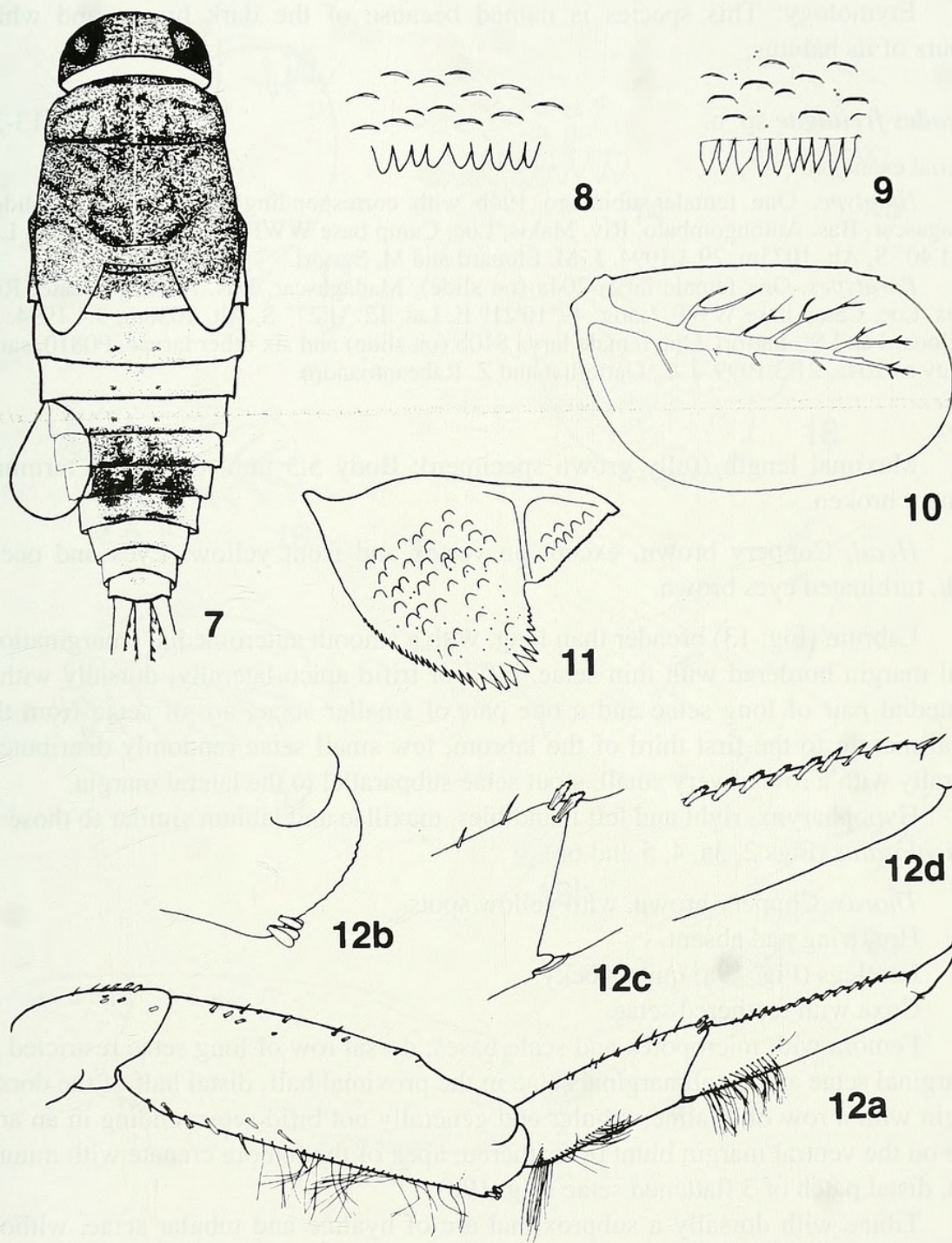
Sternum 1 dark brown; sternum 2 to 4 light yellow, sternum 5 to 10 yellow slightly darker; covered with numerous scale bases; insertions of setae randomly arranged between the scale bases, generally grouped by couple; posterior marginal spines pointed, triangular, more than two times longer than wide; 2 symmetrical rows of 6 to 10 insertions of setae on segments 2 to 6.

Gills on abdominal segments 1 to 7 (Fig. 10), tracheation poorly developed and hyaline; slightly serrated at the apex; distal margin extremely smooth.

Paraproct (Fig. 11) with about 30 irregular and pointed marginal spines, longer at the apex; surface covered with more than 30 scale bases; insertion of setae randomly distributed mostly abundant near the apex; postero-lateral extension with numerous small denticles along the margin; about 8 scale bases subparallel to the margin.

Cerci and median caudal filament light brown, darker at the apex; tuft of setae on the inner margin of the cerci and on both margins of the median filament.

Male and female imagoes unknown.



FIGS 7-12

Larval structures of *Cloeodes bicoloratus*. 7: habitus (dorsal view). 8: distal margin of the fourth tergum. 9: distal margin of the fourth sternum. 10: fourth gill. 11: paraproct. 12a: left foreleg. 12b: apex of the forefemur. 12c: apex of the foretibia. 12d: detail of the foretarsus.

Etymology: This species is named because of the dark brown and white colours of its habitus.

Cloeodes freitagae sp. n.

Figs 13-22

Material examined

Holotype. One female subimago 194b with corresponding larval skin (on slide), Madagascar, Bas. Antongombato, Riv. Makis, Loc. Camp base WWF, Long. 49°10'09" E, Lat. 12°31'40" S, Alt. 1075m, 29.3.1994. J.-M. Elouard and M. Sartori.

Paratypes. One female larva 204a (on slide), Madagascar, Bas. Antongombato, Riv. Makis, Loc. Camp base WWF, Long. 49°10'21" E, Lat. 12°31'27" S, Alt. 1030m, 3.4.1994. J.-M. Elouard and M. Sartori. One female larva 810b (on slide) and six other larvae, P0810, same locality as 204a, 21.3.1999. J.-L. Gattolliat and Z. Rabeantoandro.

Larva.

Maximal length (fully grown specimen): Body 5.5 mm. Cerci and terminal filament broken.

Head. Coppery brown, except on vertex and front yellow. Eyes and ocelli black, turbinate eyes brown.

Labrum (Fig. 13) broader than long, with a smooth anteromedial emargination; distal margin bordered with thin setae, bifid or trifid apico-laterally; dorsally with a submedial pair of long setae and a one pair of smaller setae, arc of setae from the lateral margin to the first third of the labrum, few small setae randomly distributed; ventrally with a row of very small, stout setae subparallel to the lateral margin.

Hypopharynx, right and left mandibles, maxillae and labium similar to those of *C. bicoloratus* (Figs 2, 3a, 4, 5 and 6a).

Thorax. Coppery brown, with yellow spots.

Hindwing pad absent.

Forelegs (Fig. 19a) quite stocky.

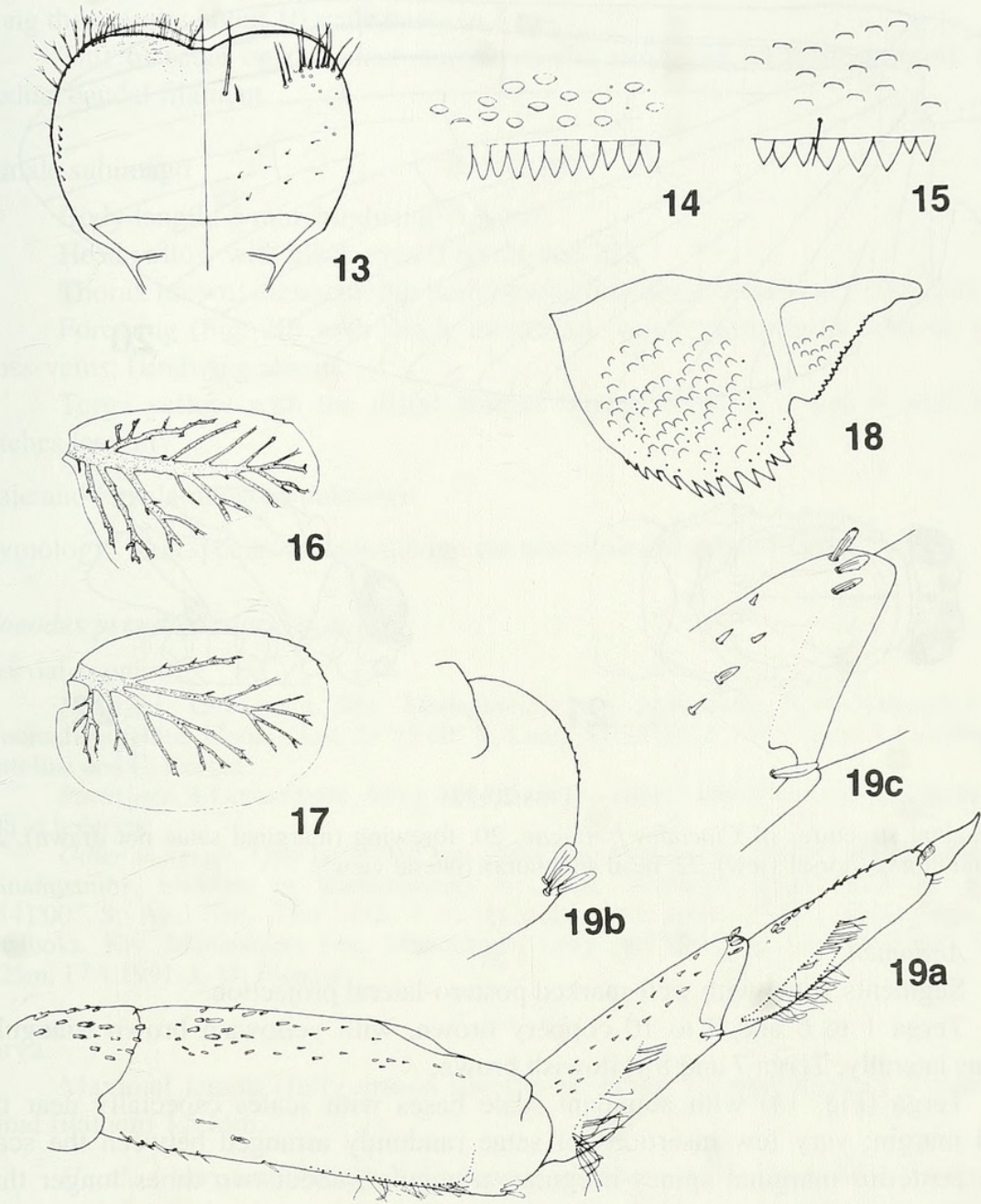
Coxa with feathered setae.

Femora with micropores and scale bases; dorsal row of long setae restricted to 8 marginal setae and 2 submarginal setae in the proximal half, distal half of the dorsal margin with a row of hyaline, tubular and generally not bifid setae, ending in an arc; setae on the ventral margin blunt or feathered; apex of the femora crenate with minute teeth, distal patch of 3 flattened setae (Fig. 19b)

Tibiae with dorsally a subproximal arc of hyaline and tubular setae, without other setae; apex subdorsally with a single spatulated seta (Fig. 19c); ventral margin with pointed setae, apically with two feathered and one acute setae (Fig. 19c); tibio-patellar suture absent.

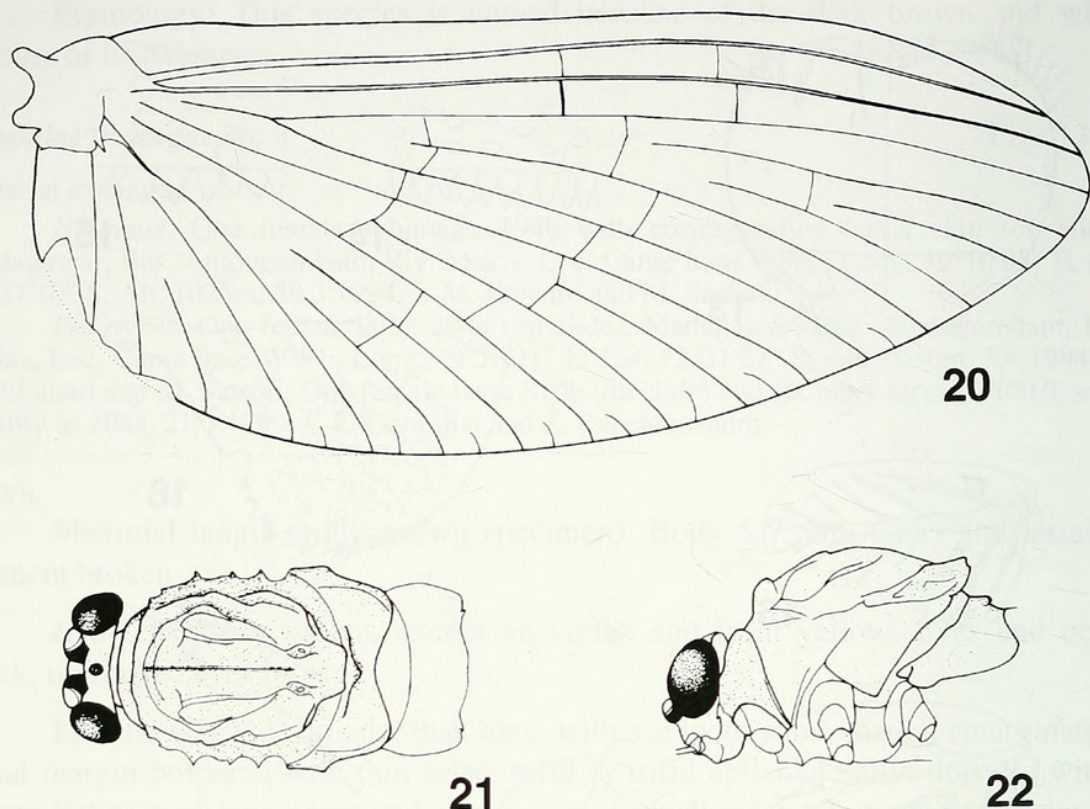
Tarsi with dorsally an arc of long and hyaline and tubular setae; ventrally, with a row of feathered setae; tarsal claws (Fig. 12) stout without tooth, subapical pair of setae absent.

Second and third legs similar to foreleg, except setae not feathered, the dorso-distal spatulated seta of the tibia absent and the acute setae on the ventral margin less abundant and tibio-patellar suture present.



FIGS 13-19

Larval structures of *Cloeodes freitagae*. 13: labrum (left: ventral; right: dorsal). 14: distal margin of the fourth tergum. 15: distal margin of the fourth sternum. 16: fourth gill. 17: sixth gill. 18: paraproct. 19a: left foreleg. 19b: apex of the forefemur. 19c: apex of the foretibia.



FIGS 20-22

Subimaginal structures of *Cloeodes freitagae*. 20: forewing (marginal setae not drawn). 21: head and thorax (dorsal view). 22: head and thorax (lateral view).

Abdomen

Segments 1 to 4 with well-marked postero-lateral projection.

Terga 1 to 6 and 9 to 10 coppery brown, with yellowish brown triangular patterns laterally. Terga 7 and 8 yellowish brown.

Terga (Fig. 14) with abundant scale bases with scales especially near the lateral margin; very few insertions of setae randomly arranged between the scale bases; posterior marginal spines irregular, triangular, about two times longer than wide.

All sterna (Fig. 15) uniformly light yellow; covered with numerous scale bases; very few insertions of setae; posterior marginal spines pointed, triangular, slightly longer than wide; 2 symmetrical rows of 7 to 11 insertions of setae on segments 2 to 6.

Gills (Fig. 17) on abdominal segments 1 to 7, tracheation well-developed and dark; serrated at the apex; only the leading edge sclerified, distal margin extremely smooth.

Paraproct (Fig. 18) with about 20 irregular and pointed marginal spines; surface covered with more than 50 scale bases; setae insertion randomly distributed

most abundant near the margin; postero-lateral extension with small blunt spines along the margin; about 10 scale bases in 3 rows.

Tuft of setae on the inner margin of the cerci and on both margins of the median caudal filament.

Female subimago

Body length: 5 mm, hindwing: 5,9 mm.

Head yellow with black eyes (Figs 21 and 22).

Thorax brown; metascutellar hump projecting dorso-posteriorly (Fig. 22).

Forewing (Fig. 20) with single intercalary veins; pterostigma without visible cross-veins. Hindwing absent.

Terga yellow with the distal margin brown; terga 3, 5 and 6 with brown patches laterally.

Male and female imagoes unknown

Etymology: This species is dedicated to the entomologist Anne Freitag.

Cloeodes pseudogladus sp. n.

Figs 23-34

Material examined

Holotype. One larva 644, Madagascar, Bas. Namorona, Riv. Namorona, Loc. Ranomafana (Hôtel Manja), Lat. 21°15'40" S, Long. 47°27'28" E, Alt. 725m, 8.11.1996. J.-L. Gattolliat and C. Rochat.

Paratypes. 4 Larvae 644c, 644d, 644e, 644f (on slides) and fifteen larvae, P0644, same data as holotype

Other material. One larva 91d (on slide) and two larvae, P0091, Madagascar, Bas. Manampanihy, tributary of Manampanihy riv., Loc. Fenoëvo, Long. 46°53'39" E, Lat. 24°41'00" S, Alt. 70m, 15.4.1992, J.-M. Elouard. One larva, P0045, Madagascar, Bas. Betsiboka, Riv. Manankazo, Loc. Manankazo, Long. 47°12'39" E, Lat. 18°09'23" S, Alt. 1425m, 17.4.1991. J.-M. Elouard.

Larva.

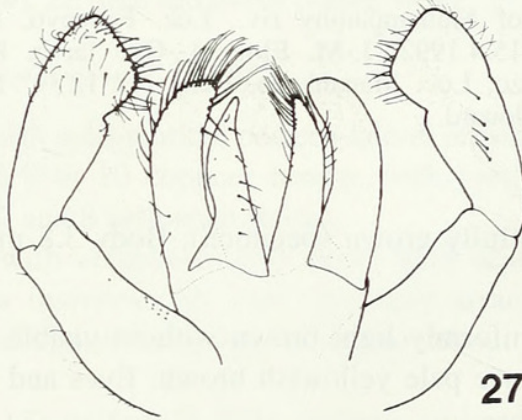
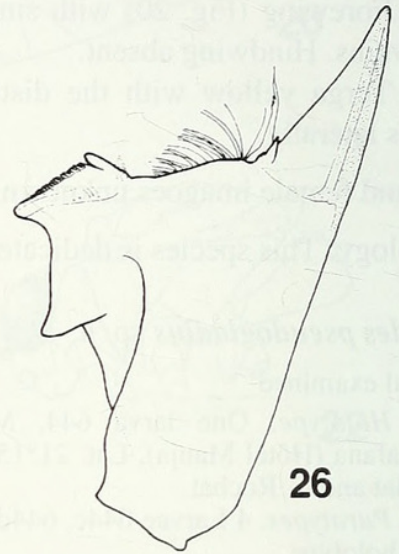
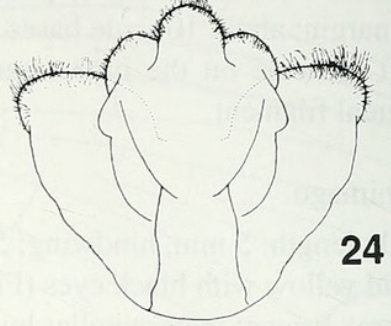
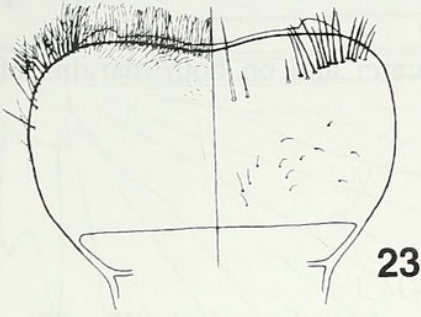
Maximal length (fully grown specimen): Body 3.8 mm. Cerci 1.7 mm. Terminal filament 1.5 mm.

Head. Almost uniformly light brown without visible vermiform marking on vertex and front. Antennae pale yellowish brown. Eyes and ocelli black, turbinate eyes brown.

Labrum (Fig. 23) rectangular almost without anteromedial emargination; apical lip with two apophyses laterally; distal margin bordered with thin setae, multifid apico-laterally; dorsally with a submedial pair of long setae and a pair of smaller setae, arc of 14 to 18 long and stout setae from the lateral margin to the first half of the labrum, few randomly distributed setae in the proximal half.

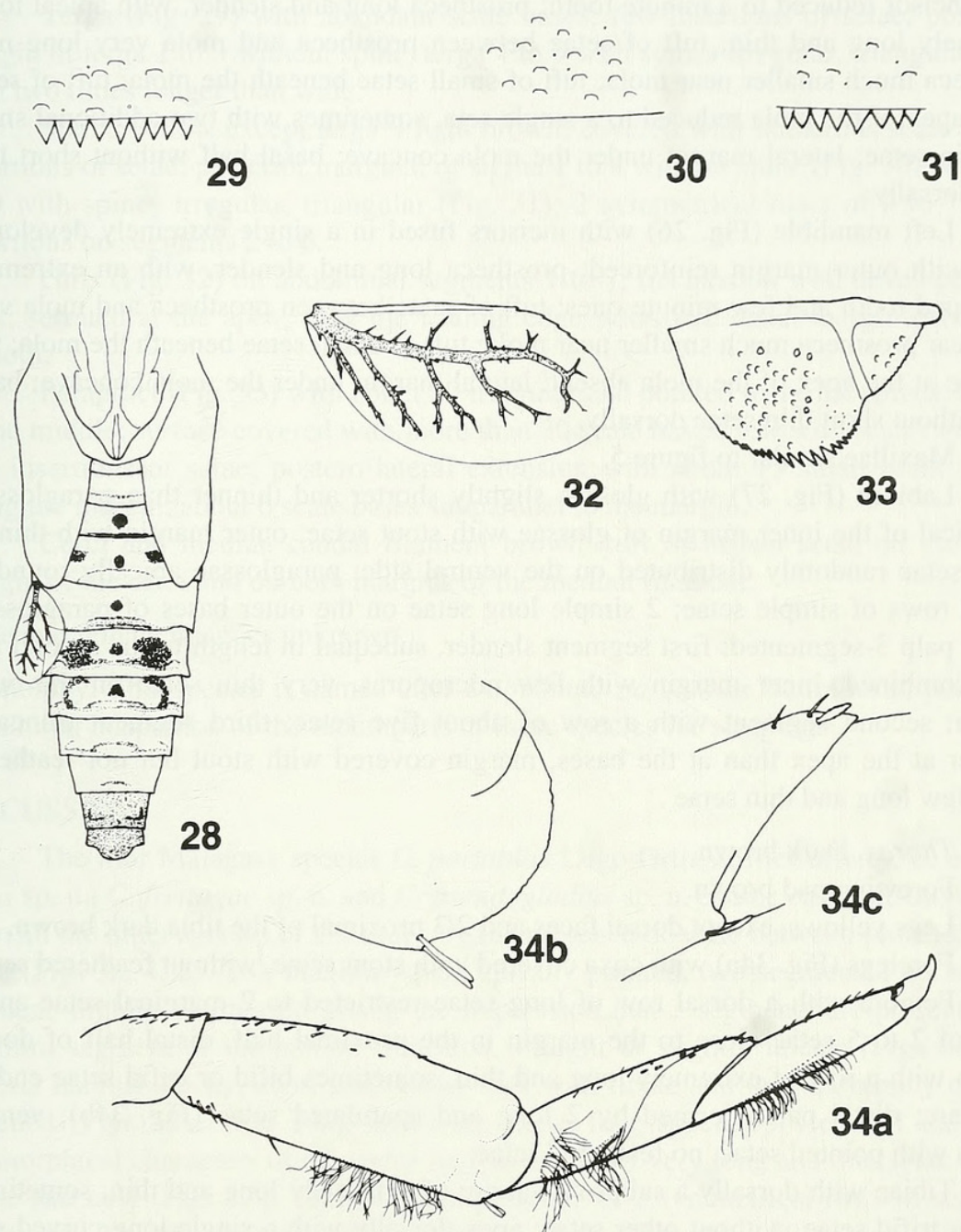
Hypopharynx (Fig. 24) with well developed lingua, especially the median lobe; lingua and superlingua covered only with thin setae.

Right mandible (Fig. 25) with straight extern margin; two sets of incisors, the extern formed only by an extremely developed tooth with outer margin reinforced, the



FIGS 23-27

Larval structures of *Cloeodes pseudogladius*. 23: labrum (left: ventral; right: dorsal). 24: hypopharynx. 25: right mandible. 26: left mandible. 27: labium.



FIGS 28-34

Larval structures of *Cloeodes pseudogladus*. 28: abdomen (dorsal view). 29: distal margin of the fourth tergum. 30: distal margin of the fourth sternum. 31: distal margin of the sixth sternum. 32: fourth gill. 33: paraproct. 34a: left foreleg. 34b: apex of the forefemur. 34c: apex of the foretibia.

inner incisor reduced to a minute tooth; prostheca long and slender, with apical tooth extremely long and thin; tuft of setae between prostheca and mola very long near prostheca much smaller near mola; tuft of small setae beneath the mola; tuft of setae at the apex of the mola reduced to a single seta, sometimes with two additional small and thin setae; lateral margin under the mola concave; basal half without short thin setae dorsally.

Left mandible (Fig. 26) with incisors fused in a single extremely developed tooth with outer margin reinforced; prostheca long and slender, with an extremely developed tooth and few minute ones; tuft of setae between prostheca and mola very long near prostheca much smaller near mola; tuft of small setae beneath the mola; tuft of setae at the apex of the mola absent; lateral margin under the mola concave; basal half without short thin setae dorsally.

Maxillae similar to figure 5.

Labium (Fig. 27) with glossae slightly shorter and thinner than paraglossae; 4/5 apical of the inner margin of glossae with stout setae, outer margin with thinner setae, setae randomly distributed on the ventral side; paraglossae apically rounded, with 2 rows of simple setae; 2 simple long setae on the outer bases of paraglossae. Labial palp 3-segmented; first segment slender, subequal in length to the second and third combined, inner margin with few micropores, very thin setae on the outer margin; second segment with a row of about five setae; third segment truncated broader at the apex than at the bases, margin covered with stout but not feathered setae, few long and thin setae.

Thorax. Dark brown.

Forewing pad brown.

Legs yellows, except dorsal faces and 2/3 proximal of the tibia dark brown.

Forelegs (Fig. 34a) with coxa covered with stout setae, without feathered setae.

Femora with a dorsal row of long setae restricted to 2 marginal setae and a patch of 2 to 5 setae close to the margin in the proximal half, distal half of dorsal margin with a row of extremely long and thin, sometimes bifid or trifid setae ending in an arc; distal patch formed by 2 long and spatulated setae (Fig. 34b); ventral margin with pointed setae, no feathered setae.

Tibiae with dorsally a subproximal arc of extremely long and thin, sometimes bifid or trifid setae, without other setae; apex dorsally with a single long curved seta (Fig. 34c); ventral margin with few pointed setae, apically with one feathered and one stout setae; tibio-patellar suture absent.

Tarsi with dorsally an arc of extremely long and thin bifid or trifid setae; ventrally, with a row of stout setae; tarsal claws stout without tooth, subapical pair of setae absent.

Second and third legs similar to foreleg, except the dorsal margin of the femora with 4 to 5 stout setae and tibio-patellar suture present.

Abdomen. Terga yellow with dark brown patterns, except terga 9 and 10 brown.

Terga (Fig. 29) with abundant scale bases; few insertions of setae; posterior margin of terga 1 to 3 without spine, terga 4 to 9 with spines irregular, triangular, less than two times longer than wide.

Sterna yellow except terga 9 light brown; covered with numerous scale bases; insertions of setae; posterior marginal of sterna 1 to 4 without spine (Fig. 30), sterna 5 to 9 with spines irregular, triangular (Fig. 31); 2 symmetrical rows of 9 to 12 seta insertions on segments 2 to 6.

Gills (Fig. 32) on abdominal segments 1 to 7, tracheation well developed and dark; serrated at the apex; only the leading edge sclerified, distal margin extremely smooth.

Paraproct (Fig. 33) with about 20 irregular and pointed marginal spines, longer in the middle; surface covered with more than 30 scale bases, few with scales present; few insertions of setae; postero-lateral extension with about 15 small blunt spines along the margin; about 6 scale bases subparallel to the margin.

Cerci and median caudal filament brown; tuft of brown setae on the inner margin of the cerci and on both margins of the median filament.

Male and female imagoes unknown

Etymology: This species is named after *Dabulamanzia gladius* Gattolliat to point out the similar adaptation of the mouthparts of these species for scraping.

DISCUSSION

The four Malagasy species *C. portabilis* Lugo-Ortiz & McCafferty, *C. bicoloratus* sp. n., *C. freitagae* sp. n. and *C. pseudogladius* sp. n. can be easily distinguished from all the other species of *Cloeodes* by the presence of setae between prostheca and mola (Figs 3a, 4, 25, 26), maxillary palp apically pointed, two-segmented but second segment slightly constricted giving the impression that 3 segments are present (Fig. 5), third segment of the labium truncated, straight or slightly falcate (Figs 6a, 27), general habitus stocky, short and stocky legs with tibiae and tarsi extremely closely attached (Figs 12a, 19a, 34a). However, these four species possess all the main apomorphical characters of *Cloeodes* such as an arc of very long and thin setae on the tibiae and tarsi (Figs 12a, 19a, 34a) and presence of 2 symmetrical rows of setae on the sterna 2-6 and tapering claws without teeth (Figs 12a, 19a, 34a) (Waltz & McCafferty, 1987a, 1987b, 1994).

Cloeodes pseudogladius presents high-modified mouthparts: bladelike mandibles with prostheca long and slender (Figs 25, 26) and broad labrum with an almost straight distal margin (Fig. 23). This kind of adaptation for scrapping is unique among the genus *Cloeodes*, but occurs independently in different lineage of Baetidae in Madagascar. In certain genera, such as *Xyrodromeus* Lugo-Ortiz and McCafferty and *Rheoptilum* Gattolliat, all the species present these adaptations (Lugo-Ortiz & McCafferty 1997; Gattolliat, 2001). In *Dabulamanzia* Lugo-Ortiz and McCafferty, only *D. gladius* has evolved this character (Gattolliat & Sartori, 2000).

Cloeodes bicoloratus can be distinguished by the labrum very narrow (Fig. 1), gills with reduced hyaline venation (Fig. 10) and ventral margin of the foretibiae with feathered setae (Fig. 12d).

Cloeodes freitagae possesses a rectangular labrum (Fig. 13), gills with dark well-developed venation (Figs 16, 17) and stocky legs with abundant setae on the ventral margin (Fig. 19a).

Cloeodes portabilis is the only Malagasy species with the third labial segment falcate (Lugo-Ortiz, *et al.* 1999). In the material that I have studied, this species presents some variations between the different populations: the size and the number of setae on the ventral margin, the number and the shape of the setae of the femoral patch, the shape of the tarsal claw can vary. However, these variations must be considered as intraspecific because all the intermediate stages are present.

Moreover, the coloration and pattern of the abdomen allow the four species to be distinguished easily.

ECOLOGY AND DISTRIBUTION

Based on extensive studies led during 8 years by the LRSAE (Laboratoire de Recherche sur les Systèmes Aquatiques et leur Environnement, Antananarivo, Madagascar) at over 660 different localities (more than 1000 sampling points), I can assume that the distributions of the species of *Cloeodes* are very different. *C. bicoloratus* and *C. pseudogladus* appear to be very localised but quite abundant. On the other hand, *C. portabilis* exhibits a large distribution but is never abundant. *C. freitagae* appears to be both rare and localised.

C. bicoloratus lives on dead wood in deep pool with slow current, close to a waterfall. Conversely, *C. pseudogladus* lives in little depth streams with fast current. All the species have been mainly found in cold and well-oxygenated streams. They are able to swim quite fast and to move their gills.

A lot of similarities can be found between the two closely related genera *Cloeodes* and *Dabulamanzia*. They both possess one species with a large distribution and other living in restricted area; such situation is quite usual among the Malagasy mayfly fauna (Elouard & Sartori, 1997; Gattolliat & Sartori, 1998, 2000). Moreover, they both possess a species specialised for scraping stones. In one sampling, both species have been collected.

KEY TO THE MALAGASY SPECIES OF *CLOEODES*

1. Bladelike mandibles with both prostheca long and slender (Figs 25, 26); broad labrum with an almost straight distal margin (Fig. 23); cerci and median caudal filament brown *C. pseudogladus*
- Mouthparts without particular adaptations for scrapping; cerci and median caudal filament uncoloured 2
2. Labrum narrow (Fig. 1); body clearly bicolour, head thorax and terga 1 and 5 to 7 dark brown, other part of the body yellow (Fig. 7) . . *C. bicoloratus*

- Labrum broad (Figs 13, 23); body with other pattern of colour (Fig. 28) 3
- 3. Third segment of the labial palp truncated (Fig. 6a); stocky femora with abundant setae on the ventral margin (Fig. 19a), some of them feathered; max. length > 5mm *C. freitagae*
- Third segment of the labial palp slightly falcate; femora slender with less abundant simple small setae; max. length < 5mm *C. portabilis*

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