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Notes on predator-prey relationships among Tanypodinae larvae (Diptera, Chironomidae) and mites (Acariformes) in Brazilian subterranean aquatic environments

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Abstract
Chironomidae larvae and mites are abundant and diversified groups that coexist in several environments. However, little importance has been attributed to their ecological relationships (predator–prey, parasitism, etc.). Therefore, the present study aimed to report the predation of mites by Tanypodinae larvae in Neotropical quartzite caves.

Keywords
Gut content, cave; interaction, predation

Chironomidae represents an abundant and diverse family of the order Diptera. Its larval forms are one of the most important groups of aquatic insects, representing an abundant part of the fauna present in lake and river biotopes (Trivinho-Strixino 2014). Also, many species are commonly found in habitats with environmental conditions that are unfavorable for other organisms (e.g., polluted or with low oxygen content) (Silva et al. 2008). Hence, chironomids are considered as good indicators of water quality (Saether 1979, Quinlan and Smol 2001). They have also been found in terrestrial habitats and caves, where conditions are distinct from those in external habitats, particularly with respect to permanent absence of light. Darkness imposes a strong selective pressure on the organisms that inhabit caves, and it is impossible for photosynthetic organisms to survive in these habitats, indirectly indicating the oligotrophic conditions of these environments (Simon et al. 2007).

Independent of their habitat, chironomid larvae play an important role in the trophic chains of aquatic communities (Schmid-Araya and Schmid 2000). These organisms ingest various food items, such as algae and detritus and their associated microorganisms, besides some invertebrates (Silva et al. 2008). They also serve as food for many other aquatic invertebrates (Schmid-Araya and Schmid 2000). Among the several chironomid subfamilies, the Tanypodinae larvae comprise the main predators in this family (Merritt and Cummins 1984).

Studies have highlighted that Tanypodinae larvae show a well-defined food preference, mainly consuming larval forms of other Chironomidae species (Baker and McLachlan 1979). However, in unfavorable foraging conditions, they may adopt generalized and opportunistic strategies, using a variety of foods that are available in the environment (Silva et al. 2008). Mites are among the food items that may be consumed by Tanypodinae (Blakely et al. 2010).

Although some studies have reported this trophic interaction between mites and Tanypodinae (e.g., Smith and Oliver 1986, Proctor and Pritchard 1989), they have only identified mite as the group present or absent in the gut of Chironomidae larvae, without any accurate identification of the prey (Blakely et al. 2010). Furthermore, these reports have only focused on the epigean environment and not on subterranean habitats. Therefore, given the lack of information regarding the predator–prey relationship among Tanypodinae larvae and mites in caves, the present work aimed to report and illustrate this interaction, providing more detailed data on the identification of involved specimens and the frequency of its occurrence.

For this purpose, the specimens were collected across eight sampling events (from June 2013 to January 2014). The study area comprised three subterranean allogenic streams that run through the following quartzite caves: Mandembe cave (21°32'38.1"S, 44°47'57.3"W), Serra Grande cave (21°33'33.5"S, 44°49'10.7"W), and Toca cave (21°28'24"S, 44°40'02"W), all of which are located in southern Minas Gerais, Brazil. Specimens were collected along a 100-m stretch of each stream divided into 11 transects, with three replicates per transect, using a Surber net of 400 cm^2. Tanypodinae larvae were separated from other organisms and mounted on slides using Hoyer medium. The predator and prey specimens were identified using an optical microscope ZEISS Primo Star, with identification keys presented by Walter et al. (2009), Smith et al. (2009), Cook (1988), and Trivinho-Strixino (2014).

The gut content of 287 Tanypodinae specimens collected across all sampling events were analyzed; only seven of them had preyed on mites (Figures 1–3) (Pellegrini 2016).

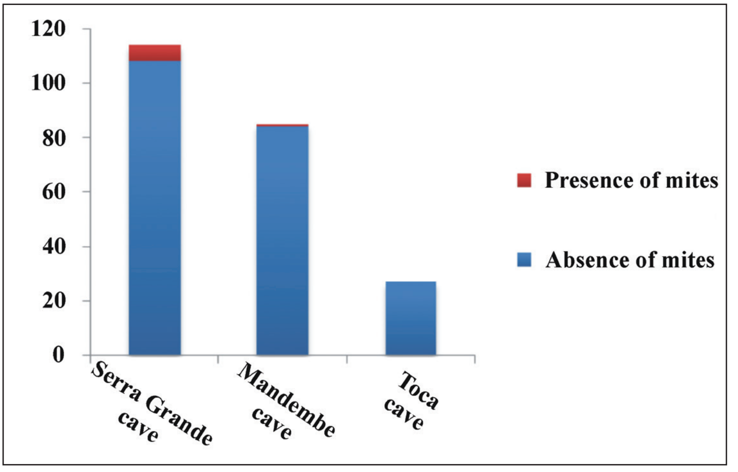

Figure 1. Tanypodinae preying on mites at each studied cave.

Among all analyzed specimens, 114 were found from Mandembe cave, 85 from Serra Grande cave, and 27 from Toca cave. The gut contents of these specimens showed the presence of mainly other chironomid larval and some copepod species. Among the specimens that preyed on mites, 85% (6 individuals) were found from Mandembe cave, 15% (1 individual) from Serra Grande cave, and none from Toca cave (Figure 1). These specimens belonged to the following Tanypodinae species: four to *Pentaneura* spp., two to *Ablabesmyia* (Karelia) spp., and one to *Parapentaneura* spp., all belonging to the Pentaneurini tribe. The following prey taxa were identified in the gut content: one of the Limnesiidae family (Acariformes: Trombidiformes), probably of the *Limnesia* genus (Fig. 2A), one of the Teratopiidae family (Acariformes: Sarcoptiformes) (Fig. 3), one of the *Tyrophagus* sp. (Acariformes: Sarcoptiformes: Acaridae) (Fig. 4A and 4B), and one possibly of the Frontipodopsidae family (Acariformes: Trombidiformes) (Fig. 4C) as well as unidentified parts of Hydrachnidia specimens (Trombidifomes: Parasitengona) (Fig. 2B–D).

These results suggested that Tanypodinae larvae had no preferences for mite species. Because these chironomids are opportunistic organisms (Silva et al. 2008), they can consume a variety of food items in oligotrophic environments, thus consuming mites at random.

The greatest number of individuals preying on mites were observed at the Mandembe cave, which may be due to greater abundance of Tanypodinae in this cave. The greater abundance of such organisms in a single cave compared with other caves may be related to the small size of the Mandembe cave. The short allogenic stream stretch running through this cave allows higher connectivity with the epigean environment (Miller 1996), thus favoring greater abundance and colonization by a large number of surface species (Watson 2010).

Although a less intense prey–predator relationship was observed between Tanypodinae and mites, such relationship has been reported for the first time in a hypogean

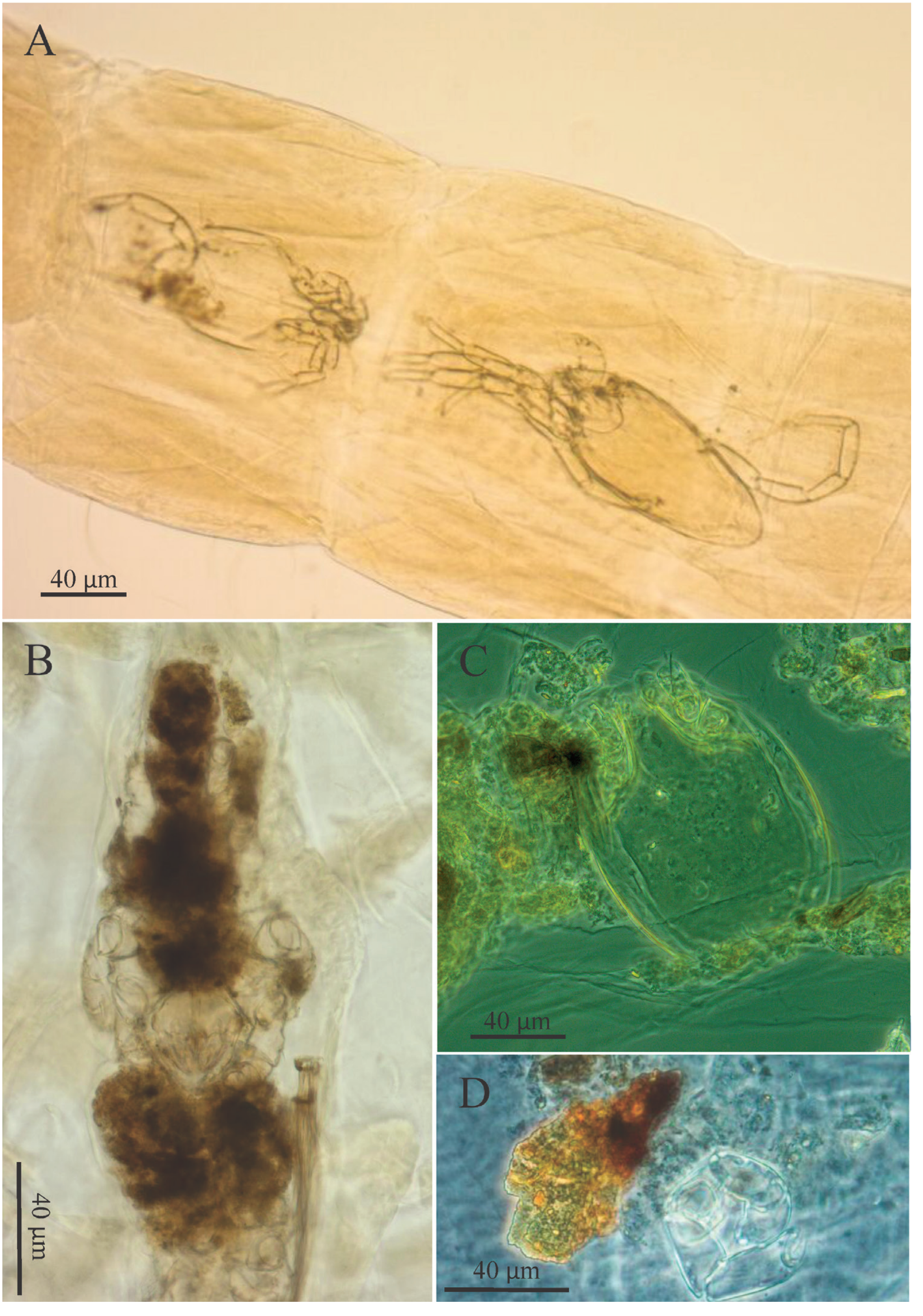

Figure 2. Mites found in gut contents of four specimens of Tanypodinae (Chironomidae). **A** Two examples of Limnesiidae larvae (Acariformes: Trombidiformes), probably belonging to the genus *Limnesia* **B–D** partially digested mites, probably Hydrachnidia.

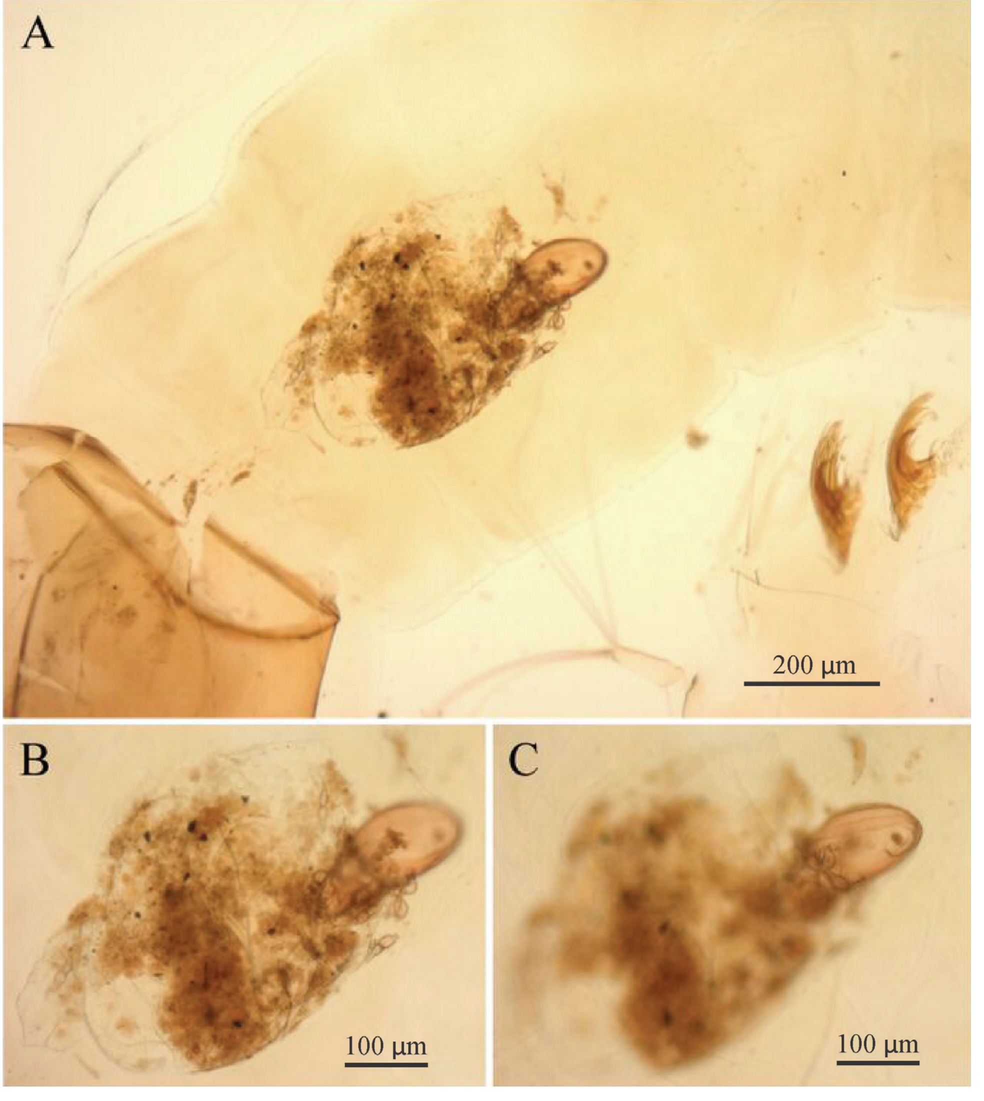

Figure 3. A–C Teratopiidae (Acariformes: Sarcoptiformes) found in gut contents of four specimens of Tanypodinae (Chironomidae).

environment in this study. Theoretical ecologists assume the importance of such weak interactions (with few occurrences in a community) due to their stabilizing effect on the trophic dynamics of systems (e.g., Pimm 1984, Paine 1992, Gorman and Emmerson 2009). Empirical studies have confirmed that such interactions allow food-web flexibility, thus preventing destabilization of all the trophic dynamics during disturbances (e.g., McCann et al. 2005, Navarrete and Berlow 2006, Eveleigh et al. 2007, McCann and Rooney 2009), including in benthic communities (Chase 2003).

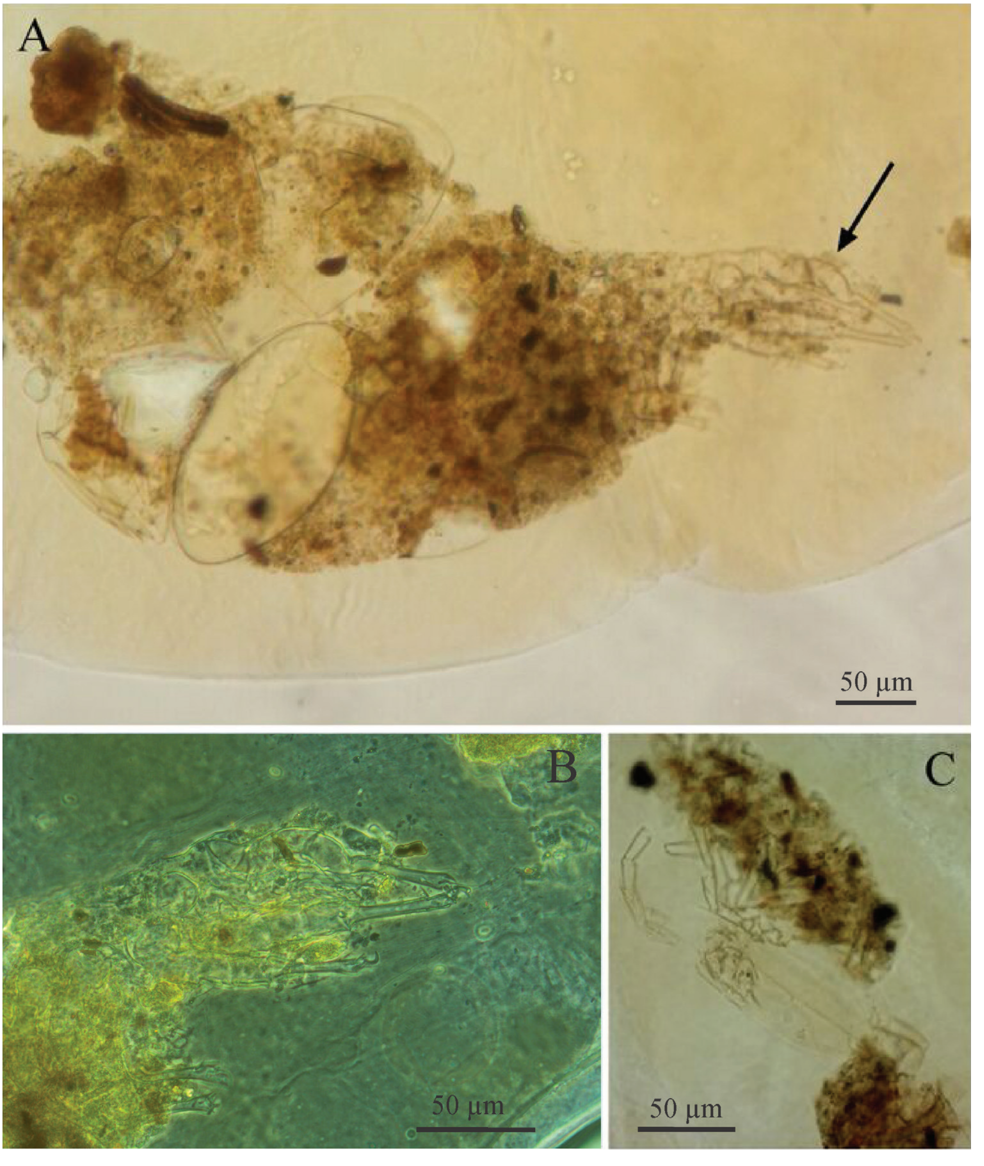

Figure 4. A General view of gut contents from a specimen of Tanypodinae (Chironomidae), where the arrow shows an specimen of *Tyrophagus* sp. (Acariformes: Sarcoptiformes: Acaridae) among alimentary items **B** Detail view of the partially digested *Tyrophagus* sp. **C** Detail of specimen already partially digested which possibly belongs to the family Frontipodopsidae (Acariformes: Trombidiformes).

Therefore, the comprehension of possible food-web routes, including systems with omnivorous organisms, has important implications for the management and conservation of natural communities (Paine 1992), mainly when considering poorly understood communities, such as those associated with subterranean environments.

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