

First record of Corethrellidae (Diptera), frog-biting midges, in Madagascar

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Abstract

The presence of Corethrellidae, collected with CDC light traps, is reported for the first time in Madagascar. These specimens came from widely separated sites and at altitudes ranging from sea level to 1,600 m. They belong to at least seven species, presently under study, with at least six new to science and probably endemic to Madagascar. A brief overview of the current knowledge on *Corethrella* is presented.

Key words: insect, Corethrellidae, CDC light trap, Madagascar

Résumé détaillé

La famille des Corethrellidae appartient aux Diptères Nématocères, ressemblant grossièrement à tous les stades, à de très petits moustiques. Cette famille monogénique est présente dans l'Ancien et le Nouveau Monde, principalement dans les zones tropicales. Les stades préimaginaux sont aquatiques et les larves sont prédatrices, notamment de jeunes larves de moustiques. Les nymphes sont mobiles, mais ne se nourrissent pas. Les mâles ne sont pas hématophages, à la différence des femelles qui piquent des Amphibiens Anoures. Le mécanisme de détection et de localisation de l'hôte à piquer est exceptionnel puisqu'il implique un attractant sonore, le chant nuptial de l'anoure mâle. Ainsi, la femelle de Corethrellidae prend un repas de sang sur un anoure mâle. Dans les régions où les Corethrellidae sont vecteurs de trypanosomes, les anoures mâles, contrairement aux femelles, sont infectés de trypanosomes.

La présence de Corethrellidae, collectés au piège lumineux CDC, est ici rapportée pour la première fois à Madagascar. Des spécimens du genre *Corethrella*,

actuellement à l'étude et encore non décrites, appartiennent à au moins sept espèces dont au moins six d'entre elles sont nouvelles pour la science et probablement endémiques de Madagascar. Ils ont été collectés depuis le niveau de la mer jusqu'à 1600 m d'altitude. Les six sites de collecte sont les suivants (du nord au sud) : Montagne d'Ambre, Tsingy d'Ankarana, Forêt d'Ambohitantely, Tsingy de Bemaraha, Andringitra, Forêt de Mandena. Aucune larve n'a été observée. La découverte de *Corethrella* à Madagascar est importante car elle comble une lacune des connaissances dans la région biogéographique malgache, particulièrement riche en Anoures.

Mot clés : insecte, Corethrellidae, piège lumineux CDC, Madagascar

Brief overview of the current knowledge on *Corethrella*

Corethrellidae, with only one genus, *Corethrella* Coquillett, is a family of nematoceros Diptera and is the sister group of Chaoboridae (phantom midges) + Culicidae (mosquitoes). It is an ancient group and fossils are known from Lebanese amber, 122 million years old. The genus consists of 105 extant and seven fossil species and has a worldwide distribution between 50°N and 50°S but with most species are restricted to between 30°N and 30°S and below 1500 m in elevation. The genus has been extensively monographed across many areas of its distribution, including all available bionomic and ecological information by Borkent (2008), with further species described from Borneo by Borkent & Grafe (2012).

Female adult *Corethrella* are haematophagous on anurans but have a remarkable and distinctive manner of detecting their hosts. Unlike other biting flies, which smell CO₂ emanating from their hosts as their primary attractant, female *Corethrella* are able to hear calling male frogs and toads at substantial distances and thereby locate their host. They likely use their antennae, with its basal Johnston's Organ as an acoustic organ. Other than species of *Corethrella*, the only other arthropods known to be attracted to calls of their vertebrate hosts are some *Uranotaenia* Lynch Arribálzaga and *Mimomyia* Theobald mosquitoes attracted to calling male frogs

(Borkent & Belton, 2006) and an argasid tick attracted to nesting cliff swallows (Webb *et al.*, 1977). However, it is likely that additional chemical cues are important at short distances for successful feeding to occur by *Corethrella* females as they near their frog hosts.

Female *Corethrella* are easily collected by placing a Center for Disease Control (CDC) miniature mosquito trap (without light) in front of a speaker broadcasting calls of various frog species (McKeever & Hartberg, 1980). In a trapping period of 1 hour, with calls of *Hyla gratiosa* as an attractant, hundreds of *Corethrella* can be collected with one trap.

Females of all species of *Corethrella* have sclerotized mouthparts with one or all structures toothed (McKeever, 1986). There is one exception, an Australian species, in which the females have toothless mouthparts and are unable to take any blood meal (McKeever & Colless, 1991). Male *Corethrella* are thought to feed upon nectar and/or aphid excrement, but this has never been observed. They are not haematophagous.

Larvae and pupae are aquatic. In the New World, larval *Corethrella* are found in ground pools or marshes, small pools at the edges of bogs, streams or small lakes, various phytotelmes and, more rarely in streams where surface and ground water mix (hyporheic zones) (Borkent, 2008). Larvae are ambush predators. In the laboratory, *C. brakeleyi* (Coquillett) larvae consumed an average of 3.0 *Anopheles quadrimaculatus* Say during a 19-day larval period and were observed feeding upon *An. crucians* Wiedemann as well as *An. quadrimaculatus* in rice fields of Louisiana (McLaughlin, 1990). On the contrary, in the Old World, larval breeding places of *Corethrella* remain largely unknown, with the exception of a species in carnivorous pitcher plants in southeast Asia (Borkent & Grafe, 2012) and pools along a stream in Australia (Borkent, 2008). Extensive examination of other phytotelmes in Borneo indicates that these were not utilized by the immatures of *Corethrella* spp. (Borkent & Grafe, 2012).

Anurans are hosts of a large number of trypanosomes, which are vectored by leeches (Anderson & Ayala, 1968) and by sand-flies and mosquitoes when infected females carrying the infectious stage of the parasite are ingested (Desser *et al.*, 1973; Ramos & Urdaneta-Morales, 1977). Anuran trypanosomes are quite common and widespread around the world (Bardsley & Harmsen, 1969). As far as we are aware, these trypanosomes have not been reported in Madagascar, which is most likely because they have not been researched. The

role of Corethrellidae as vectors of frog *Trypanosoma* was demonstrated by Johnson *et al.* (1993) in Florida. Numbers of female *C. wirthi* Stone collected on or near male frogs in the field had trypanosomes in their mid and hindgut, suggesting a posterior station transmission. Female frogs do not call and, therefore, do not attract *Corethrella*; as reported, no female frogs collected at the same time and area as the males were infected, although female frogs were susceptible to infection after inoculation. Other species of *Corethrella* likely are vectors of trypanosomes in Panama (Bernal *et al.*, 2006). Their role as vectors in Madagascar is entirely unstudied.

Corethrella in Madagascar

No Corethrellidae have been previously reported from Madagascar (Irwin *et al.*, 2003; Borkent, 2008). In the framework of different research programs carried out between 2002 and 2012, mainly focusing on mosquitoes and sand-flies, considerable numbers of CDC light trap samples were made, using a small incandescent bulb or black light tube. The following collection sites included specimens of the genus *Corethrella* (listed from the north to south) (Figure 1):

- 1) Montagne d'Ambre, evergreen rain forest of the Western Domain, 1135 m, 19 June 2010;
- 2) Tsingy d'Ankarana, Western Domain, 200 m, 20 to 26 June 2003;
- 3) Forêt d'Ambositantely, in the Central Domain, 1550 m, 6 January 2004 and 12 September 2012;
- 4) Tsingy de Bemaraha in the Western Domain, 100 m, both in the northern part near Beanka, 100 m, 8 June 2010, and in the southern part near Bekopaka, 6 November 2012;
- 5) Andringitra, evergreen rain in the Eastern Domain, 850 and 1600 m, 30 November and 13 December 2002;
- 6) Forêt de Mandena, in the Eastern Domain, 25 m, 10 to 25 November 2002.

The collected *Corethrella* are currently under study and this preliminary report does not deal with the description of the new species, a task that will be presented elsewhere. At least seven distinct species are present in the collections conserved in alcohol. Slide mounting and more detailed examination may reveal the presence of further species. Of the seven species, one species with a single wing band, which we designated here as "species A" may be conspecific with *C. pallitarsis* Edwards known from continental Africa. Six species, designated as



Figure 1. Location of samples of *Corethrella* (2002-2012) from Madagascar.

“species B-G” (Figure 2), seem likely endemic to Madagascar, but further studies are needed.

The presence of Corethrellidae in Madagascar is not surprising considering the otherwise Pantropical distribution and considerable age of the genus. Borkent (2008) predicted substantial increases in the number of known species of *Corethrella* once they are more carefully sampled. The discovery of eight new species in Borneo (largely from the small country of Brunei) by Borkent & Grafe (2012) and the observation of a further six undescribed species in Costa Rica and six undescribed species (based on eight specimens) from Colombia (Borkent, pers. obs.) strongly indicate many more are yet to be collected.

Our discoveries are important because they fill a gap in our knowledge of Malagasy insect families. Our report may open new areas of research in Madagascar and strongly indicates that running frog-call traps would substantially increase the number of species known from this country. Considering the presence of something approaching more than 460 species of Amphibians on Madagascar that are all frogs and toads, with more than 99% endemic (Glaw & Vences, 2003; Vietes *et al.*, 2009), there are exciting opportunities to further study the interactions between the newly discovered species of *Corethrella* and their anuran hosts.



Figure 2. Habitus of *Corethrella* from Madagascar, in lateral view. Letters for species are for temporary reference only. *Corethrella* sp. B, male, from Beanka, 8 June 2010. *Corethrella* sp. C, male, from Montagne d'Ambre, 19 June 2010. *Corethrella* sp. D, male, from Ambohitantely, 12 September 2012. *Corethrella* sp. E, male, from the Tsingy d'Ankarana, 20 June 2003. *Corethrella* sp. F, male, from Andringitra. *Corethrella* sp. G, female, from the Tsingy d'Ankarana, 20 June 2003.

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