Chironomidae of Central America

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An Illustrated Introduction to Larval Subfossils

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Preface

Larvae of tiny insects belonging to the family Chironomidae, known as non-biting midges, chironomids, and bloodworms, are powerful indicators of environmental conditions. Not only do they live all over our planet, colonizing virtually all types of aquatic ecosystems from the smallest ponds to the deepest lakes, and have thousands of species with various ecological requirements, but after they die, their head capsules remain in lake sediments for thousands of years. After obtaining a sample of the sediment, their remains can be used to reconstruct the history of the lake and its surroundings. For reliable paleolimnological reconstructions, accurate identification of subfossil remains is essential, since with misidentified subfossil material, even the most comprehensive study will be meaningless. However, for a long period, reliable identification of the remains was rather problematic because the existing identification literature focused on identification of living insects, which possess significantly more identification features relative to dramatically worn down subfossil remains with a minimum of such structures.

The situation changed markedly with the publication of the paleokey by Brooks et al. (2007). This comprehensive guide summarized and illustrated 198 morphotypes from 112 genera of 6 subfamilies taken from lake sediments mainly deposited all over Europe. Moreover, they reviewed the knowledge on chironomid taxonomy, ecology, and paleolimnology, as well as field and laboratory techniques. It is not an exaggeration to say that this guide is essential for all "dead head" specialists; there are plenty of (using Ian Walker's words) "well-abused, coffee-stained and dog-eared" copies on laboratory desks all over the world (including the authors'). Since most of the featured taxa in the guide are widespread, it is relevant also in other parts of the world. However, when it comes to other biogeographical regions with a large number of endemic taxa, such as the Neotropical region, a Palaearctic guide may have limited applicability.

Paleolimnological investigations using chironomid remains in Central America and adjacent areas have not been extensive, but lately have undergone a resurgence of interest with many workers following the success of chironomid-based reconstructions in many parts of the world.

This highlights the need for a taxonomic guide that will ultimately be helpful for a thorough analysis of the diversity and distribution of the taxa encountered to date in the region. In this context, we decided to publish this identification guide, illustrating the main chironomid morphotypes found in lake-surface sediments and sediment cores in Northern Central America. Of the total 64 genera found, it includes 20 endemic ones not listed in Brooks et al. (2007) and many new/different morphotypes from the listed genera. We hope that this guide will be useful for people working with subfossil material, not only in Central America, but in the whole Neotropical region.

Finally, this book is a result of a joint effort of a (paleo)limnologist and a taxonomist. We are convinced that a reliable subfossil guide cannot be developed without a thorough taxonomical knowledge of the region's recent chironomid fauna. At the same time, using a paleolimnological approach, it is possible to transmit this information to morphotypes that can be linked with ecology and, reaching beyond taxonomy and limnology, used to reconstruct the past development of nature. After all, paleoworkers and taxonomists have the same goal: to learn more about these fascinating insects and, through them, discover the world around us.

Authors

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CHIRONOMIDAE IN A NUTSHELL

Non-biting midges (Diptera, Chironomidae) are the most widely distributed free-living holometabolous insects, with larvae occurring in most aquatic and semiaquatic habitats, and to a lesser extent in brackish and marine waters, and semi-terrestrial and terrestrial ecosystems (Oliver 1971). The range of environmental conditions under which chironomids are found is more extensive than that of any other family of aquatic insects (Silva et al. 2018). They often dominate aquatic insect communities in both abundance and species richness (e.g., Cranston 1982; Ferrington 2008) and compose a significant fraction of the macrozoobenthos of most freshwater ecosystems. Oliver (1971) and Armitage et al. (1995) have provided a sufficient overview of chironomid biology and ecology. Their great species and habitat diversity, combined with ecological adaptability, makes these insects an important environmental indicator for aquatic ecosystems.

The family Chironomidae possibly originated in the middle Triassic, around 248–210 million years ago (Cranston et al. 2010). The group includes 11 subfamilies (Aphroteniinae, Buchonomyiinae, Chironominae, Chilenomyiinae, Diamesinae, Orthocladiinae, Podonominae, Prodiamesinae, Tanypodinae, Telmatogetoninae, and Usambaromyiinae) and comprises at least 10,000 species in more than 400 genera (Armitage et al. 1995; Sæther 2000). This high species diversity has been attributed to the antiquity of the family, with rather low vagility, leading to isolation and evolutionary plasticity (Armitage et al. 1995). Approximately 900 species of Chironomidae are recognized from the Neotropical region (M. Spies, pers. comm.), of which most are assigned to one of the three largest subfamilies: Chironominae, Orthocladiinae, and Tanypodinae. The remaining subfamilies are, in general, less species-rich and have one or only few species within one or few genera (Spies et al. 2009).

Compared with other insects, chironomid larvae are well preserved in lake sediments for a long period due to their chitinized head capsules, which allow their remains to be used for both limnological and paleolimnological studies. As lakes accumulate organic and inorganic remains constantly since their formation, their sediments represent a continuous environmental archive that holds information about the past of the lake and its environment. Moreover, lake-surface sediments, accumulating in the deepest parts of the lake, can also be important sources of recent distribution of species, because they contain remains of the contemporary biota from different parts of the system (Frey 1976). While recent years have seen increased activity regarding Chironomidae in the Neotropical region (e.g., Watson and Heyn 1992; Silva and Gessner 2009; Andersen et al. 2015; Siri 2015; Trivinho-Strixino et al. 2013, 2015; Parise and Pinho 2016; Silva and Oliveira 2016; Epler 2017; Silva and Ferrington 2018; Dantas et al. 2020), the knowledge of paleoenvironmental archives preserved in lake sediments, particularly in Central America and the Caribbean region, remains fragmentary and limited to only a few studies (Vinogradova and Riss 2007; Pérez et al. 2010, 2013; Hamerlík et al. 2018a,b; Hamerlík and Silva 2018; Wu et al. 2015, 2017, 2019a,b).

GEOGRAPHICAL RANGE

Central America is a region of particular interest for ecological and biogeographical studies, because it represents a bridge between two main biogeographical realms, the Nearctic and the Neotropical regions. In spite of its reduced area, the equatorial position, complex topography, and range of local weather patterns produce numerous microhabitats that support one of the largest global biodiversity hotspots, the Mesoamerican forest, which extends from northern Guatemala to central Panama. Although this biome is one of the most endangered ecosystems in the Neotropics (Sánchez-Azofeifa et al. 2014) due to high rates of habitat loss and fragmentation (Chacon 2005), there is still considerable opportunity for conservation action (Albuquerque et al. 2015). In this context, lake sediments may be a valuable source of information, not only of past environmental changes but also of recent distribution of species, since the sediment accumulating in the deepest part of a lake represents the mixture of the biological community from different parts of the lake and its surroundings, as well as accumulation of communities from different time periods (Hamerlík et al. 2018b).

Several biogeographic investigations indicate that the Neotropical region is composed of several subregions with a divergent evolutionary history, showing relationships with different continents in the past (Cione et al. 2015; Silva and Farrell, 2017). Therefore, the biogeographical coverage here adopts limits to the Neotropical region (sensu Morrone 2014), focusing mainly on Central America. This area does not include the Neotropical Transition Zone and Andean-Patagonian units, and their endemic genera are not covered herein.

PURPOSE AND SCOPE

Identification of larval Chironomidae tends to be complicated due to a lack of diagnostic morphological features to distinguish several genera. Moreover, identification of some species can only be achieved by individual rearing of larvae and collecting larval and pupal skins to establish the associations between life stages (Silva and Wiedenbrug 2014). Therefore, without larval rearing, genus identification of isolated immature stages must often be considered as tentative (Spies et al. 2009). Consequently, a key to living chironomids can be offered here only partly, since many records for Central America are based only on adult male specimens. On the other hand, the key to subfossil chironomids is fully illustrated and includes all the genera that were examined from sediment samples, from lakes across Central America (for review, see Hamerlík et al. 2018b, 2020).

Before a chironomid head capsule becomes buried in the sediment, it is part of a larva of a living individual. The head of a living larva contains a myriad of minute structures, such as organelles, palps, setae, lamellae, etc., that are often essential for distinguishing different taxa. When a larva dies or goes through molting, the hard-sclerotized remains of the body are buried in the sediment, while the rest of the body disintegrates. Moreover, due to taphonomical processes and mechanical damage over time, several fragile structures are lost and the diagnostic characters are usually reduced to the basic, most robust structures, such as the mentum and mandibles. Reduced diagnostic characters lead to limited potential for accurate identification of remains and require specific identification keys focusing only on the basic characters. The applicability of this approach, called parataxonomy, is limited, but in some fields, it can be the only way to get results on highly important scientific questions (Krell 2004). In surface sediments, both living larva and subfossil remains can be encountered. Thus, in this book, we provide two identification keys: (1) to living chironomids, which can be used to identify larvae bearing all the important diagnostic features and (2) to subfossil chironomids, which aims to distinguish larval subfossil remains containing only a limited number of characters.

Paleolimnology is the science that uses the physical, chemical, and biological information preserved in lake sediments to reconstruct past environmental changes in inland aquatic ecosystems. This subject area includes knowledge from a number of diverse fields of study, such as limnology, geology and ecology, but because of challenges that separate researchers from direct knowledge on past lake conditions, the discipline is multidisciplinary by necessity (Whitmore and Riedinger-Whitmore 2014). In light of this, we hope this book will be useful for students, investigators, and other professionals working in Central America and will bridge the gap between taxonomists, limnologists and paleolimnologists.

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