COMPARISON OF EMERGENCE AND TAXONOMIC COMPOSITION OF CHIRONOMIDAE (INSECTA: DIPTERA) IN TORTUGUERO NATIONAL PARK, COSTA RICA

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ABSTRACT

Traditional methods of collecting aquatic macroinvertebrates can be time consuming and expensive. One efficient form of sampling involves collection of surface floating pupal exuviae (SFPE) of a group of aquatic flies of the family Chironomidae. Previous studies have shown the efficacy of the SFPE collection technique to determine chironomid taxonomic composition and temporal organization in small streams of northwestern Costa Rica. However, the methodology has never been employed in a Neotropical brackish water setting and its efficacy was unknown in this context. The primary goal of this study was to test the SFPE method in a Neotropical brackish water setting and to expand the knowledge base of chironomid taxonomy and ecology in Costa Rica. The objectives of this research were to determine the economy of the SFPE method for studies in Neotropical brackish waters and the variability of Chironomidae emergence and taxonomic composition. Collections of chironomid SFPE were made in the brackish water estuary, Laguna del Tortuguero, and freshwater stream, Quebrada, in Tortuguero National Park, Costa Rica on seven consecutive days during both the dry and wet seasons. The SFPE method appears to be a reasonably economical method for sampling Chironomidae in Neotropical brackish waters and it is successful in detecting spatial differences in emergence between sites in the dry and wet season. The results indicate that Chironomidae SFPE sampling could be employed as part of a rapid biomonitoring program for monitoring water and sediment quality in Tortuguero National Park, Costa Rica. Generally, these data will expand the knowledge base of Neotropical

Chironomidae taxonomy and ecology, which will facilitate entomological and aquatic ecology research and teaching in Latin America.

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LIST OF ABBREVIATIONS

ANOVA	analysis of variance
°C	Celsius
CI	Confidence Interval
km	kilometer
LT	Laguna del Tortuguero
m	meter
min	minutes
mm	millimeter
N	sample size
pg	page
ppt	parts per thousand
Q	Quebrada
S_{clas}	Sorensen classic index
S_{abd}	Sorensen abundance-based index
SFPE	surface floating pupal euxivae
sp.	species

CHAPTER 1: INTRODUCTION

Aquatic biological monitoring

Biological communities provide information on overall water quality conditions. In particular, aquatic macroinvertebrates have been used in water quality assessment due to their sedentary nature, relatively long life cycles, low dispersal capabilities, and the range of responses to environmental stresses by different species. Their community assemblage reflects the physical and chemical aquatic conditions present during their lifecycles (Barbour *et al.* 1999). Some aquatic macroinvertebrates inhabit water of high quality, while others dwell in water of low quality (Epler 2001). Consequently, aquatic macroinvertebrate sampling can be used to infer the current conditions and recent water quality of specific water bodies (Barbour *et al.* 1999). However, traditional methods of collecting aquatic macroinvertebrates, such as the dip-net and grab sampler, can be time consuming, expensive, and only measure the aquatic macroinvertebrate assemblage from a particular microhabitat (Ferrington *et al.* 1991).

Collection of Surface Floating Pupal Exuviae (SFPE)

One efficient form of sampling involves collection of surface floating pupal exuviae (SFPE) of a group of aquatic flies of the family Chironomidae (Spies *et al.* 2009). Chironomidae are commonly known as non-biting midges. Collection of SFPE is an effective method that allows for the rapid measure and assessment of chironomid communities. Chironomid community composition has been used in many studies in monitoring organic pollution and eutrophication (Murphy & Edwards 1982; Armitage & Blackburn 1985; Wilson 1987; Rae 1989). The method has several advantages over other

methods commonly used to assess chironomid communities. It has been used across a range of aquatic systems, from small, freshwater streams to large rivers and lakes (Armitage *et al.* 1995; Wilson & Ruse 2005; Hayford & Ferrington 2006). A large number of chironomid species are tolerant of a wide range of salinities and have shown to be a major component of the fauna of brackish water (Rawson & Moore 1944). The SFPE technique is capable of monitoring rivers from their source to their outlet into ocean and may be used to monitor these aquatic habitats over either a long or short term (Wilson & Ruse 2005). Generally, the collection of accumulated SFPE provides an average of the chironomids emerging over a 24-48 hour period (Bouchard 2007). The wide predominance of the group in benthic communities, in combination with the widely varying species-specific ranges of tolerance to water quality, make Chironomidae a highly valuable aquatic macroinvertebrate for surveying and monitoring both pristine and disturbed habitats (Armitage *et al.* 1995).

Chironomidae are widely distributed and frequently the most abundant macroinvertebrates in aquatic systems (Armitage *et al.* 1995). In many aquatic habitats, species richness of Chironomidae is among the highest of aquatic insect families detected (Ferrington *et al.* 2008). There are estimated to be as many as 15,000 species of Chironomidae worldwide (Armitage *et al.* 1995). In North America, about 1,100 nominal species are recognized (Oliver *et al.* 1990; Oliver & Dillon 1994), while in the Neotropical Region the corresponding number is about 900 (Spies & Reiss 1996; Spies pers. comm. 2011). Only $1/5^{th}$ of the estimated 1,000 species of Chironomidae in Central America have been recorded (Spies *et al.* 2009). Additionally, only a few studies have

assessed Chironomidae composition or ecology in Costa Rica (Watson & Heyn 1992; Coffman *et al.* 1992, Coffman & De la Rosa 1998; Jackson & Sweeny 1995; Ramirez & Pringle 2006). There have not been studies that have focused on the brackish water insects of Costa Rica or Central America (Springer 2009).

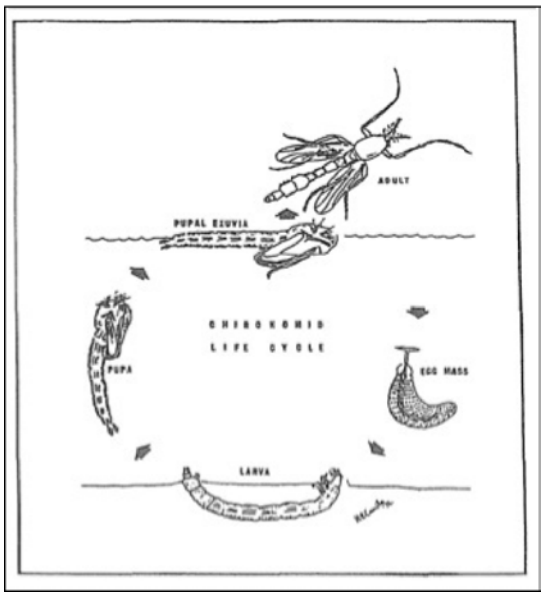

Figure 1. Chironomidae life cycle (adapted from Ferrington *et al.* 1991).

As holometabolous insects, chironomids have four distinct life stages: egg, larva, pupa, and adult (Ferrington *et al.* 2008). The immature stages of most species develop in aquatic habitats, and most types of aquatic ecosystems have chironomid inhabitants. The habitats range from flowing waters (trickles, torrents, streams, rivers) and standing waters (puddles, pools, lakes) to temporary rain-pools, plant-held waters, and even thin films of water on high-altitude glaciers (Armitage *et al.* 1995). Upon completion of the larval life stage, the larva constructs a tubelike shelter and attaches itself with silken secretions to the surrounding substrate and pupation occurs. Once the developing adult has matured, the pupa frees itself from the tubelike shelter and swims to the surface of the water where

the adult can emerge from the pupal skin (also called exuviae) (Fig. 1). The exuviae fills with air and by virtue of an outer waxy layer of the cuticle it remains floating on the water surface until bacteria begin to decompose the wax layer. Currents concentrate floating exuviae in areas downstream of rocks of points where riparian vegetation or fallen trees contact the water surface. By collecting exuviae from these natural collection points, one can rapidly evaluate the emergence of Chironomidae from a broad spectrum of microhabitats in the aquatic system (Ferrington *et al.* 1991; Coffman & de la Rosa 1998).

History of SFPE Method in Brackish Waters

While popular for biological monitoring projects in Europe, the SFPE technique has not been widely used in ecological studies of Chironomidae in brackish waters (Murphy & Edwards 1982; Wilson & McGill 1982; Wilson 1987; Wilson & Ruse 2005). Collections of chironomid SFPE have been used in one ecological study of European brackish waters of three lagoons in southern Spain to determine the effects of mineralization of water and characteristics of sediments on chironomid assemblages (Casas & Vilchez-Quero 1996). Casas and Vilchez-Quero 1996 documented species richness, but did measure the efficacy or economy of using the method in a brackish water setting.

However, the use of chironomid pupal exuviae is more common in ecological studies of Chironomidae in Neotropical lentic and lotic waters (Coffman *et al.* 1992; Coffman & De la Rosa 1998; Siqueira *et al.* 2008). Coffman and de la Rosa (1998)

demonstrated the efficacy of the SFPE collection technique to determine chironomid taxonomic composition and temporal organization in small streams of northwestern Costa Rica. They found over 250 species in four streams in Guanacaste National Park, Costa Rica (Coffman & De la Rosa 1998). However, the SFPE methodology has never been used in Neotropical brackish waters and its efficacy is unknown. The natural history and taxonomy of Neotropical Chironomidae in northeastern lowlands of Costa Rica is unknown. It is expected that hundreds of undescribed species and many new genera still exist in these regions (Spies & Reiss 1996).

Neotropical brackish waters were chosen in Tortuguero National Park, Costa Rica to test the methodology and its ability to measure and assess Chironomidae richness. Only one study by Mora *et al.* (2003) has looked at any aspect of aquatic insect diversity and ecology in Tortuguero National Park. In this study, dip net samples were taken at seven stations and 12 sample sites for timed intervals of 30 minutes. All of the aquatic insects, including family Chironomidae, were analyzed at the family-level. The results of this study show the presence of Chironomidae in aquatic root, detritus, and floating or emergent flowering plant microhabitats (Mora *et al.* 2003).

The primary intent of this thesis was to test the Chironomidae surface floating pupal exuviae method in Neotropical brackish waters and to expand the knowledge of chironomid taxonomy and ecology in Costa Rica and the Neotropics. In this introductory chapter, the study area and methods used to collect, process, and identify chironomid pupal exuviae for chapters 2-4 are presented to reduce repetition in subsequent chapters. Chapter 2 reports the economy of the SFPE method in Neotropical brackish waters

compared to temperate streams. Chapter 3 measures the spatial (site-to-site) and temporal (day-to-day) variability of Chironomidae emergence and taxonomic richness in the dry and wet seasons. Chapter 4 is an identification guide and key to the chironomid pupal exuviae found in Tortuguero National Park, Costa Rica.

STUDY AREA

Data were collected from three sample sites in the brackish water estuary, Laguna del Tortuguero, and one sample site in the freshwater stream, Quebrada, in Tortuguero National Park, Costa Rica. Tortuguero National Park lies within the Caribbean coastal lowlands of Costa Rica's Limon providence between 10°20' and 10°35' latitude north (Fig. 2). The park contains a diverse terrestrial environment ranging from lowland tropical rainforest to palm swamps and halophytic coastal vegetation. Average daily temperature is 26°C and over 5000 mm of rainfall per year with two main rainy seasons from July to August and November to January. Generally, no month receives less than 50 mm of rain and temperatures shows little seasonal variation (Hirth 1963; Nuhn *et al.* 1967).

Sample sites were randomly selected in Laguna del Tortuguero and Quebrada with restrictions due to accessibility. For the purpose of this study, freshwater is defined as having water salinity of less than 0.5 ppt and brackish water is between 0.5 to 30 ppt (Levinton 1995). Nordlie & Kelso (1975) observed a tongue of saline water (8.7-10.5 ppt) near the bottom of the Laguna del Tortuguero (depths > 5m) during both the dry and

wet seasons. By contrast, salinity measurements from the upper reaches of Quebrada and nearby forest pools never exceeded 0.1 ppt (Winemiller & Leslie 1992).

Laguna Tortuguero is a 16 km elongate, narrow (300 m) basin with an average depth of 4 m (Carr 1982). Samples were collected from the northern basin of Laguna Tortuguero. This northern basin is a 6.5 km elongate channel with an average depth of 7 m and a width of 300-400 m (Nordlie & Kelso 1975). The estuary comes into contact with the Caribbean Sea via a shallow pass through which fresh and salt water are exchanged (Carr 1982). Sample sites were selected approximately equidistant along the northern basin of Laguna Tortuguero and approximately 1 km apart. The distance drifted by pupal exuviae is usually less than 250 m in most streams and river (Wilson & Ruse 2005). Therefore, sample sites that are at least 250 m apart should be sufficient to measure independent areas of Chironomidae emergence and taxonomic composition. The three sample sites on Laguna Tortuguero were as follows: (1) Laguna del Tortuguero near the outlet to the Caribbean Sea, (2) Laguna Tortuguero between the airport and Tortuguero village, and (3) Laguna Tortuguero adjacent to the Tortuguero National Park headquarters (Fig. 2).

There was one sample site on Quebrada, which was located approximately 20 meters north of the national park headquarters. This slightly brackish, freshwater stream was chosen as a point of comparison from the brackish water estuary, Laguna del Tortuguero. During the year, Quebrada changes from being a temporary forest pool to a small creek and was located on the barrier island that forms the partition between the sea and Laguna del Tortuguero (Winemiller & Leslie 1998) (Fig. 2).

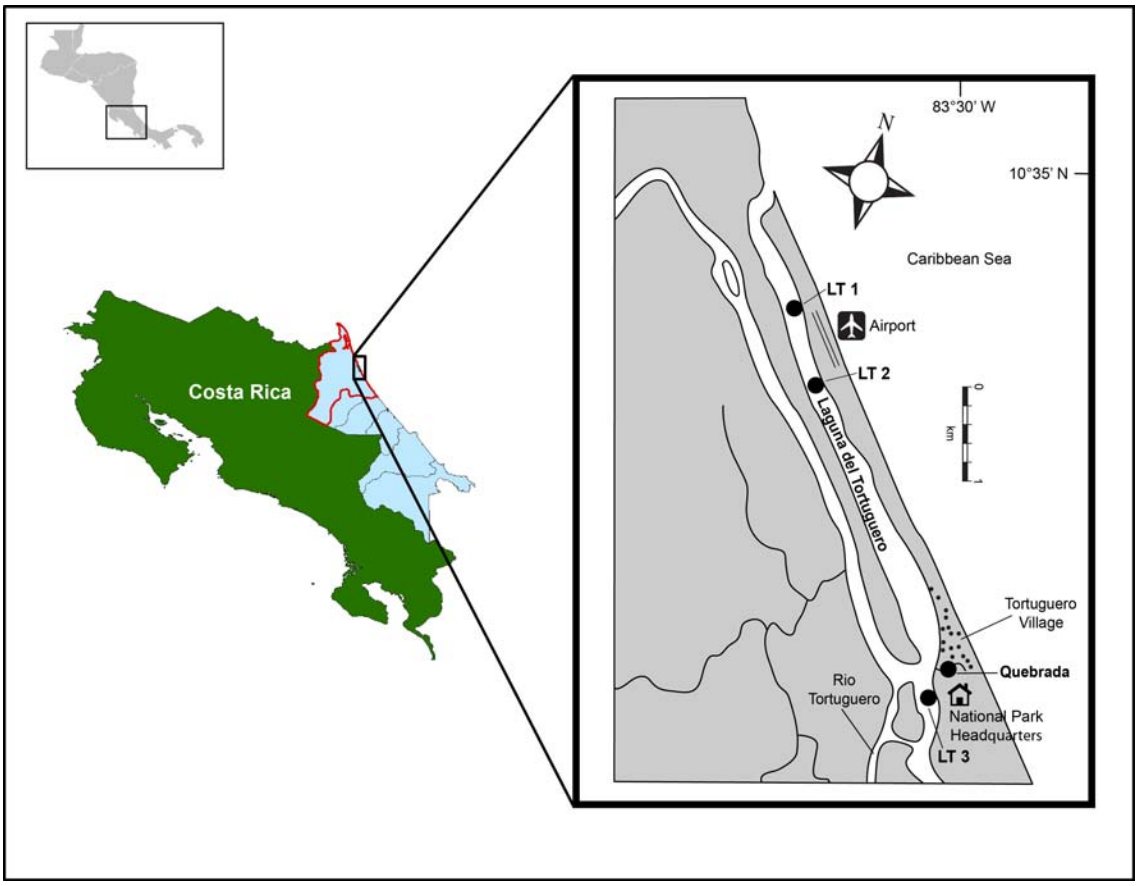

Figure 2. Sample sites in Tortuguero National Park, Costa Rica (LT = Laguna del Tortuguero).

MATERIALS AND METHODS

Sample Collection

Chironomid SFPE samples were collected on seven consecutive days, June 22 to 28, 2010 and January 4 to 10, 2011 (i.e., 14 sampling events), following the methods of Ferrington *et al.* (1991). June collections fell within the dry season, with less rainfall, and January collections fell within the wet season, with more rainfall (Hirth 1963). SFPE Collections were done along 100-meter reaches of each sample site at the edge of the estuary or stream. SFPE collections involve dipping an enameled pan into the water near areas of natural accumulation. Water, detritus, and the pupal exuviae filled the pan and

then the contents were passed through a U.S. Standard Testing Sieve with a mesh size of 125 microns to retain detritus and exuviae. This collecting method was repeated twice at each sample site for approximately 10 minutes. The contents were transferred to a sample jar and field preserved with 95% ethanol. Overall, 56 samples were collected, processed, and used for data analysis (14 sample events/site x 4 sites x 1 sample/site/sample event). Samples were transported from Costa Rica to the University of Minnesota where they were processed in the laboratory.

Laboratory Processing

Sample Picking and Subsampling

Samples were picked and sorted using forceps under a dissecting scope. Picking and sorting involves pipetting a small portion of the sample onto a glass Petri dish and removing all chironomid pupal exuviae and adults with forceps. All adult Chironomidae were placed into one labeled 1-dram snap top vial with 70% ethanol and all exuviae into a second labeled vial. Labels vials contain one locality and one determination label. After a complete pass of the sample in the Petri dish, the dish was swirled and visually scanned again for additional Chironomidae. This was repeated until no additional chironomid SFPE or adults were found. Samples were picked for specimens until the entire sample was picked or a total of 500 specimens were picked. A subsample size of 500 specimens was on average sufficient to identify a large proportion (91%) of the taxa collected in previous SFPE studies (Bouchard & Ferrington 2010).

Slide Mounting and Identification

Exuviae were dehydrated in 95% ethanol, dissected, and slide mounted in Euparol. Out of the subsample of 500 specimens that were picked from each sample, a subsample of 300 specimens was randomly selected for slide mounting from each sample. Pupal exuviae that were less than three-fourths complete were not slide mounted to avoid identification problems. According to Bouchard and Ferrington (2010), a subsample size of 300 specimens should be sufficient to identify a large proportion (85%) of the taxa collected in the SFPE samples. One specimen was slide mounted on each glass slide. The remainder of the larger samples were preserved, stored, and made available for future processing and studies.

Identifications of slide-mounted specimens were made under a Leica compound microscope at magnification of 100-400x. Genus and some species identifications were made using Coffman and Ferrington (2008) and Wiederholm (1986). See Chapter 4 for more information on the species sources of literature and taxonomic identifications of the specimens from this collection. Voucher specimens were deposited in the University of Minnesota Insect Collection, Saint Paul, Minnesota and University of Costa Rica Insect Collection, San Jose, Costa Rica.

REFERENCES CITED

Anderson, A.M. and Ferrington, L.C. in press. Time-efficiency of sorting Chironomidae surface floating pupal exuviae samples from urban trout streams in northeastern Minnesota. Proceedings of the 18th International Symposium on Chironomidae.

Armitage, P.D. and Blackburn, J.H. 1985. Chironomidae in a Pennine stream system receiving mine drainage and organic enrichment. Hydrobiologia 121: 165-172.

Armitage, P., P.S. Cranston, and L.C.V. Pinder. 1995. The Chironomidae: The Biology and Ecology of Non-biting Midges. Chapman and Hall, London.

Barbour, M.T., J. Gerritsen, B.D. Snyder and J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: Periphyton, benthic macroinvertebrates, and Fish. 2nd edition. Report number EPA 841-B-99-002. US EPA, Washington, U.S.A.

Bouchard, R.W., Jr. 2007. Comparison of phenology and taxonomic composition of lotic Chironomidae (Diptera) communities in contrasting thermal regimes. University of Minnesota, 411 pp.

Bouchard, R.W., Jr. and L.C. Ferrington. 2010. The effects of subsampling and sampling frequency on the use of surface-floating pupal exuviae to measure Chironomidae (Diptera) communities in wadeable temperate streams. Environmental Monitoring and Assessment 181: 205-23.

Carr, A. 1982. Tropical forest conservation and estuarine ecology. Biological Conservation 23: 247-259.

Casas, J, and A Vilchez-Quero. 1996. Chironomid assemblages of three endoreic karstic lagoons (Southern Spain) determined by collection of pupal exuviae: Importance of the water mineralization and sediment characteristics. Internationale Revue der gesamten Hydrobiologie 81: 555-564.

Coffman, W.P., C.L. de la Rosa, K.W. Cummins, and M.A. Wilzbach. 1992. Species richness in some neotropical (Costa Rica) and afrotropical (west Africa) lotic communities of Chironomidae (Diptera). Netherlands Journal of Aquatic Ecology 26: 229-237.

Coffman, W.P., and C.L. de la Rosa. 1998. Taxonomic composition and temporal organization of tropical and temperate species assemblages of lotic Chironomidae. Journal of the Kansas Entomological Society 71: 388-406.

Ferrington, L.C., Jr., M.A. Blackwood, C.A. Wright, N.H. Crisp, J.L. Kavanaugh and

F.J. Schmidt. 1991. A protocol for using surface-floating pupal exuviae of Chironomidae for rapid bioassessment of changing water quality. Pp.181-190. In: Sediment and Stream Water Quality in a Changing Environment: Trends and Explanations. IAHS Publication Number 203. 374 pp.

Ferrington, Jr., L.C., M.B. Berg and W.P. Coffman. 2008. Chironomidae. Chapter 26 In: Merritt, R.W., K.W. Cummins, and M.B. Berg, eds. An introduction to the aquatic insects of North America. 4th Ed., Kendall/Hunt Publishing Co., Dubuque, Iowa.

Ferrington Jr., L.C., E.C. Masteller and J.A. Santiago-Blay. 2009. Comparison and significance of Chironomidae emergence from Lake Erie and Presque Isle Bay, Erie, Pennsylvania, U.S.A. In: Hughes, S. J., Khadem, M. and Carvalho, M. A. (eds.): Proceedings of the 16th International Chironomid Symposium, Boletim do Museu Municipal do Funchal Supplement 13: 21-28.

Hayford, B. and L.C. Ferrington Jr. 2006. Distribution of Chironomidae (Diptera) in Lake Hövsgöl, Mongolia. In Goulden, C. E., T. Sitnikova, J. Gelhaus, B. Boldgiv (eds), The Geology, Biodiversity, Ecology of Lake Hövsgöl (Mongolia). Backhuys Publishers, Leiden, The Netherlands, 433–452, Chapter 26.

Hirth, H .F. 1963. The ecology of two lizards on a tropical beach. Ecological Monographs 33: 83-112.

Jackson, J.K. and B.W. Sweeney. 1995. Egg and larval development times for 35 species of tropical stream insects from Costa Rica. Journal of the North American Benthological Society 14: 115-130.

Kavanaugh, J.L., R.W. Bouchard, Jr., L.C. Ferrington, Jr. 2003. Efficacy of surface-floating pupal exuviae collections for estimating emergence frequencies of abundant species. Poster at XV International Chironomidae Symposium.

Levinton, J.S. 1995. Marine biology: function, biodiversity, ecology. New York: Oxford University Press.

Mora, B., R. Rodriguez and U. Lopez. 2003. Sondeo ecológico rápido y monitoreo de especies indicadoras en el Parque Nacional Tortuguero. Editorial Guápiles. 150.

Murphy, P.M. and R.W. Edwards. 1982. The spatial distribution of the freshwater macroinvertebrate fauna of the River Ely, South Wales, in relation to pollutional discharges. Environmental Pollution (Series A). 29: 111-124.

Nordlie, F. G. and D.P. Kelso. 1975. Trophic relationships in a tropical estuary. Revista de Biologia Tropical 23: 77–99.

Nuhn, H. and S. Pérez. 1967. Estudio geográfico regional: zona atlántico norte de Costa Rica. Programa de Asistencia Técnica del Gobierno de la Republica Federal de Alemania, Instituto de Tierras y Colonización. San José, Costa Rica.

Oliver, D. R., M.E. Dillon and P.S. Cranston. 1990. A catalog of Nearctic Chironomidae. Research Branch Agriculture Canada, Publication 1857/B.

Oliver, D. R. and M.E. Dillon. 1994. Corrections and additions to "A catalog of Nearctic Chironomidae". Proceedings of the Entomological Society of Washington 96: 8-10.

Rae, J.G. 1989. Chironomid midges as indicators of organic pollution in the Sciotio River Basin, Ohio. The Ohio Journal of Science 89: 5-9.

Raunio J., T. Ihaksi, A. Haapala and T. Muotka. 2007. Within- and among-lake variation in benthic macroinvertebrate communities—comparison of profundal grab sampling and the chironomid pupal exuvial technique. Journal of the North American Benthological Society 26: 708-718.

Siqueira, T, F.O. Roque and S. Trivinho-Strixino. 2008. Species richness, abundance, and body size relationships from a Neotropical chironomid assemblage: looking for patterns. Basic and Applied Ecology 9: 606-612.

Spies, M. and F. Reiss. 1996. Catalog and bibliography of Neotropical and Mexican Chironomidae (Insecta, Diptera). Spixiana Supplement 22: 61-119.

Spies, M., T. Andersen, J.H. Epler and C.N. Watson, Jr. 2009. Chironomidae (non-biting midges). In: Brown, B.V. et al. (eds.) Manual of Central American Diptera, vol. 1. - NRC Research Press, Ottawa.

Springer, M. 2009. Marine Insects. In: I.S. Wehrtmann & J. Cortés (eds). Marine Biodiversity of Costa Rica, Central America. Monographiae Biologicae 86. SpringerScience + Business Media B.V., Germany.

Ramirez, A. and C.M. Pringle. 2006. Fast growth and turnover of chironomid assemblages in response to stream phosphorus levels in a tropical lowland landscape. Limnology and Oceanography 51: 189-196.

Rawson, D. S. and J.E. Moore. 1944. The saline lakes of Saskatchewan. Canadian Journal of Forest Research 22: 141-201.

Watson, C. N., Jr. and M.W. Heyn. 1992. A preliminary survey of Chironomidae (Diptera) of Costa Rica, with emphasis on the lotic fauna. Netherlands Journal of Aquatic Ecology 26: 257-262.

Wiederholm, T. 1989. Chironomidae of the Holarctic Region: Keys and diagnoses. Part 2. Pupae Entomologica Scandinavica Supplement 28: 1-482.

Wilson, R.S. and J.D. McGill. 1982. A practical key to the genera of pupal exuviae of the British Chironomidae (Diptera, Insecta). University of Bristol Press. UK.

Wilson, R.S. 1987. Chironomid communities in the River Trent in relation to water chemistry. Entomologica Scandinavica Supplement 29: 387-193.

Wilson R.S. and L.P. Ruse. 2005. A guide to the identification of genera of chironomid pupal exuviae occurring in Britain and Ireland (including common genera from northern Europe) and their use in monitoring lotic and lentic fresh waters. Special Publication No 13. Freshwater Biological Association, Ambleside, Cumbria, UK.

Winemiller, K.O. and B.J. Ponwith. 1998. Comparative ecology of eleotrid fishes in Central American coastal streams. Environmental Biology of Fishes 53: 373-384.

CHAPTER 2: ECONOMY OF SORTING CHIRONOMIDAE SURFACE FLOATING PUPAL EXUVIAE SAMPLES FROM NEOTROPICAL BRACKISH WATERS IN TORTUGUERO, COSTA RICA

INTRODUCTION

Chironomidae are found worldwide and are frequently the most abundant insect family in aquatic systems (Armitage *et al.* 1995). Larvae are ecologically important since they comprise all of the functional feeding groups in a benthic ecosystem (Ruse 2002). Nonetheless, family Chironomidae is often ignored in ecological studies or only identified to the family-level, since it is relatively difficult and time-consuming to identify the larval life stage to a lower taxonomic resolution (Wilson & McGill 1977).

There are a variety of methods to collect chironomids for ecological and taxonomic purposes. Previous studies on Chironomidae in brackish waters have used sampling methods such as kick nets, sediment cores, and emergent traps (Menzie 1980; Kawai *et al.* 2000; Dimitriadis & Cranston 2007; Ramirez 2008). However, these traditional methods of collecting Chironomidae can be time consuming and expensive in certain aquatic habitats (Ferrington *et al.* 1991). Merritt *et al.* (2008) provide detailed descriptions of these methods used to collect aquatic insects. One efficient form of sampling involves collection of surface floating pupal exuviae (SFPE) (Ferrington *et al.* 1991).

Ferrington *et al.* (1991) demonstrated the economy of using SFPE and dip-net methodology to assess Chironomidae in organically enriched streams in eastern Kansas. Economy was defined as a measure of the cost of a given methodology relative to alternative methodologies that have similar standards of efficiency and efficacy (Ferrington *et al.* 1991), and in this study dip-net samples were compared with samples of SFPE. Samples of SFPE were sorted and specimens were identified on average in 52.7

minutes. In contrast, the average time required to sort and identify a dip-net sample was around 190 minutes. Therefore, SFPE samples took approximately one-third the time to process compared to dip-net samples. As well, Anderson and Ferrington (in press), working in trout streams near Duluth, found it took an average of 51.9 minutes to sort 300 SFPE specimens/sample. The average time to sort subsamples of 100 specimens was 22.5 minutes for SFPE samples, compared to 37.7 minutes for 100 macroinvertebrates in dip-net samples. No published studies have tested the economy of the SFPE sampling technique in a Neotropical brackish water setting. Therefore, the objective of this chapter was to determine the economy of SFPE sampling method for studies in Neotropical brackish waters compared to temperate streams. To measure economy of the SFPE method one hypothesis was tested, H_0: No difference between sorting times using SFPE sampling methods in Neotropical brackish waters and temperate streams, H_a: Sorting times of Neotropical brackish water SFPE samples were greater than sorting times of temperate stream SFPE samples.

MATERIALS AND METHODS

Sorting Times of SFPE Method

See Chapter 1 for a description of the study area and sample collection and processing. Sort times (in minutes) needed to pick a pre-determined number of specimens from each sample were recorded. Sort times were used as a measure of economy. These sorting times were compared to sorting times of SFPE collections from an urban trout stream in Duluth, Minnesota (Ferrington *et al.* 1991; Anderson &

Ferrington, in press). SFPE collections from trout streams in Duluth were used to represent temperate streams, since raw data was directly available from the authors (Anderson & Ferrington, in press). A two-way t-test was used to test for the difference between mean sort times of a 300-subsample SFPE collection from an urban trout stream in northeast Minnesota (Duluth) and Neotropical brackish waters in Tortuguero National Park, Costa Rica (Tortuguero). Any Costa Rican SFPE sample with more than 300 specimens was taken out for comparison of sort times.

Size Distribution of Pupal Exuviae

Mean Chironomidae pupal body length was used to quantify and compare the size distribution of pupal exuviae subfamilies from Tortuguero, Duluth, and the Holarctic region. Pupal body length is typically measured from the top of the cephalothorax to the bottom of the abdomen (Ferrington pers. comm. 2011). For the Tortuguero collection, the mean body length of individuals from collected genera of the three subfamilies, Chironominae, Orthocladiinae, and Tanypodinae, was measured. Body length was measured for all individuals if there were less than 20 individuals in the genus, or a subsample of 20 individuals if there were more than 20 individuals in the genus. For each selected individual, the cephalothorax and abdomen of slide mounted specimens was measured to the nearest 0.5-millimeter using a dissecting microscope.

Ranges of generic pupal body length from Wiederholm (1989) were used to quantify pupal body lengths from Duluth and the Holarctic region. For the Duluth collection, ranges of generic body length of collected genera of the three subfamilies,

Chirononominae, Orthocladiinae, and Tanypodiane, was recorded. While, all the ranges of generic body length of the three subfamilies, Chironominae, Orthocladiinae, Tanypodnae in Wiederholm (1989) were recorded for the Holarctic region. Body lengths recorded by Wiederholm (1989) were often given as the largest species of the genus, or as ranges from smallest to largest. Consequently, the mean body lengths were estimated by genus using either the medians when the range was reported, or upper limits of each genus. A two-sample t-test was used to compare the mean body lengths of individuals in each subfamily.

RESULTS

Sorting Times of SFPE Method

Figure 1 is a histogram of the time (in minutes) required to sort the 56 pupal exuviae samples. The minimum time required to sort a sample was 15 minutes and the maximum time required was 320 minutes. Around 80 percent of the samples were sorted in 100 minutes or less per sample (Fig. 1). The average sort times (in minutes) to achieve various SFPE sample-sorting end-points are given in Table 1. The mean time to sort a pupal exuviae sample of less than 100 total specimens was 69 minutes. By comparison, the mean amount of time needed to sort 500-count subsamples of SFPE was 74 minutes (Table 1). There was no significant difference between samples sorted from the June 2010 and January 2011 collections. The samples collected in June 2010 had a mean sort time of 68 minutes, while samples collected in January 2011 had a mean sort time of 81 minutes ($p = 0.4$, 95% CI = 144.37 - 18.16).

The mean amount of time needed to sort 300-count subsamples of Tortuguero SFPE were significantly more than that needed to sort Duluth SFPE samples ($p = 0.0008$; 95% CI = 12.23 - 44.96 min). Tortuguero SFPE samples took, on average, 28 minutes longer to sort than Duluth SFPE samples (71 min vs. 43 min) (Fig. 2).

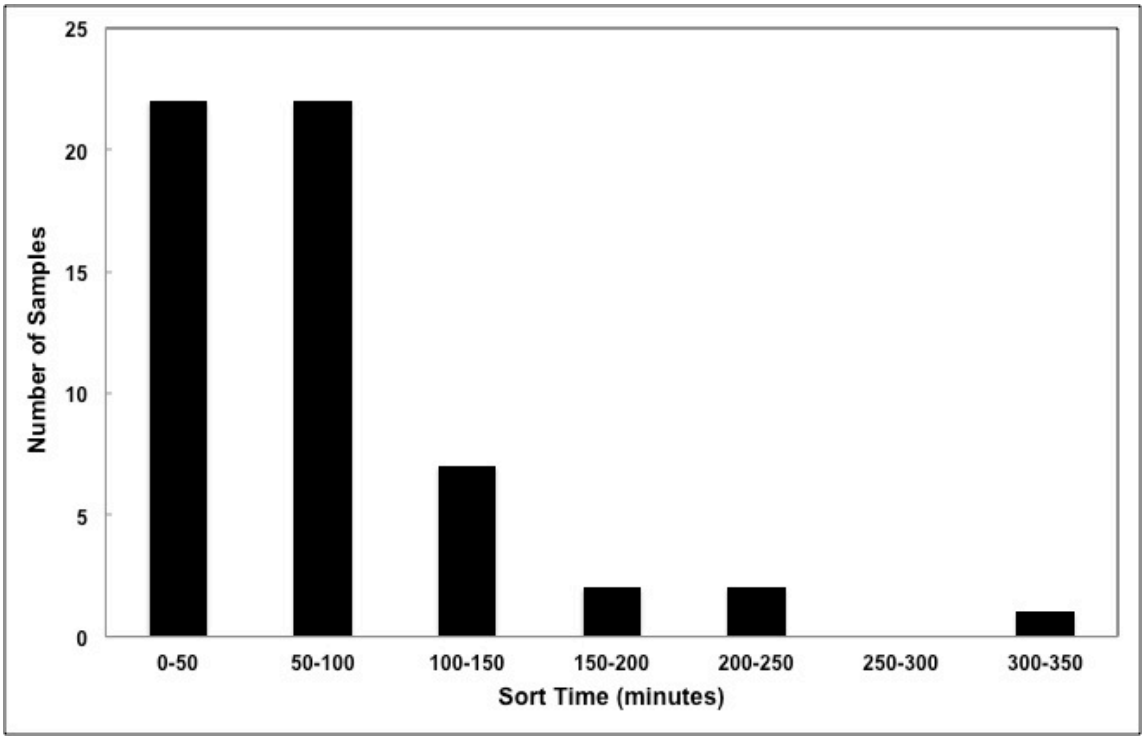

Figure 1. Time required to sort samples of pupal exuviae.

Table 1. Time needed to achieve various SFPE sample-sorting end-points.

Activity	Sort Time (min)
Average time to sort a sample of less than 100 total specimens	69
Average time to sort 101 to 500 specimens when sample was large and subsampled to 500	101
Average time to sort a sample with more than 100, but less than 500 specimens	86
Average time to sort a subsample of 500 specimens when sample was large and subsampled to 500	74

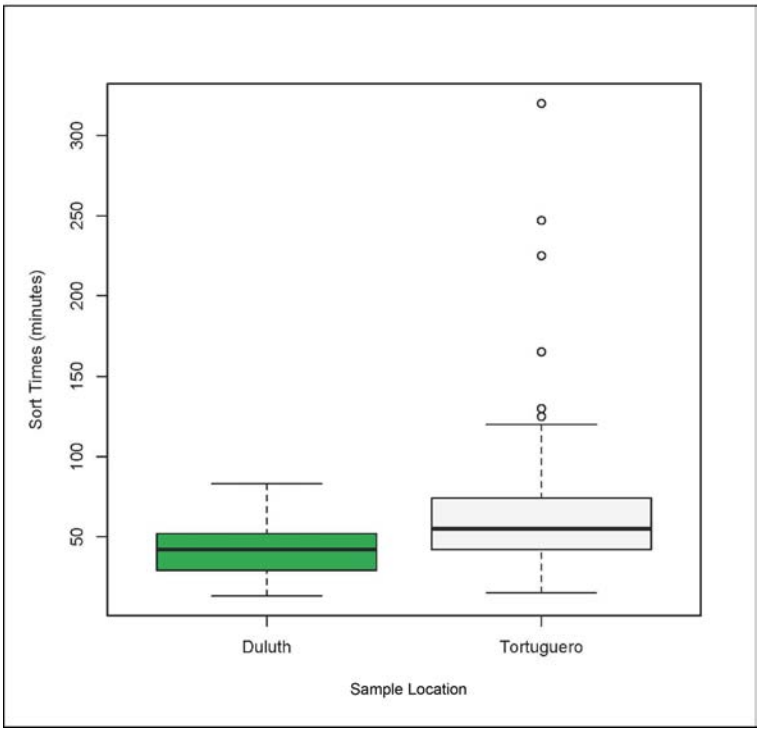

Figure 2. Average time needed to sort 300-count SFPE samples, with 95% CI for the mean.

Size Distribution of Pupal Exuviae

Mean body lengths of individual pupal exuviae collected in Tortuguero are smaller than Duluth or the Holarctic region (Table 2). The Tortuguero collection included 44 genera, while Duluth included 79 genera, and Holarctic region included approximately 230 genera. The mean lengths of genera within all three subfamilies from Tortuguero were statistically smaller than the Holarctic region (Chironominae: $p < 0.0001$, Orthocladiinae: $p= 0.0001$, Tanypodinae: $p = 0.02$). All generic lengths within each subfamily, except Tanypodinae, were statistically smaller from Tortuguero than Duluth (Chironominae: $p = 0.02$, Orthocladiinae: $p = 0.0002$, Tanypodinae: $p = 0.1$) (Fig. 3). At Tortuguero, the average genus body length ranged from approximately 2 to 6 mm, while at Duluth the genera ranged from 5 to 6 mm, and for the Holarctic region ranged

from 6 to 7 mm (Table 2).

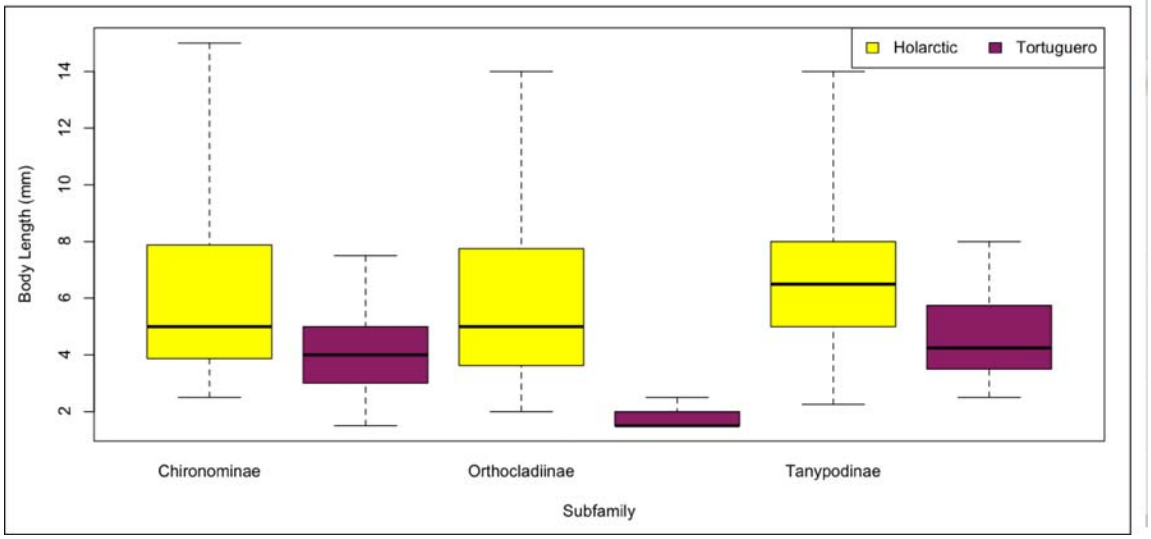

Figure 3. Mean body length of three subfamilies in Holarctic region versus Tortuguero, with 95% CI for the means.

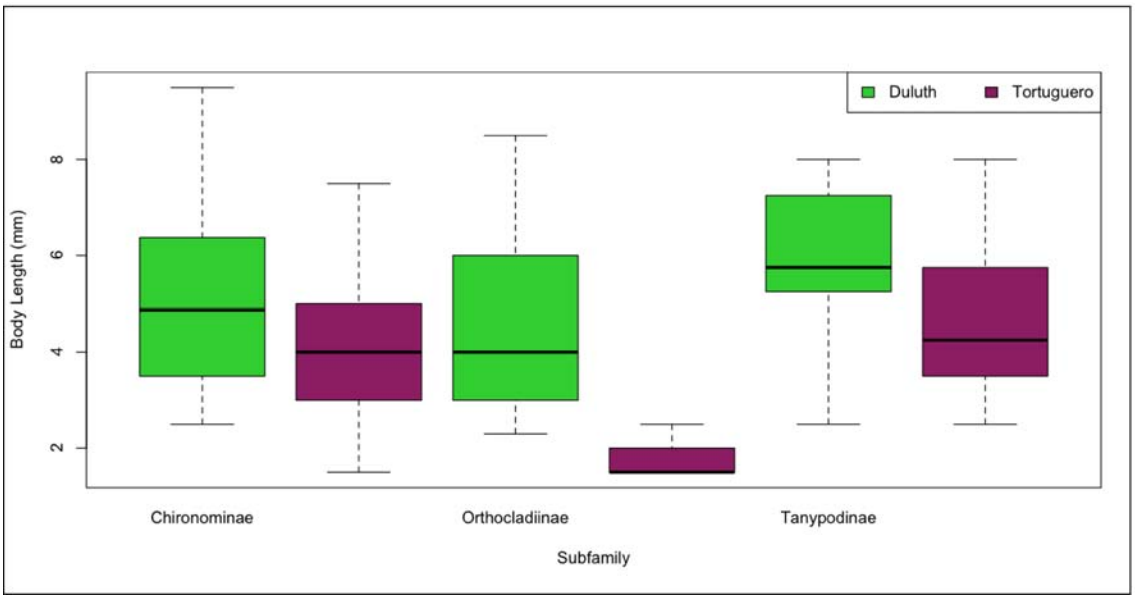

Figure 4. Mean body length of three subfamilies in Duluth versus Tortuguero, with 95% CI for the means.

Table 2. Mean generic body length of three subfamilies in Holarctic region, Duluth, and Tortuguero.

	Chironominae	*Orthocladiinae*	*Tanypodinae*
Holarctic	5.9 (N=72)	5.7 (N=80)	6.6 (N=40)
Duluth	5.0 (N=28)	4.8 (N=29)	5.9 (N=12)
Tortuguero	4.0 (N=33)	1.8 (N=3)	4.7 (N=8)

DISCUSSION

This is the first study that quantified the economy of collections of Chironomidae surface floating pupal exuviae in Neotropical brackish waters of Costa Rica compared to temperate streams in the United States. Before this study, no published studies had tested the economy of the SFPE sampling technique in Neotropical brackish waters. The results indicate that the sorting times of Chironomidae SFPE samples from Neotropical brackish waters were less time-efficient than sorting times of urban trout streams samples in the temperate regions of the United States. The mean amount of time needed to sort 300-count subsamples of Tortuguero SFPE were significantly more than that needed to sort Duluth SFPE sample (Anderson & Ferrington, in press). Average times to sort and identify specimens in the study by Ferrington *et al.* (1991) were lower than sort times alone in this study. The higher sorting times for the Neotropical brackish water samples could be due to a variety of factors such as small body length of the pupal exuviae and high non-chironomid organic and inorganic content in the samples.

One factor that appears to affect the SFPE sample sort times is the body size of the pupae. Many of the Chironomidae taxa collected in this Neotropical SPFE study are significantly smaller than the taxa collected in the temperate SFPE studies. See appendix for list of chironomid taxa and generic and species abundances. On average, the genera

of Chironomidae pupae collected in Tortuguero were several millimeters shorter in length that those genera collected in Duluth or that occur in the Holarctic Region. It is logical to assume that the smaller the pupae, the more time consuming it is to pick them from the residue in the sample. Small pupae get stuck to pieces of leaves, flowers, sticks, and small sand grains and it takes more time to find them and then remove them from the samples.

Another factor contributing to higher sort times for Neotropical brackish water versus temperate stream SFPE samples is the content of non-chironomidae organic and inorganic material. Both coarse and fine particulate matter accumulates in areas downstream of rocks or where riparian vegetation or fallen trees contact the water surface, similar to the pupal exuviae. Therefore, organic material such as pieces of leaves, flowers, sticks, terrestrial and aquatic insects and inorganic material such as plastic, Styrofoam, and silt are indirectly transferred to the sieve and are included within the SFPE sample.

A relatively simple modification of the sampling pan could improve the economy of the method. The modification consists of securing a 5-10 mm aperture mesh screen over the top of the pan, which would reduce the amount of coarse material transferred to the sieve and ultimately into the samples. The aperture of the screen would be large enough to allow the pupal exuviae to pass through and be retained on the sieve, but small enough to reduce the inadvertent collection of coarse particulate material. This would reduce the sample sorting times and increase the economy of the overall collection method. Future Chironomidae studies should test the economy and efficiency of the

SFPE method with various mesh sizes, possible ranging from 5 to 20 mm, on sample sorting times of habits in both temperate and Neotropical settings.

While the sorting times of Chironomidae SFPE in this Neotropical brackish water study were more time consuming than temperate urban trout and organically enriched streams, it appears that alternative sampling methods such as the traditional dip-net would be relatively more time consuming. Ferrington *et al.* (1991) documented that samples of chironomid SFPE took approximately 66% less time to sort than traditional dip-net samples. Anderson and Ferrington (in press) found dip-net samples took, on average, 10.3 minutes longer to sort than SFPE samples. At this point, we assume that sorting samples with a dip-net in Neotropical brackish water settings would take more time than the SFPE method. Also, it is presumed that field collection times would be much longer using a standardized dip-net method compared to the SFPE method. Most standardized dip-net methods require direct collection over all available microhabitats of a sample site, while the SFPE method collects an accumulation of chironomids from all nearby microhabitats. Besides the fact that the dip-net method would require more manual labor and time, it would be nearly impossible to use the dip-net to collect taxa from deep benthic microhabitats in the estuary since some portions of the estuary are over 7 m deep.

Other sampling devices such a sediment core sampler can effectively collect larval Chironomidae samples in deeper zones of lentic estuarine systems (Menzie 1980; Merrit *et al.* 2008). However, coring or dredging methods require multiple people, a boat, often a mechanical or electrical winch, and many samples to assess all of the

microhabitats in an estuary. Consequently, the sampling design can require transects and/or randomly placed sampling, which is expensive and/or difficult to accomplish over large spatial scales. For instance, Menzie (1980) collected larval chironomids using a core sampler on a 30 km long and 18 m diameter cove of the Hudson River. Every 5 km, the cove was partitioned into four areas within which random samples were collected (Menzie 1980). While this sampling method was random, based on taxa reported in the study, it doesn't appear to have surveyed all of the microhabitats in the estuary. In contrast, SFPE method does not require much equipment, supplies or labor. One person using a couple pieces of handheld equipment and supplies is capable of sampling several sample sites and collecting many samples within just a few hours.

The results from this chapter provide quantitative estimates that the SFPE method is a reasonably economical method for sampling the Chironomidae community in a Neotropical brackish water setting. Upcoming chapters demonstrate that a very diverse assemblage of taxa can be collected in a short period of time, and the sample data can be used to quantify the spatial and temporal variability of Chironomidae emergence in Neotropical brackish waters (see Chapter 3). In addition, it is shown that the genera and species are easily distinguishable in the pupal stage, even if a formal generic or species name cannot be given (see Chapter 4). Future studies should measure the economy of the Chironomidae SFPE method compared with other sampling methods in a variety of brackish waters in other parts of Costa Rica and Central America.

REFERENCES CITED

Anderson, A.M. and Ferrington, L.C. in press. Time-efficiency of sorting Chironomidae surface floating pupal exuviae samples from urban trout streams in northeastern Minnesota. Proceedings of the 18th International Symposium on Chironomidae.

Coffman, W. P. and L.C. Ferrington Jr. 2008. Chironomidae. In: Meritt, R.W. and K.W. Cummins (eds), An introduction to the aquatic insects of North America, Third Edition. Kendall/Hunt Publishing Company, Dubuque, IW: 635-643.

Dimitriadis, S. and P.S. Cranston. 2007. From the mountains to the sea: assemblage structure and dynamics in Chironomidae (Insecta: Diptera) in the Clyde River estuary gradient, New South Wales, southeastern Australia. Australian Journal of Entomology 46: 188-197.

Ferrington, L. C., Jr., M.A. Blackwood, C.A. Wright, N.H. Crisp, J.L. Kavanaugh and F.J. Schmidt. 1991. A protocol for using surface-floating pupal exuviae of Chironomidae for rapid bioassessment of changing water quality. In: Sediment and Stream Water Quality in a Changing Environment: Trends and Explanations. IAHS Publication Number 203. 374 pp

Kawai, K., S. Morihiro, and H. Imabayashi. 2000. Transectional distribution patterns of chironomid larvae in estuaries. Medical Entomology and Zoology 51: 215-220.

Menzie, C.A. 1980. The chironomid (Insecta: Diptera) and other fauna of a *Myriophyllum spicatum L*. plant bed in the lower Hudson River. Estuaries 3: 38-54.

Merritt, R.W., K.W. Cummins and M.B. Berg. 2008. An introduction to the aquatic insects of North America. 4th Ed., Kendall/Hunt Publishing Co., Dubuque, Iowa.

Mora, B., R. Rodriguez, U. Lopez. 2003. Sondeo ecológico rápido y monitoreo de especies indicadoras en el Parque Nacional Tortuguero. Editorial Guápiles. 150.

Ramirez, M.F. 2008. Emergent aquatic insects: assemblage structure and patterns of availability in freshwater wetlands of the lower Columbia River Estuary. Unpublished Master's thesis, University of Washington.

Ruse, L. 2002. Chironomid pupal exuviae as indicators of lake status. Archiv für Hydrobiologie 153: 367-390.

Wiederholm, T. 1989. Chironomidae of the Holarctic Region: Keys and diagnoses. Part 2. Pupae. Entomologica Scandanavica Supplement 28: 1-482.

Wilson , R.S. and J.D. McGill. 1977. A new method of monitoring water quality in a stream receiving sewage effluent, using Chironomid pupal exuviae. Water Research 11: 959–962.

CHAPTER 3: VARIABILITY OF CHIRONOMIDAE EMERGENCE AND TAXONOMIC RICHNESS IN LAGUNA DEL TORTUGERO AND QUEBRADA, TORTUGUERO NATIONAL PARK, COSTA RICA

INTRODUCTION

Chironomidae have long been known as reliable biological indicators of water quality. Some groups of genera and/or species inhabit water of high quality, while others dwell in water of low quality (Epler 2001). Chironomidae community composition has effectively been used in monitoring organic pollution and excessive nutrients (Murphy & Edwards 1982; Armitage & Blackburn 1985; Wilson 1987; Ferrington & Crisp 1989; Rae 1989). Despite their importance as a freshwater bioindicator, only a few studies have examined the variability of emergence and taxonomic composition of temperate or tropical species assemblages of Chironomidae (Coffman & de la Rosa 1998; Ferrington *et al.* 2009). Taxonomic composition is defined the number and arrangement of distinct species that are found in an assemblage (Barbour *et al.* 1999).

Coffman and de la Rosa (1998) compared the taxonomic composition and temporal change in composition for subfamilies and tribes from streams in northwestern Costa Rica and western Pennsylvania. This study measured Chironomidae emergence composition over one year and across several streams of similar size in northwestern Costa Rica. They reported the mean change in the Sørensen classic similarity index, which ranged from 0.5-0.58 for tropical streams in Costa Rica versus 0.73-0.74 for temperate streams in Pennsylvania. This index can be used to quantify variability in emergence by converting it into a dissimilarity index (= 1.0 minus the similarity index), which is a measure of temporal and spatial variability. Thus, over the course of a year both the temperate and tropical chironomid stream assemblages had low temporal taxonomic overlap, but tropical streams had higher overlap than temperate streams. The

authors suggested that the pronounced seasonal differences in the number of species emerging from the temperate streams versus tropical streams could be due to less constraint of emergence patterns on the temporal axis in the tropics. Therefore, most species are present the majority of the time and consecutive generations are developing throughout the year without diapause (Coffman & de la Rosa 1998).

Over smaller scales, Ferrington *et al.* (2009) documented spatial and temporal variability of Chironomidae emergence and composition from Lake Erie and Presque Isle Bay in Pennsylvania for use in rapid bioassessment protocols. This study measured chironomids over three days at two shallow water sites, bay and lake, that were separated by an isthmus, but less than 300 meters apart. Average Sørensen classic similarities of samples collected in the bay and lake were both high (0.712 and 0.718, respectively). The results of this study demonstrated that SFPE samples collected over restricted temporal scales should exhibit high precision for assessing Chironomidae emergence and taxonomic composition and a few consecutive days of sampling should be sufficient for biomonitoring programs (Ferrington *et al.* 2009).

Despite the findings of these two studies, no study has tested the temporal or spatial variability of Chironomidae emergence composition in a Neotropical brackish water setting. The goal of this chapter is to quantify the temporal and spatial variability of the Chironomidae community assemblage in Laguna del Tortuguero and Quebrada. By quantifying emergence variability, we can answer the following questions: Are there differences between chironomids emerging in the dry versus wet season? Are there differences among sites over small spatial scales in a single estuary across a gradient of

salinity? Are there differences in daily emergence in either season? Consequently, a field design was developed to address the following objectives: (1) to measure variability of emergence in the dry and wet seasons; (2) to measure variability across samples sites; and (3) to measure variability across samples dates. The following hypotheses were tested regarding temporal and spatial variability of Chironomidae community in Tortuguero National Park, Costa Rica.

H_{01}: Variability in emergence across samples sites in Laguna del Tortuguero is equal.

$$LT1_{dry+wet} = LT2_{dry+wet} = LT3_{dry+wet}$$

H_{a1}: Variability in emergence is not equal across samples sites in Laguna del Tortuguero.

$$LT1_{dry+wet} \neq LT2_{dry+wet} \neq LT3_{dry+wet}$$

H_{02}: Variability in emergence across samples sites in Laguna del Tortuguero is equal in the dry season.

$$LT1_{dry} = LT2_{dry} = LT3_{dry}$$

H_{a2}: Variability in emergence is not equal across sample sites in Laguna del Tortuguero in the dry season.

$$LT1_{dry} \neq LT2_{dry} \neq LT3_{dry}$$

H_{03}: Variability in emergence across samples sites in Laguna del Tortuguero is equal in the wet season.

$$LT1_{wet} = LT2_{wet} = LT3_{wet}$$

H_{a3}: Variability in emergence is not equal across sample sites in Laguna del Tortuguero in the wet season.

$$LT1_{wet} \neq LT2_{wet} \neq LT3_{wet}$$

H_{04}: Variability in emergence across sample dates in Laguna del Tortuguero in the dry season is equal.

$$\text{Day } 1_{dry} = \text{Day } 2_{dry} = \text{Day } 3_{dry} = \text{Day } 4_{dry} = \text{Day } 5_{dry} = \text{Day } 6_{dry} = \text{Day } 7_{dry}$$

H_{a4}: Variability in emergence is not equal across sample dates in Laguna del Tortuguero in the dry season.

$$\text{Day } 1_{dry} \neq \text{Day } 2_{dry} \neq \text{Day } 3_{dry} \neq \text{Day } 4_{dry} \neq \text{Day } 5_{dry} \neq \text{Day } 6_{dry} \neq \text{Day } 7_{dry}$$

H_{05}: Variability in emergence across sample dates in Laguna del Tortuguero in the wet season is equal.

$$\text{Day } 1_{wet} = \text{Day } 2_{wet} = \text{Day } 3_{wet} = \text{Day } 4_{wet} = \text{Day } 5_{wet} = \text{Day } 6_{wet} = \text{Day } 7_{wet}$$

H_{a5}: Variability in emergence is not equal across sample dates in Laguna del Tortuguero in the wet season.

$$\text{Day } 1_{wet} \neq \text{Day } 2_{wet} \neq \text{Day } 3_{wet} \neq \text{Day } 4_{wet} \neq \text{Day } 5_{wet} \neq \text{Day } 6_{wet} \neq \text{Day } 7_{wet}$$

MATERIALS AND METHODS

Taxonomic Composition

See chapter 1 for a description of the study area and Chironomidae SFPE sample collection, processing, and identification. Specimens from Laguna del Tortuguero and Quebrada were numbered and categorized by subfamily, tribe, genus, and species. The number of individuals was graphically displayed by genus and subfamily. See Chapter 4 for descriptions of the genera and species collected in this study and a comprehensive taxonomic list. See Appendix for tables of generic and species richness of samples collected in each of the sample sites.

Chironomidae Community Similarity

Temporal and spatial variability of species data were measured using two shared species estimators, Sørensen's classic and Sørensen's abundance-based index. For both of these indices, an index value of 1.0 means that all taxa are shared between a pair of samples, while an index value of 0.0 means that no taxa are shared between a pair of samples. As indicated earlier, one minus the calculated similarity value is a measure of dissimilarity or variability in composition between two samples (Magurran 2004).

The Sørensen's classic index is an incidence-based index (qualitative), and is one of the most-commonly reported in the literature (Magurran 2004; Chao *et al.* 2006; Coffman & de la Rosa; Colwell 2009). Coffman *et al.* (2008) reported this index in the Chironomidae composition studies of Costa Rica.

The classic Sørensen incidence-based index equation is calculated as follows:

$$S_{clas} = (2A)/(2A+B+C)$$

A is equal to the number of species shared among samples 1 and 2, B is equal to the number of species unique to sample 1, and C is equal to the number of species unique to sample 2. The Sørensen classic index compares two samples or assemblages based on species presence/absence data. Despite the wide use of this classical index in ecological studies, it does not take species abundance into account. Therefore, abundant and rare species are treated equally (Chao *et al.* 2006).

Chao *et al.* 2006 proposed a probabilistic derivation of the incidence-based Sørensen's classic index that was based on species abundance data. The Sørensen's abundance-based index equation is calculated as follows:

$$S_{abd} = (2UV)/(U+V)$$

U denotes the total relative abundances of individuals belonging to shared species in sample 1. Likewise, V denotes the total relative abundances of individuals belonging to shared species in sample 2. UV represents the total abundances of shared species in samples 1 and 2. In this equation, all individuals are treated equally. Frequencies of rare, shared taxa from the samples were used to estimate and adjust U and V to account for rare or unseen shared species (i.e., species that are predicted to occur at a sample site but do not occur in the sample because of their rarity). This index was originally developed to analyze vegetation patterns in tropical habitats where species richness was high, but abundance of many species was low. Consequently, the Sorensen's abundance-based index was also used to analyze data in this study, since many samples had rare taxa and low abundances, and this index adjusts for undersampling bias. This index accounts for the chance that larger samples would reveal a larger proportion of shared species (Chao *et al.* 2005; Chao *et al.* 2006).

Similarity was calculated for all possible pair-wise combinations of samples from Laguna del Tortuguero across all sites and on all dates. There were 42 samples collected in Laguna del Tortuguero, and therefore a total of 861 pair-wise sample comparisons were made. The data from the Quebrada sample site were not included for community similarity analysis, since there were very few taxa and specimens. The following permutations were calculated for species data: similarity of emergence in dry versus wet season for all sites and dates, mean similarity of emergence in Laguna del Tortuguero for all sites and dates, mean emergence of sites 1, 2, and 3 for all dates, mean emergence of

sites 1, 2, and 3 for all dates in either the dry or wet season, and days one through seven for all Laguna del Tortuguero sample sites in either the dry or wet season (see Table 2).

The Sørensen's classic incidence-based and abundance-based indices were computed using EstimateS (Colwell 2009). In EstimateS output, S_{clas}, is called the "Sørensen Classic" estimator and, S_{abd}, is called the "Chao-Jaccard-Est Abundance-based" estimator (Colwell 2009). Calculated Sørensen's similarity estimates from this study were compared to Sørensen's similarity estimates from the data collected in the study by Ferrington *et al.* (2009). Originally, Ferrington *et al.* (2009) calculated similarity estimates based on Jaccard's Coefficient and Whittaker's Percentage Similarity; however, similarities were recalculated using both the Sørensen's classic and abundance-based indices in EstimateS (Colwell 2009). Statistical significance among temporal and spatial similarity means was tested using a one-way analysis of variance (ANOVA) (R Development Core Team 2009).

RESULTS

Taxonomic Composition

A total of 3,471 exuviae were picked and sorted. From this material, 2,926 exuviae were slide mounted and identified to the lowest taxonomic resolution. Cumulative taxonomic distribution of the collections was quantified. The exuviae represented a total of 111 species, which belonged to 3 subfamilies, at least 9 tribes, and 44 genera. Eleven of the 44 genera were unidentifiable to genus and placed in the "unknown" category. The percent of total species richness collected from site-to-site and

day-to-day ranged from 4 to 65 percent. For Laguna del Tortuguero samples, the dry season had the highest proportion of total species collected at the first site on the fourth day, 65%, while the highest proportion in the wet season was at the second site on the third day, 44% (Table 1). See Appendix for generic and species taxonomic distributions by sample site and date. Total number of individuals per genus ranged from 1 to 989. The four most abundant genera included *Tanytarsus*, *Polypedilum*, *Cricotopus*, and *Cryptotendipes*, and collectively these genera accounted for 71% of total specimens. Generally, there were a large number of rare species and genera in the collection, with 28 of the genera represented by 15 or fewer specimens. Approximately, 1 specimen out of every 30 specimens in the collection was a new taxon (Fig. 1).

The chironomid composition consisted of 11 Tanypodinae genera, 6 Orthocladiinae genera, and 26 Chironominae genera. Within Chironominae, there were 20 Chironomini genera, 1 Pseudochironomini genus, and 5 Tanytarsini genera. The most species rich subfamily was Chironominae for samples sites Laguna del Tortuguero 1, 2, and Quebrada with a total of 1,902 individuals, while species within Orthocladiinae were the most abundant for sample site Laguna del Tortuguero 3 with a total of 338 individuals (Fig. 2).

Table. 1. Proportion of total species richness collected each day for each sample site. The most species-rich day for each season is bolded (LT = Laguna del Tortuguero, Q = Quebrada).

	Dry							Wet						
	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun	4-Jan	5-Jan	6-Jan	7-Jan	8-Jan	9-Jan	10-Jan
LT 1	0.04	0.15	0.19	**0.65**	0.29	0.42	0.10	0.04	0.06	**0.19**	0.08	0.06	0.10	0.02
LT 2	0.11	0.40	0.44	**0.49**	0.16	0.23	0.19	0.19	0.13	**0.44**	0.10	0.17	0.30	0.06
LT 3	0.05	0.05	0.05	0.20	0.15	**0.45**	0.08	0.18	0.10	0.20	0.13	**0.40**	0.10	0.10
Q	0.00	0.04	0.04	0.04	**0.08**	**0.08**	0.00	0.38	0.23	0.42	**0.54**	0.12	0.12	0.04

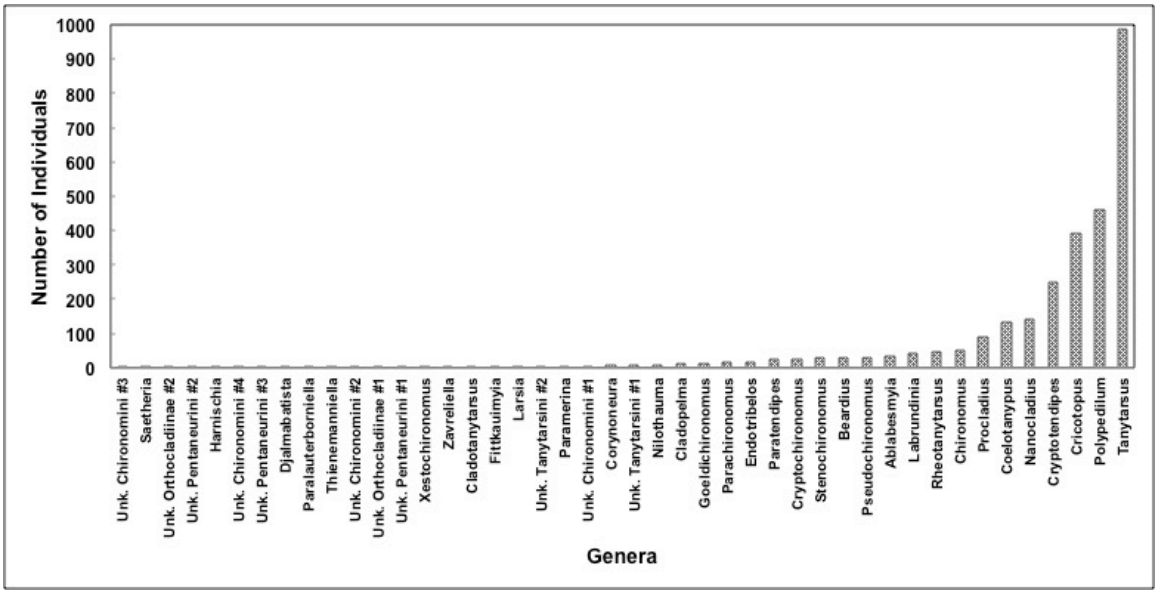

Figure 1. Number of individuals in each genus.

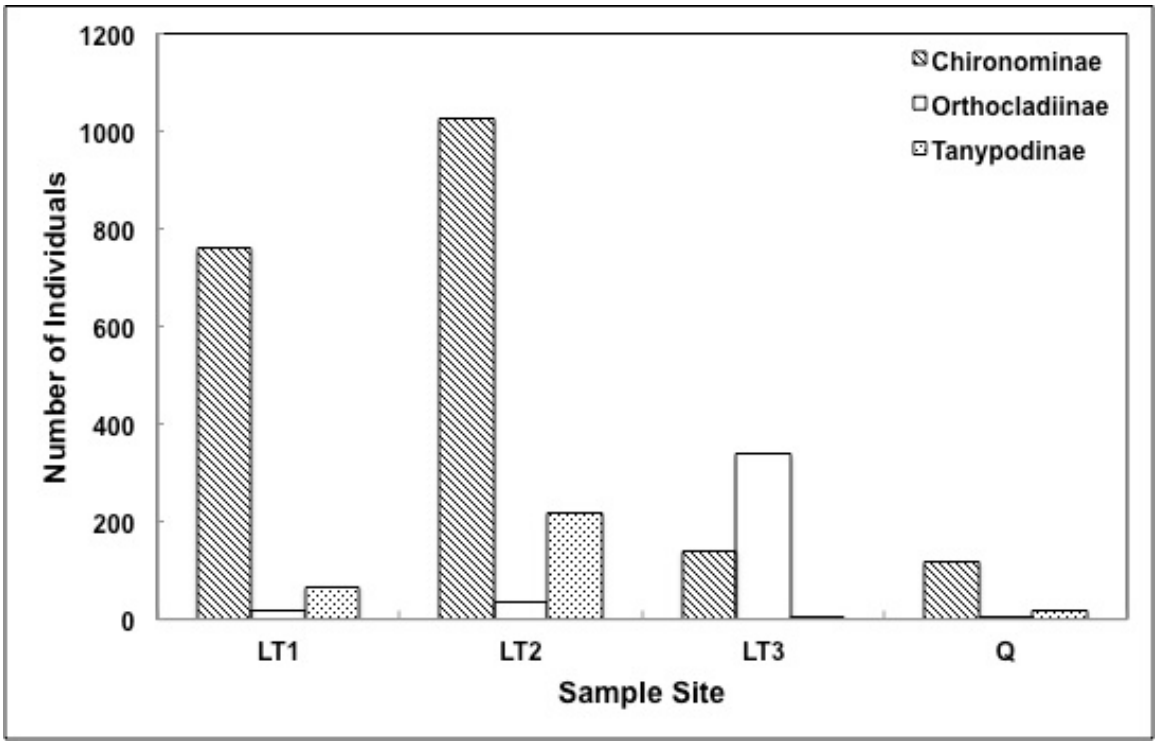

Figure 2. Number of individuals of each subfamily (Chironominae, Orthocladiinae, and Tanypodinae) at each sample site (LT = Laguna del Tortuguero, Q = Quebrada).

Seventy-two percent of the samples had 50 or fewer specimens, about 13% of the samples had 50 to 100 specimens, and about 16% had 100 to 500 specimens. Approximately, 4% of the samples had more than 500 exuviae. For samples with 450-500+ specimens, there was no determination of the total number of exuviae in the sample, but in some samples, the numbers could have exceeded 1,000 specimens based on the proportion of the sample that was picked. There were some differences in the distribution of the size of samples between samples collected in June of 2010 and January of 2011, with samples collected in June of 2010 tending to have more specimens than samples in January of 2011. From June 2010, 72% of the samples had 100 or fewer specimens compared to 96% of the samples from January 2011. Additionally, 18% of

June 2010 samples had over 200 specimens, while there were no samples with over 200 specimens collected in January 2011 (Fig. 3).

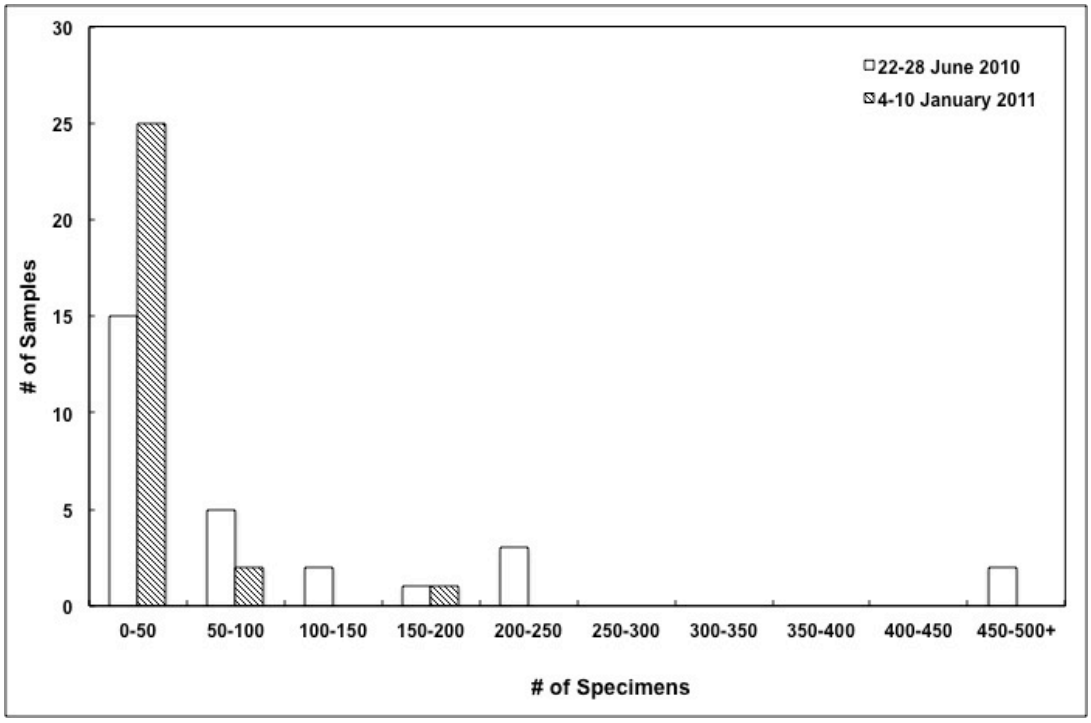

Figure 3. Distribution of the number of exuviae picked from samples.

Chironomidae Community Similarity

Species temporal and spatial Chironomidae similarity and variability were measured from three samples sites, Laguna del Tortuguero 1, 2, and 3, and seven sample dates in both the dry and wet seasons. Table 2 shows the species-level Sørensen's individual or mean similarity index values. Figures 4 through 7 show the mean species Sørensen's abundance-based similarity values. Sørensen's abundance-based index values were always greater than Sørensen's classic index values. There was very high similarity when the dry and wet seasons were compared. Samples from the wet versus the dry season had qualitative similarities of 0.706 or quantitative similarities of 0.99. There was

low to moderate similarity when samples were compared within a site and amongst all dates in both seasons. Mean qualitative similarities ranged from 0.252 to 0.357 and quantitative similarities of 0.345 to 0.653 when comparing within samples sites across all dates and seasons. The first null hypothesis can be rejected, since the one-way ANOVA f-test indicates that there is significant difference between Laguna del Tortuguero sites ($p < 0.0001$) (Table 2).

Mean similarities were moderate to high when comparing samples within a site and amongst all dates in each season. Mean temporal quantitative similarities in the dry season ranged from 0.477 to 0.773, while wet season ranged from 0.465 to 0.724 (Table 2). The second and third null hypotheses can be rejected, since the one-way ANOVA f-test indicates that there is significant difference between Laguna del Tortuguero sample sites in both the dry and wet season ($p_{dry} = 0.006$, $p_{wet} = 0.008$, Figs. 4 & 5).

Mean similarities were zero to very high when comparing samples within a date and among sites in each season. Mean spatial quantitative similarities ranged from 0.045 to 0.950 in the dry season, and 0.000 to 0.438 in the wet season (Table 2). The fourth null hypothesis can be rejected, since the one-way ANOVA f-test indicates that there are significant differences between Laguna del Tortuguero samples dates in the dry season ($p_{dry} = 0.00841$, Fig. 6). However, the fifth null hypothesis cannot be rejected, since the one-way ANOVA f-test indicates that there is no significant difference between Laguna del Tortuguero samples dates in the wet season ($p_{wet} = 0.1$, Fig. 7).

Table 2. Species-level Sørensen community similarity estimates (N = sample size, S_{clas} = Sørensen classic index, S_{abd} = Sørensen abundance-based index, LT = Laguna del Tortuguero).

Sample Comparison	N	S_{clas}	S_{abd}
Dry vs. Wet (all dates & sites)	1	0.706	0.99
LT 1 (all dates)	14	0.252	0.345
LT 2 (all dates)	14	0.357	0.653
LT 3 (all dates)	14	0.308	0.572
LT 1 (all dates, dry)	7	0.293	0.477
LT 2 (all dates, dry)	7	0.444	0.773
LT 3 (all dates, dry)	7	0.355	0.689
LT 1 (all dates, wet)	7	0.334	0.511
LT 2 (all dates, wet)	7	0.349	0.724
LT 3 (all dates, wet)	7	0.261	0.465
Day 1 (all sites, dry)	3	0.067	0.045
Day 2 (all sites, dry)	3	0.224	0.244
Day 3 (all sites, dry)	3	0.158	0.288
Day 4 (all sites, dry)	3	0.334	0.950
Day 5 (all sites, dry)	3	0.266	0.419
Day 6 (all sites, dry)	3	0.502	0.882
Day 7 (all sites, dry)	3	0.319	0.443
Day 1 (all sites, wet)	3	0.230	0.438
Day 2 (all sites, wet)	3	0.000	0.000
Day 3 (all sites, wet)	3	0.109	0.123
Day 4 (all sites, wet)	3	0.195	0.295
Day 5 (all sites, wet)	3	0.239	0.369
Day 6 (all sites, wet)	3	0.086	0.097
Day 7 (all sites, wet)	3	0.000	0.000

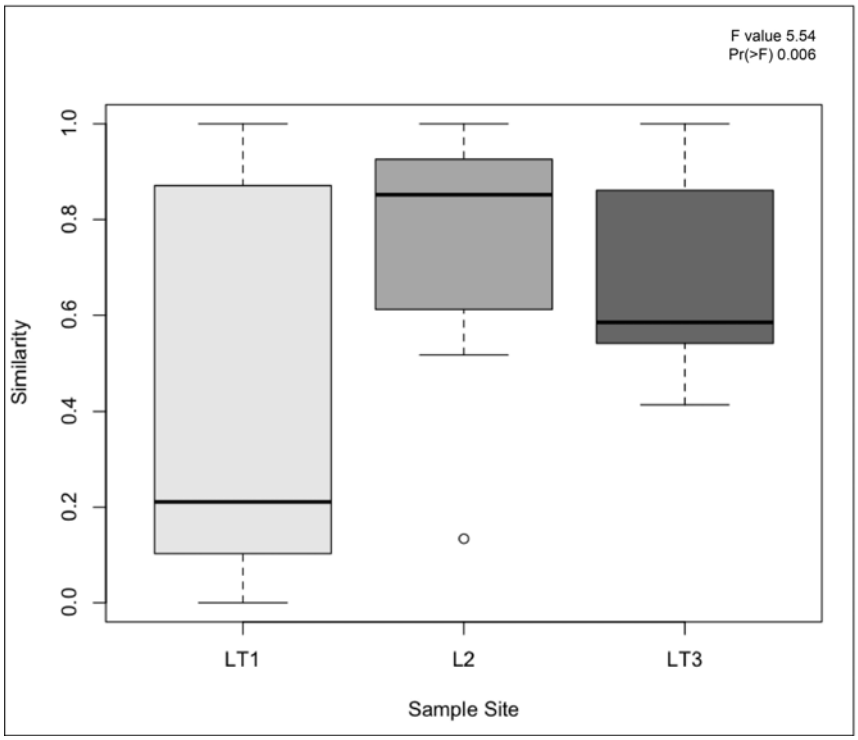

Figure 4. Mean species-level Sørensen's abundance-based similarities at each sample site in the dry season (LT = Laguna del Tortuguero).

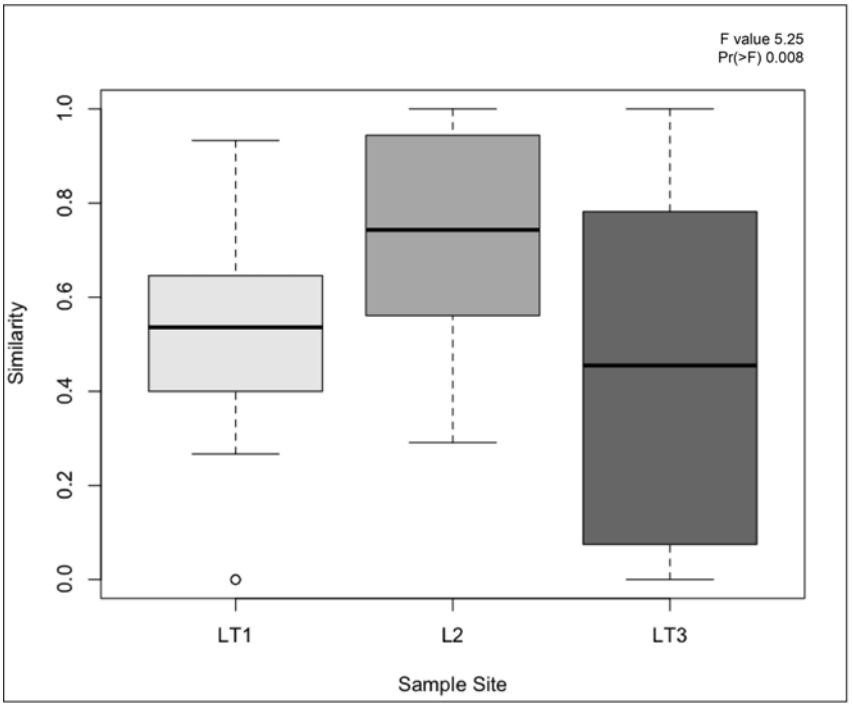

Figure 5. Mean species-level Sørensen's abundance-based similarities at each sample site in the wet season (LT = Laguna del Tortuguero).

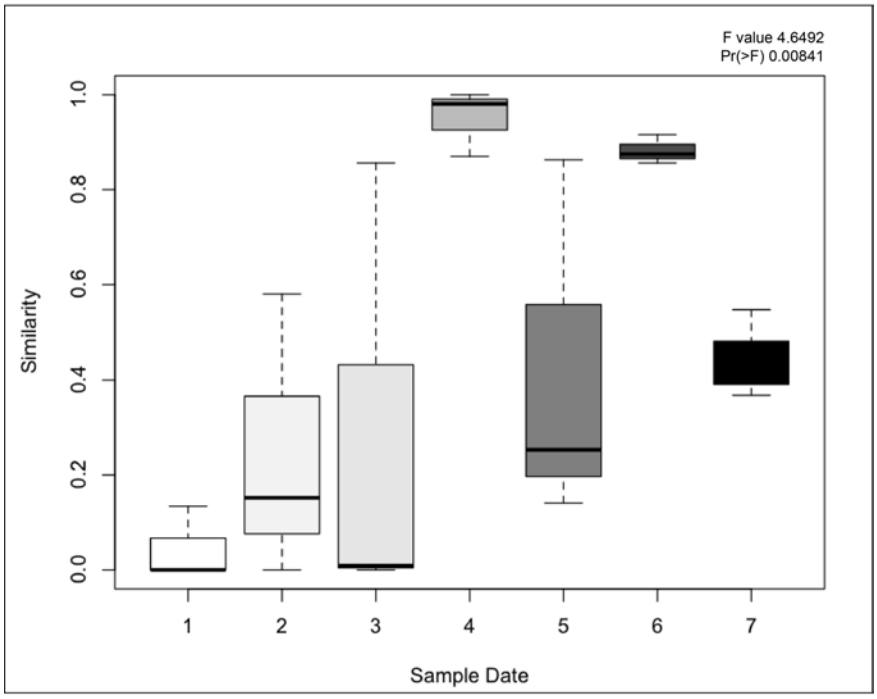

Figure 6. Mean species-level Sørensen's abundance-based similarities for each sample date in the dry season (LT = Laguna del Tortuguero).

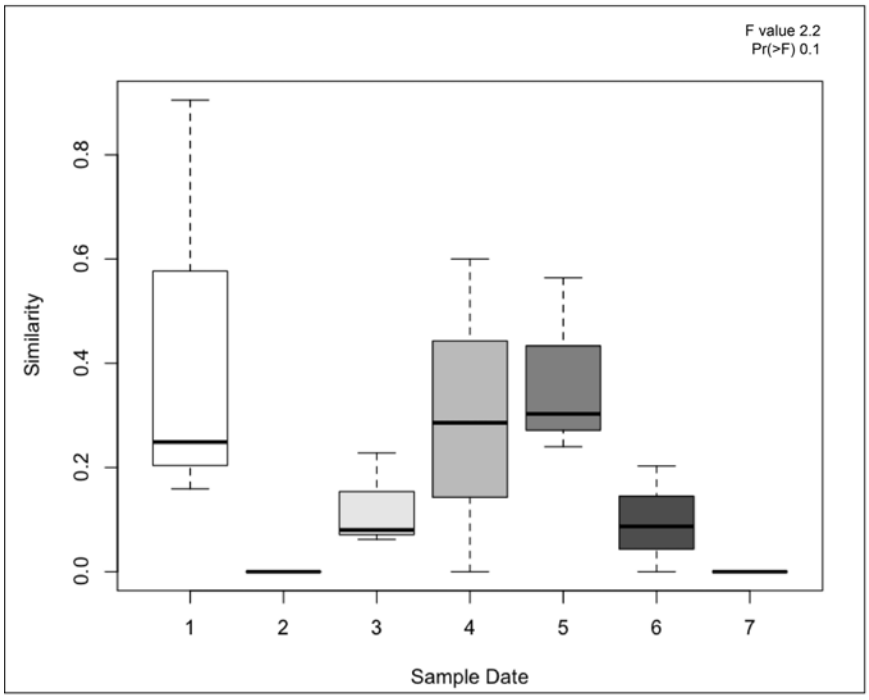

Figure 7. Mean species-level Sørensen's abundance-based similarities for each sample date in the wet season (LT = Laguna del Tortuguero).

DISCUSSION

Taxonomic Distribution

The Chironomidae community in these Neotropical brackish waters appears to be both taxonomically narrow (few subfamilies and tribes) and taxonomically deep (many closely related genera and species) as defined by Coffman *et al.* (1992). Similar patterns of low taxonomic breadth and high taxonomic depth of tropical chironomid communities were encountered in studies of tropical streams by Coffman *et al.* (1992), Watson and Heyn (1992), and Ferrington *et al.* 1993. Only three out of the eleven subfamilies were encountered, but there were at least 111 species belonging to 44 genera. Coffman *et al.* (1992) made the argument that the formation and fragmentation of an ancient isthmus connecting North and South American, as well as the formation of the present isthmus, may have played a role in generating high species richness in Costa Rica.

Chironomidae taxonomic richness appears to be quite high in this Neotropical estuary and stream. In a Costa Rican survey of Chironomidae, Watson and Heyn (1992) found at least 148 species, many belonging to genera that did not include the 250 species encountered in the four study sites reported by Coffman and de la Rosa (1998). However, the number of Chironomidae genera collected in this study, 44, is much higher than any other temperate or Neotropical ecological brackish water study (Parma & Krebs 1977; Menzie 1980; Kawai *et al.* 2000; Dimitriadis & Cranston 2007; Ramirez 2008). In general, Neotropical assemblages appear to show more continuous emergence and are somewhat less tightly constrained on the time axis, which could explain the higher numbers of species per sample when compared to temperate collections. The high

Chironomidae diversity could result from factors such as high available niche space, specialization of niche space, and tolerance of potential insect competitors (Coffman & de la Rosa 1998).

While the diversity of taxa appeared to be high, the individual counts of many taxa were low. There were four very abundant genera, *Tanytarsus*, *Polypedilum*, *Cricotopus*, and *Cryptotendipes*. However, more commonly, there were a large number of rare species and genera in each sample, and across all samples over half of the genera were represented by less than 15 specimens. The low numbers of specimens could be due to ecological factors such as low frequency of adult emergence or low population levels due to competition from other non-insect species present in the brackish water estuary. In addition, it is possible, but less likely, that certain species or genera could have been missed while sampling and this could have resulted in low numbers. SFPE samples were collected at 100-meter reaches of each sample site and certain microhabitats in the Laguna del Tortuguero or Quebrada could have been undersampled.

These low counts of individuals collected from the estuary are consistent with low abundance patterns reported in other Neotropical studies of Chironomidae (Ferrington *et al.* 1993; Coffman & de la Rosa 1998). In Puerto Rico, Ferrington *et al.* (1993) only collected 2,451 specimens using a biweekly emergence trap covering four square meters of stream over the course of one year. Coffman and de la Rosa (1998) reported that chironomid densities in Costa Rican streams rarely reach 5000 larvae per square meter, compared with densities many times that level being typical of temperate streams (Coffman & de la Rosa 1998). The lower densities of larvae at each sample site in

Laguna del Tortuguero and Quebrada could explain lower frequencies of adults emerging (personal observation).

Presence of predatory macroinvertebrates, crustaceans, fish, and filter-feeding species of shrimp could be related to low counts of individual Chironomidae in this Neotropical stream and estuary. Other studies in Neotropical streams have documented the negative correlations between abundance of Chironomidae versus other larger macroinvertebrates, crustaceans, and fish (Flecker 1992; Ferrington *et al.* 1993; Pringle & Blake 1994; Flecker 1996; Pringle & Hamaski 1998; Souza *et al.* 2007). Filtering shrimp have been suggested to decrease the number of filter-feeding genera such as *Rheotanytarsus* in streams of Puerto Rico (Ferrington *et al.* 1993). In a coastal forest stream of Rio de Janeiro, Brazil, the dominant chironomid (*Cricotopus*) increased in number when electrical barriers excluded shrimps and ephemeropterans. The shrimps and ephemeropterans compete with chironomids by decreasing the quantity of periphyton and distribution of sediments (Souza *et al.* 2007). In tropical lowland streams of the Atlantic coast of Costa Rica, Pringle and Hamaski (1998) documented the role of omnivorous fish and shrimp in the significant reduction of Chironomidae larval densities (Pringle & Hamaski 1998). Several other studies of tropical streams in Puerto Rico and Venezuela have documented the negative effects of macroconsumers such as shrimp and fish on the densities of Chironomidae larvae (Flecker 1992; Pringle & Blake 1994; Flecker 1996). The dominance of these other aquatic animals could cause niche space and food resource depletion for the chironomids in the Tortuguero stream and estuary.

Chironomidae Community Similarity

The results show that there is high similarity and thus little variability between samples collected in the dry and wet seasons. The Sorensen's abundance-based index predicts that there was less than one percent variability between the species found in the wet and dry seasons in Laguna del Tortuguero, when adjusted for rare taxa. These results suggest that there is high continuity between the species of chironomids emerging in the dry and wet seasons in this estuary. This conclusion follows the theory that emergence of Chironomidae in low-latitude waters show less seasonality and is fairly constant throughout the year (Ferrington *et al.* 1993).

Sørensen's abundance-based index appears to better quantify emergence patterns in this system, since this estimator takes into account the predicted unseen rare or shared species. Originally developed for vegetation analyses in tropical settings, this index predicts approximately 20 percent greater similarity in emergence when adjusted for unseen rare shared taxa.

The low taxa abundance in the samples explains the low similarity values between sample site comparisons for Sorensen's classic index. Over 72% of the samples had fewer than 50 specimens and several of the genera and species only appear once or twice in the samples and consequently there are a number of singletons or species unique to each sample.

As predicted, there was high variability of Chironomidae emergence within a sample site across dates and seasons. The chironomid assemblage and relative abundance of individuals collected in the dry season were slightly different than those

collected in the wet season. Overall, more chironomids emerged in the dry season compared to the wet season in the estuary and stream. These results are consistent with the idea that seasonal patterns of rainfall affect Chironomidae emergence patterns in tropical streams and typically there is higher emergence during periods with less rainfall (Coffman & de la Rosa 1998).

Day-to-day or temporal variability of Chironomidae emergence was low to moderate, ranging from approximately 23 to 54%. These results do not match the prediction based on studies in higher latitudes that SFPE samples collected over restricted temporal scales should exhibit low community variability across dates within a sample site. Typically, it is assumed that most day-to-day variation at a given site is a result of sampling error rather than phenological or physiochemical differentiation (Ferrington *et al.* 2008). However, biological or physical factors in the estuary such as changes in the macroconsumers and/or tidal or lunar patterns could affect the day-to-day variation in emergence. Also, there was a higher daily overlap of species in the dry season compared to the wet season. Perhaps, there is more continuous period of emergence in the dry season and a more sporadic pattern with more rainfall in the wet season.

Site-to-site or spatial variability of Chironomidae emergence was low to very high, ranging from 5 to 100%. The spatial variability on a particular sample date was higher in the dry season compared to the wet season. Changes in sedimentation from the upstream rivers and fluctuations in the tides from the downstream ocean could increase or decrease salinities and types of sediments at each of the sample site. There are most likely higher changes in salinity and sedimentation during the wet season due to the

increase of movement from rainfall. These changes could affect the habitat quality at each site and therefore affect the community of Chironomidae present and differences between sites in the estuary.

Finally, samples from the temperate lake and bay study near Lake Erie, Pennsylvania, U.S.A had lower mean variability than samples from this study (Ferrington *et al.* 2009; Ferrington pers. comm. 2011). There was higher Chironomidae temporal species overlap over a course of three days in the temperate lake and bay than seven days of sampling at three sites in the Neotropical estuary. High taxonomic diversity and low frequency of individuals per sample could explain these differences.

The results of this research indicate that Chironomidae SFPE sampling can effectively be used as part of a rapid biomonitoring program for monitoring water and sediment quality of Neotropical brackish waters in Tortuguero National Park, Costa Rica. It is highly successful at detecting spatial differences in emergence between sites in the wet and dry season. However, my research has shown that there is low temporal precision and samples collected over multiple days within a season give a better estimate of emergence composition than single-sample estimates. Future research should continue to quantify the patterns of variability of Chironomidae emergence and taxonomic composition across different temporal and spatial scales in Neotropical brackish waters of Costa Rica and other parts of Central America.

REFERENCES CITED

Armitage, P.D. and J.H. Blackburn. 1985. Chironomidae in a Pennine stream system receiving mine drainage and organic enrichment. Hydrobiologia. 121: 165-172.

Barbour, M.T., J. Gerritsen, B.D. Snyder and J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: Periphyton, benthic macroinvertebrates, and Fish. 2nd edition. Report number EPA 841-B-99-002. US EPA, Washington, U.S.A.

Chao, A. 1984. Non-parametric estimation of the number of classes in a population. Scandinavian Journal of Statistics 11: 265-270.

Chao, A., R.L. Chazdon, R.K. Colwell and T.J. Shen. 2005. A new statistical approach for assessing compositional similarity based on incidence and abundance data. Ecology Letters 8: 148-159.

Chao, A., R.L. Chazdon, R.K. Colwell and T.J. Shen. 2006. Abundance-based similarity indices and their estimation when there are unseen species in samples. Biometrics 62: 361-371.

Chazdon, R.L., R.K. Colwell, J.S. Denslow and M.R. Guariguata. 1998. Statistical methods for estimating species richness of woody regeneration in primary and secondary rain forests of NE Costa Rica. Pp. 285-309 in F. Dallmeier and J. A. Comiskey, eds. Forest biodiversity research, monitoring and modeling: Conceptual background and Old World case studies. Parthenon Publishing, Paris.

Coffman, W.P., C.L. de la Rosa, K.W. Cummins and M.A. Wilzbach. 1992. Species Richness in some Neotropical (Costa Rica) and Afrotropical (west Africa) Lotic Communities of Chironomidae (Diptera). Netherlands Journal of Aquatic Ecology 26: 229-237.

Coffman, W.P. and C.L. de la Rosa. 1998. Taxonomic composition and temporal organization of tropical and temperate species assemblages of lotic Chironomidae. Journal of the Kansas Entomological Society 71: 388-406.

Colwell, R.K. and J.A. Coddington. 1994. Estimating terrestrial biodiversity through extrapolation. Philosophical Transactions of the Royal Society (Series B) 345: 101-118.

Colwell, R.K. 2009. EstimateS: Statistical estimation of species richness and shared species from samples. Version 8.2. User's Guide and application published at: http://purl.oclc.org/estimates.

Dimitriadis, S. and P.S. Cranston. 2007. From the Mountains to the Sea: assemblage structure and dynamics in Chironomidae (Insecta: Diptera) in the Clyde River estuary gradient, New South Wales, southeastern Australia. Australian Journal of Entomology 46: 188-197.

Epler, J.H. 2001. Identification Manual for the larval Chironomidae (Diptera) of North and South Carolina. A guide to the taxonomy of the midges of the southeastern United States, including Florida. Special Publication SJ2001-SP13. North Carolina Department of Environment and Natural Resources, Raleigh, NC, and St. Johns River Water Management District, Palatka, FL. 526 pp.

Ferrington, L.C., Jr. and N.H. Crisp. 1989. Water Chemistry Characteristics of Receiving Streams and the Occurrence of Chironomus riparius and Other Chironomidae in Kansas. Acta Biologia Debrecina, Oecologica Hungarica 3: 115-126.

Ferrington, L.C. Jr., K.M. Buzby and E.C. Masteller. 1993. Composition and temporal abundance of Chironomidae emergence from a tropical rainforest stream at El Verde, Puerto Rico. Journal of the Kansas Entomological Society 66: 167-180.

Ferrington Jr., L.C., E.C. Masteller and J.A. Santiago-Blay. 2009. Comparison and significance of Chironomidae emergence from Lake Erie and Presque Isle Bay, Erie, Pennsylvania, U. S. A. - In: Hughes, S. J., Khadem, M. and Carvalho, M. A. (eds.): Proceedings of the 16th International Chironomid Symposium, Boletim do Museu Municipal do Funchal Supplement 13: 21-28.

Flecker, A.S. 1992. Fish trophic guilds and the structure of a tropical stream: weak direct vs. strong indirect effects. Ecology 73: 927-940. .

Flecker, A.S. 1996. Ecosystem engineering by a dominant detritivore in a diverse tropical stream. Ecology 77: 1845-1854.

Kawai, K., Morihiro, S. and H. Imabayashi. 2000. Transectional distribution patterns of chironomid larvae in estuaries. Medical Entomology and Zoology 51: 215–220.

Magurran, A.E. 1998. Ecological diversity and its measurement. Princeton University Press, Princeton, New Jersey, U.S.A.

Magurran, A.E. 2004. Measuring biological diversity. Blackwell.

Menzie C.A. 1980. The chironomid (Insecta: Diptera) and other fauna of a *Myriophyllum spicatum L.* plant bed in the lower Hudson River. Estuaries 3: 38-54.

Murphy, P.M. and R.W. Edwards. 1982. The spatial distribution of the freshwater macroinvertebrate fauna of the River Ely, South Wales, in relation to pollutional discharges. Environmental Pollution (Series A). 29: 111-124.

Parma, S. and B.P.M. Krebs. 1977. The distribution of chironomid larvae in relation to chloride concentration in a brackish water region of the Netherlands. Hydrobiologia 52: 117-126.

Pringle, C.M. and G.A. Blake. 1994. Quantitative effects of atyid shrimp (Decapoda: Atyidae) on the depositional environment in a tropical stream: use of electricity for experimental exclusion. Canadian Journal of Fisheries and Aquatic Sciences 51: 1443-1450.

Pringle C.M. and T. Hamasaki. 1998. The role of omnivory in a Neotropical stream: Separating diurnal and nocturnal effects. Ecology 79: 269-80.

R Development Core Team. 2009. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

Rae, J.G. 1989. Chironomid midges as indicators of organic pollution in the Sciotio River Basin, Ohio. The Ohio Journal of Science 89: 5-9.

Ramirez, M.F. 2008. Emergent Aquatic Insects: Assemblage Structure and Patterns of Availability in Freshwater Wetlands of the Lower Columbia River Estuary. (Masters Thesis) University of Washington.

Souza, M.L., T.P. Moulton, R.M.L. Silveira, F.A.M. Krsulović and E.F. Brito. 2007. Responses of Chironomidae (Diptera: Insecta) to exclusion of shrimps and Ephemeroptera in a coastal forest stream, Rio de Janeiro, Brazil. Brazilian Journal of Biology 67: 631-637.

Watson, C.N., Jr. and M.W. Heyn. 1992. A preliminary survey of Chironomidae (Diptera) of Costa Rica, with emphasis on the lotic fauna. Netherlands Journal of Aquatic Ecology 26: 257-262.

Wilson, R.S. 1987. Chironomid communities in the River Trent in relation to water chemistry. Entomologica Scandinavica Supplement 29: 387-193.

CHAPTER 4: IDENTIFICATION GUIDE AND KEY TO CHIRONOMID PUPAL EXUVIAE OF TORTUGUERO NATIONAL PARK, COSTA RICA

INTRODUCTION

Aquatic biological monitoring

Biological communities provide information on overall water quality conditions. In particular, aquatic macroinvertebrates have been used in water quality assessment due to their sedentary nature, long life cycles, low dispersal capabilities, and the range of responses to environmental stresses by different species. Their population assemblage reflects the stream conditions present during their lifecycles. As a result, certain species are tolerant of pollution while others are intolerant and will be absent from water systems with poor water quality or habitat. Aquatic macroinvertebrate sampling can be used to infer the current conditions and recent water quality of specific water bodies (Barbour *et al.* 1999). However, traditional methods of collecting aquatic macroinvertebrates can be time consuming and expensive (Ferrington *et al.* 1991).

Family Chironomidae and pupal exuviae

One efficient form of sampling involves collection of surface floating pupal exuviae (SFPE) of a group of aquatic flies of the family Chironomidae (Spies *et al.* 2009). Chironomidae are commonly known as non-biting midges. Collections of SFPE have been used across a range of aquatic systems, from small, freshwater streams to large rivers and lakes (Armitage *et al.* 1995; Hayford & Ferrington 2006). The wide distribution of the group in combination with the widely varying species-specific ranges of tolerance to water quality make Chironomidae a highly valuable tool for surveying and monitoring both pristine and disturbed habitats (Armitage *et al.* 1995). A large number of chironomid species are tolerant of a wide range of salinities and may be a major component of the fauna of brackish water (Rawson & Moore 1944). Chironomid

community composition has been used in many studies in monitoring organic pollution and eutrophication (Murphy & Edwards 1982; Armitage & Blackburn 1985; Wilson 1987; Rae 1989).

Chironomidae are widely distributed and frequently the most abundant macroinvertebrates in aquatic systems (Armitage *et al.* 1995). In many aquatic habitats the chironomid species present may account for more than 50% of the total number of macroinvertebrates recorded (Ferrington *et al.* 2008). It has been estimated that the worldwide total number of Chironomidae species may be as high as 15,000 (Armitage *et al.* 1995). In North America, about 1,100 named species are recognized (Oliver *et al.* 1990; Oliver & Dillon 1994), while in the Neotropical region the corresponding number is about 900 (Spies & Reiss 1996; Spies pers. comm., 2011). Some have proposed that total chironomid richness close to 1,000 species in Central America would not be surprising (Spies *et al.* 2009).

The chironomid life cycle is divided into four distinct life stages, i.e. egg, larva, pupa, and adult. The immature stages of most species develop in aquatic habitats, and most types of aquatic ecosystems have chironomid inhabitants. The habitats range from flowing waters (trickles, torrents, streams, rivers) and standing waters (puddles, pools, lakes) to temporary rain-pools, plant-held waters, and even thin films of water on high-altitude glaciers (Armitage *et al.* 1995). Upon completion of the larval life stage, the larva attaches itself with silken secretions to the surrounding substrate and pupation occurs. Once the developing adult has matured, the

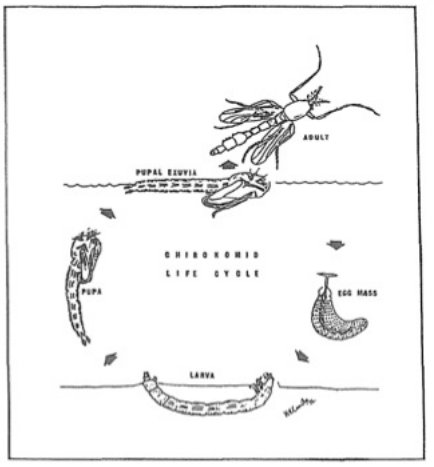

Figure 1. Life cycle of Chironomidae (adapted from Ferrington et al. 1991).

pupa frees itself from the silken chamber and swims to the surface of the water where the adult can emerge from the pupal skin (also called exuviae) (Fig. 1). The exuviae will float on the water surface and tend to accumulate in areas downstream of rocks or where riparian vegetation or fallen trees contact the water surface. These pupal exuviae can be collected while drifting on the water surface or from areas of natural accumulation to rapidly evaluate Chironomidae emergence patterns and species composition. Pupal exuviae collections take one-third the time to process compared to larval collections and can easily be identified to species or morphospecies with distinguishing morphological features (Ferrington *et al.* 1991).

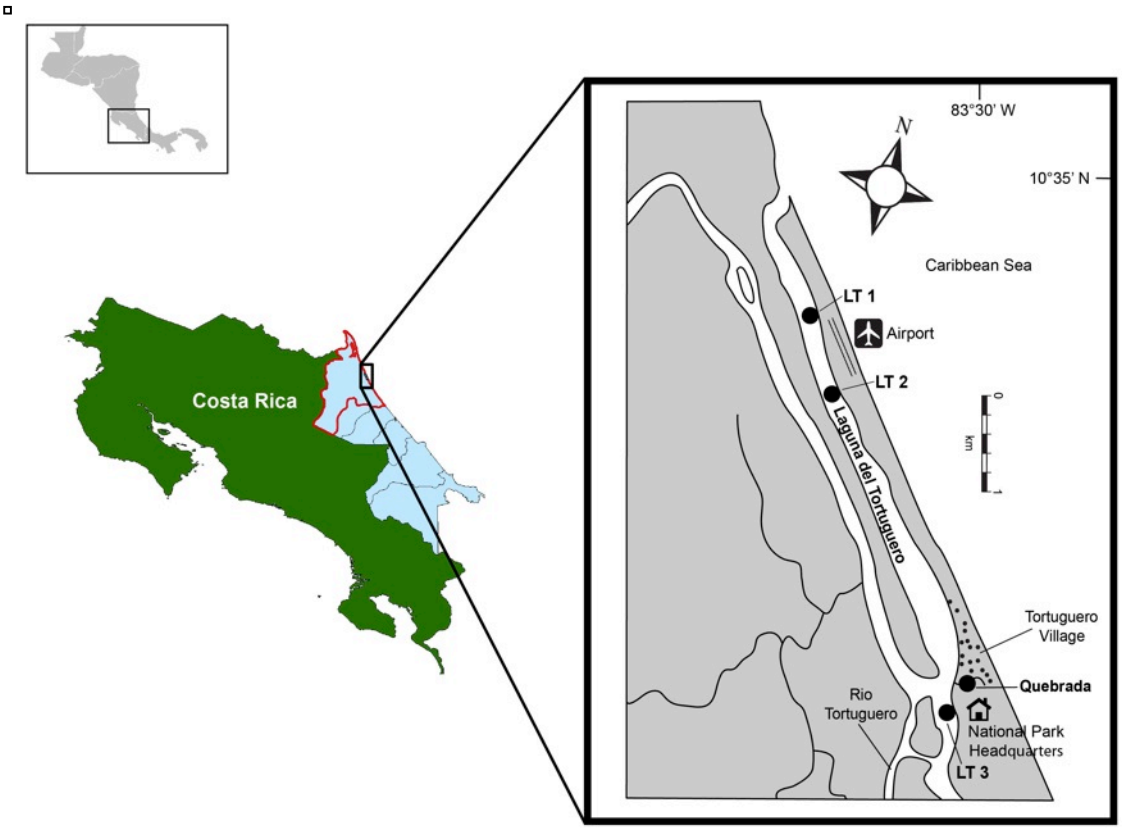

Figure 2. Sample area in Tortuguero National Park, Costa Rica (LT = Laguna del Tortuguero).

Guide Scope

This guide is based on material collected from three sample sites in the brackish water estuary, Laguna del Tortuguero, and one sample site in the freshwater stream, Quebrada, in Tortuguero National Park, Costa Rica (Fig. 2). These areas were sampled for seven consecutive days each in June 2010 and January 2011. From these samples, 3 subfamilies, 111 species, and 44 genera were identified. Consequently, this identification guide is not meant to be a comprehensive key to pupal Chironomidae of all habitats in Tortuguero National Park or Costa Rica. This guide includes keys to subfamily, tribe, genus, and species. The subfamily, tribe, and genus keys were modified from Wiederholm (1986) and Ferrington *et al.* (2008). The species keys were modified from Borkent (1984), Hayford (1998), Maschwitz and Cook (2000), and Wiedenbrug and Ospina-Torres (2005). Illustrations and photographs are included to highlight distinguishing characteristics at these taxonomic categories. The guide should be most useful to identify chironomid pupal exuviae in fresh and brackish waters in Tortuguero National Park and the surrounding Atlantic lowlands of Costa Rica, Nicaragua, and Panama.

Most of the species and some of the genera represent taxa previously unknown in the pupal stage. As a result, many taxa are left as morphospecies (e.g., *Ablabesmyia* sp. 1) or unknown genera (e.g., Unknown Chironomini #1). These taxa are unknown at the pupal stage, thus may represent either taxa with described adults or genera and species new to science. As well, these designations identify the gaps in the current state of taxonomy for the pupal stage in Chironomidae. Future rearing programs to associate adults with their immature stages and new species descriptions will reveal the identity of these taxa. Due to the great diversity of Costa Rican Chironomidae, the number of

species recorded in this guide should be considered as a low estimate and future studies will certainly document many additional taxa from this area (Spies *et al.* 2009).

How to use this guide

This guide consists of a series of dichotomous keys to subfamily, tribe, genus, and species. The subfamily sections are arranged phylogenetically, based on Ferrington *et al.* (2008). Within the subfamilies, the tribes are also arranged phylogenetically, while the genera and species are in alphabetical and numerical order. See Ferrington *et al.* (2008) for phylogenetic order of subfamilies and tribes. Unknown genera are at the end of each tribe section.

The guide starts with a dichotomous key to the three represented subfamilies. The key directs the user to tribe and/or genus keys for each subfamily. Once the tribe or genus is identified, keys are provided to species or morphospecies for known genera. If a specimen appears to be close to a described species, it is noted as being near that species (e.g., *Parachironomus* near *cayapo)*. Additionally, if a specimen is close to a described species, but has morphological variations, then it is noted as being a variation of the species (e.g. *Nilothauma* near *reissi* variation 1). Notes on the unknown genera, species, and morphospecies specific to specimens collected in this collection are provided.

Morphology and terminology of chironomid pupae

There are a number of morphological structures and characteristics that are commonly used to separate chironomid taxa. The morphology of the pupa is mostly external, which makes it easier to see the structures on the pupal exuviae. The pupal exuviae has three main body divisions: head, thorax, and abdomen. In many cases, the

head and thorax are referred to collectively as the cephalothorax (Fig. 3). Terminology in this guide follows Sæther (1980), Wiederholm (1986), and Ferrington *et al.* (2008). See those publications for a more detailed summary of morphology and terminology of Chironomidae pupae.

Head: The head region of the chironomid pupal exuviae consists of the frontal area, eyes, and antennal and mouthpart sheaths (Fig. 3). The frontal apotome is the area of integument covering the dorsal side of the pharate adult head. Some other important characters in this body region can include cephalic tubercles, frontal warts, and frontal setae (Figs. 3-4) (Ferrington *et al.* 2008).

Thorax: The thorax of the chironomid pupal exuviae includes the legs, wings, and halter sheaths. It bears structures of potential taxonomic significance such as several groups of setae and especially the thoracic horn, which can vary greatly among taxa in presence, size, and shape (Figs. 3-4) (Ferrington *et al.* 2008).

Abdomen: The abdomen of the chironomid pupa includes eight segments plus a terminal segment modified into anal lobes and genital sheaths. The dorsal tergites and ventral sternites often bear distinctive groups of spines, hookrows, shagreen, setae, and spurs (Figs. 3-4) (Ferrington *et al.* 2008).

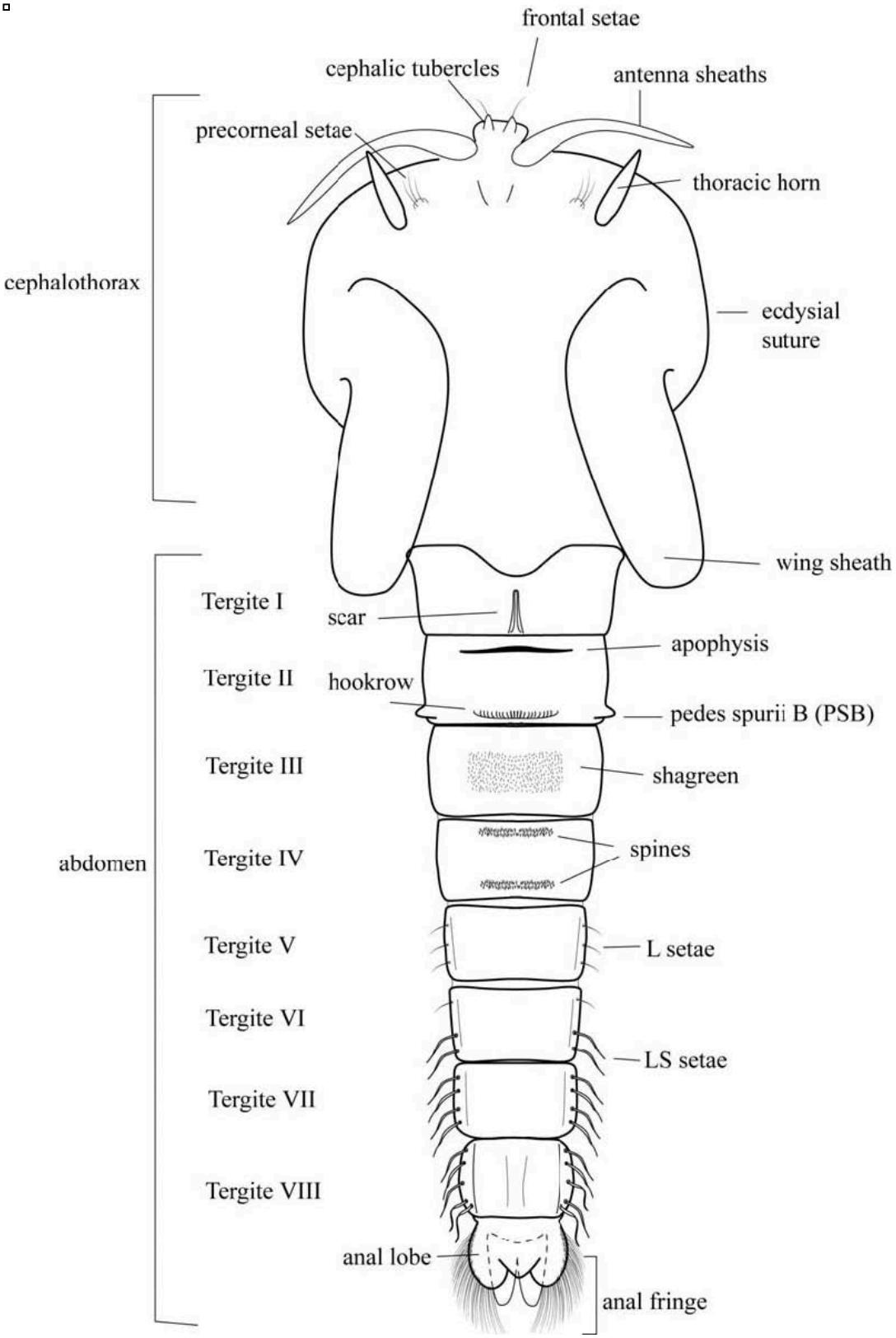

Figure 3. Morphology and terminology of Chironomidae pupal cephalothorax and abdomen (Illustrations by M. R. Rufer 2007)

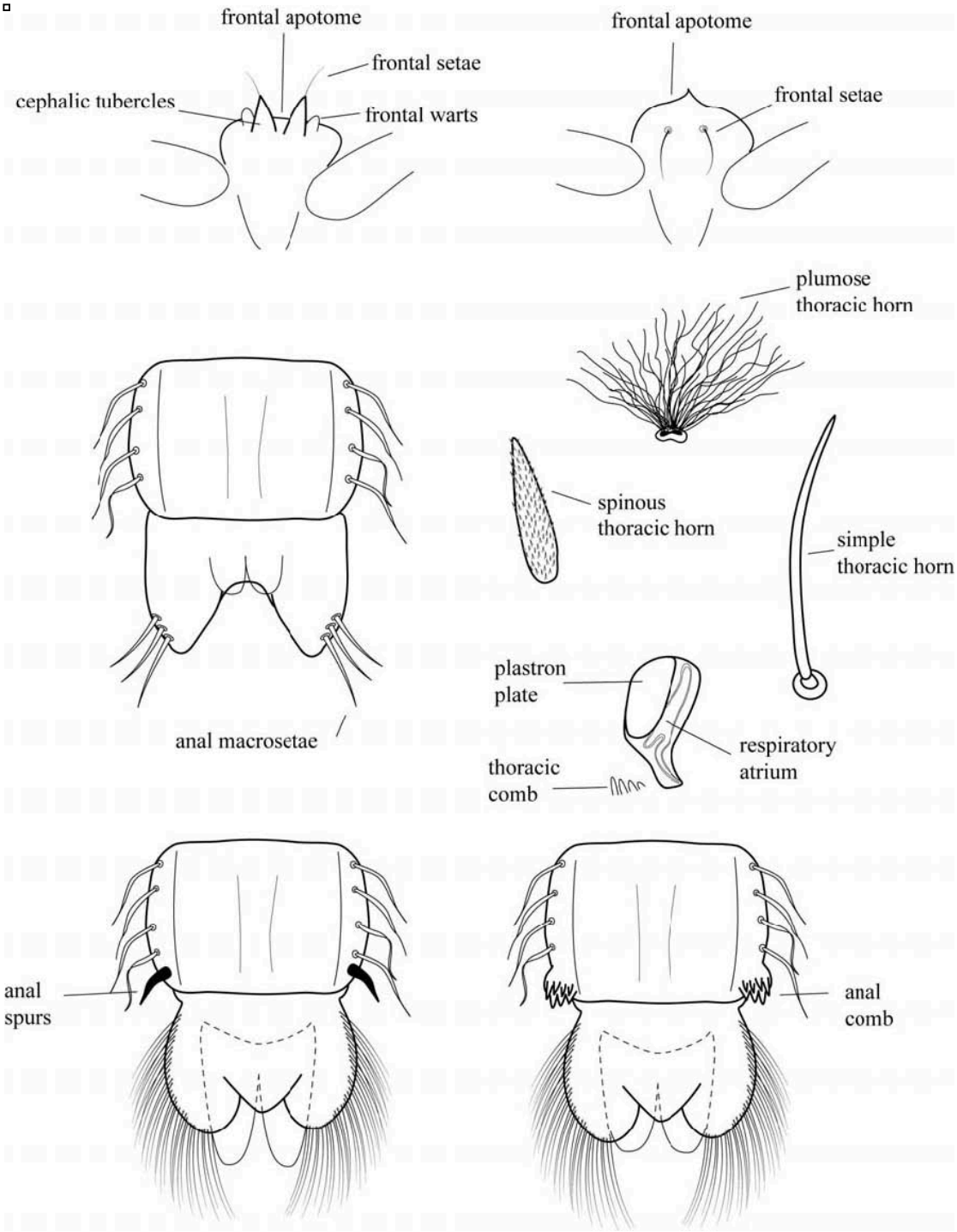

Figure 4. Morphology and terminology of Chironomidae pupal exuviae (Illustrations by M. R. Rufer 2007)

KEY TO THE SUBFAMILIES OF CHIRONOMIDAE PUPAE

1. Thoracic horn with a distinct plastron plate (Figs. 5-6), or reticulate meshwork (Fig. 7); thoracic horn never branched; anal lobes with two lateral anal macrosetae (Fig. 8)…….……...…..……...…… **Tanypodinae**

Figure 5. Thoraic horn of *Paramerina* sp. 1

Figure 6. Thoracic horn of *Coelotanypus* sp. 1

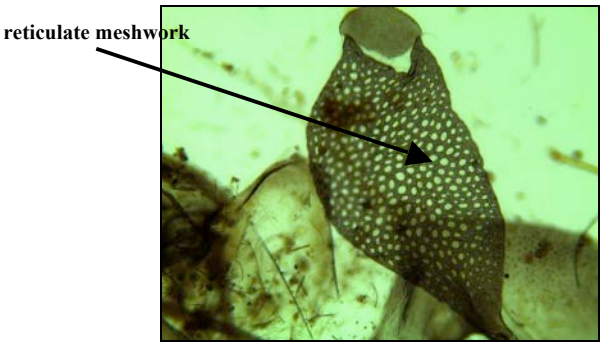

Figure 7. Thoracic horn of *Fittkauimyia crypta*

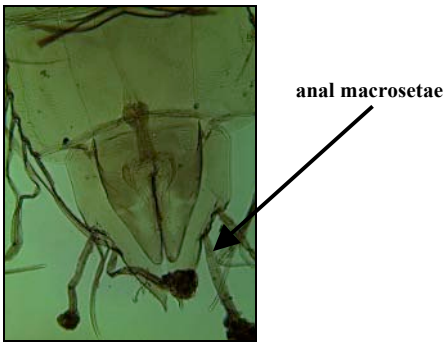

Figure 8. Anal lobes of *Albabesmyia* sp. 1

1'. Thoracic horn, if present, lacking a distinct plastron plate or large reticulate meshwork (Figs. 9-10); thoracic horn often branched; anal lobes never with two lateral anal macrosetae (Figs. 11-12) ……..... 2

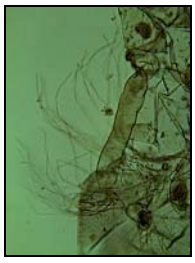

Figure 9. Thoracic horn of *Cladopelma* sp. 1

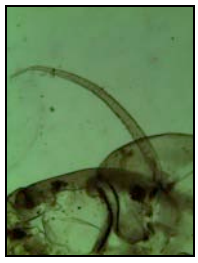

Figure 10. Thoracic horn of *Tanytarsus* sp. 1

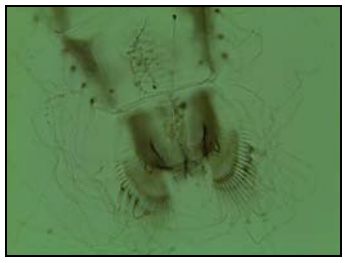

Figure 11. Anal lobes of *Thienemanniella* sp. 1

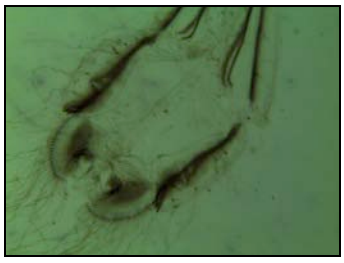

Figure 12. Anal lobes of *Tanytarsus* sp. 10

2(1'). Anal lobes often with three anal macrosetae and caudolateral margin of segment VIII rarely with an anal spur (Figs. 11, 13); thoracic horn never branched (Fig. 14) and frequently absent……..……..... **Orthocladiinae**

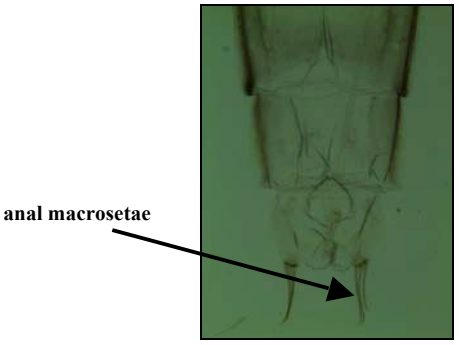

Figure 13. Anal lobes of *Cricotopous* sp. 2

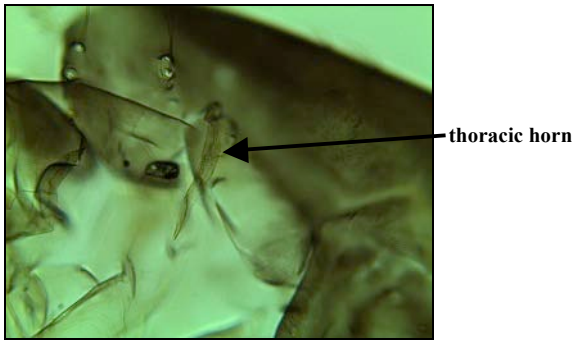

Figure 14. Thoracic horn of *Nanocladius* sp. 1

2'. Anal lobes almost always with a fringe of setae (Fig. 12) and caudolateral margin of segment VIII usually with an anal spur or comb (Figs. 15-16); thoracic horn with single (Figs. 10, 17) or multiple branches (Figs. 9, 18) ……..…….....… **Chironominae**

Figure 15. Anal spur of *Polypedilum* sp. 10

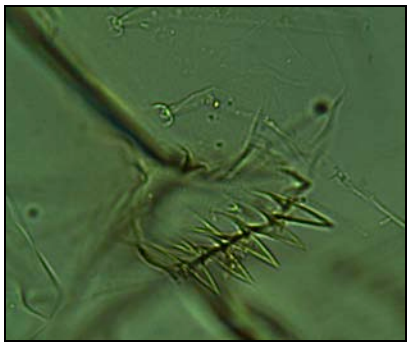

Figure 16. Anal claw of *Cladotanytarsus* sp. 1

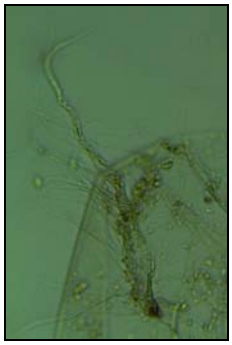

Figure 17. Thoracic horn of *Cladotanytarsus* sp. 1

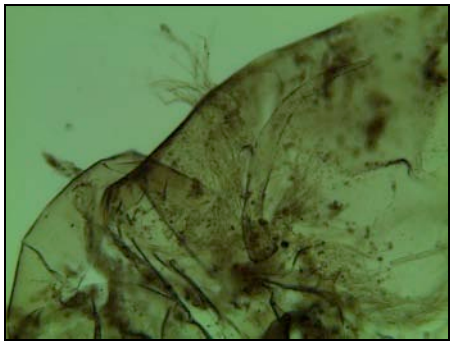

Figure 18. Thoracic horn of *Stenochironomus* sp. 1

KEYS TO GENERA OF TANYPODINAE PUPAE

1. Thoracic horn with a distinct plastron plate (Figs. 5-6, 19), but it may be small (Fig. 20) …….. 2

1'. Thoracic horn without a distinct plastron plate (Fig. 21) …….…….... 8

Figure 19. Thoracic horn of *Larsia* sp. 1

Figure 20. Thoracic horn of Unknown Pentaneurini #3

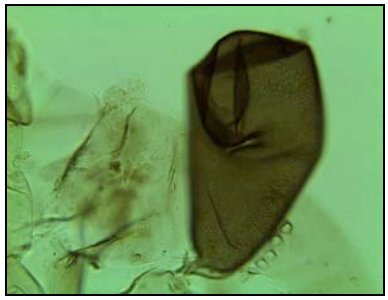

Figure 21. Thoracic horn of *Labrundinia* sp. 1

2(1). Anal lobes without a fringe of setae or setae-like spines (Fig. 22-23) ……..……..…..…… 3

2'. Anal lobes with a fringe of setae (Fig. 24) or setae-like spines (Fig. 25) ……..... 6

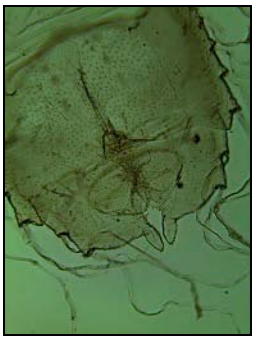

Figure 22. Anal lobes of *Djalmabatista* sp. 1

Figure 23. Anal lobes of *Larsia* sp. 1

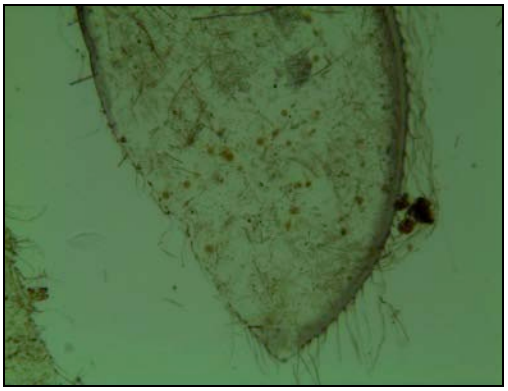

Figure 24. Anal lobe of *Fittkauimyia crypta*

Figure 25. Anal lobes of *Procladius (Psilotanypus) bellus*

3(2). Anal lobes with terminal processes (Fig. 22); abdominal segments IV-VII with dense fringe of setae (Fig. 24) ……..……..…..…… ***Djalmabatista***

3’. Anal lobes without terminal processes, however lobes are long and pointed (Figs. 23, 25-26); abdominal segments with, at most, 5 lateral setae ……..……..… 4

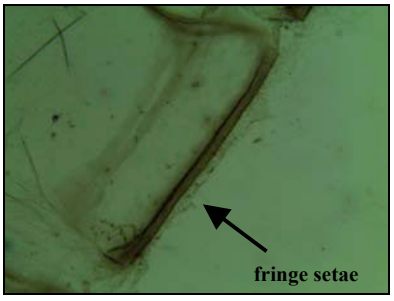

Figure 24. Tergite VII of *Djalmabatista* sp. 1


Figure 25. Anal lobes of Unknown Pentaneurini #3


Figure 26. Anal lobes of *Paramerina* sp. 1

4(3’). Thoracic horn tubular, distally flattened, 10x as long as wide (Fig. 20); thoracic comb and basal lobe absent; anal lobe about 2x as long as broad (Fig. 25) ……..……. **Unknown Pentaneurini #3**

4’. Thoracic horn elongate, curved slightly, 5x as long as wide (Figs. 5, 19); thoracic comb and basal lobe present; anal lobe about 3-4x as long as broad (Figs. 23, 26) …….. 5

5(4’). Thoracic horn with numerous convolutions of the horn sac (Figs. 19, 27), shagreen dense across entire tergite and composed of groups of 5-8 spinules (Fig. 28) ……. ***Larsia***

5’. Thoracic horn with tubular horn sac (Fig. 5), shagreen very sparse and restricted to pleural area of tergite (Fig. 29) ……..……..…… ***Paramerina***


Figure 27. Thoracic horn of *Larsia* sp. 1

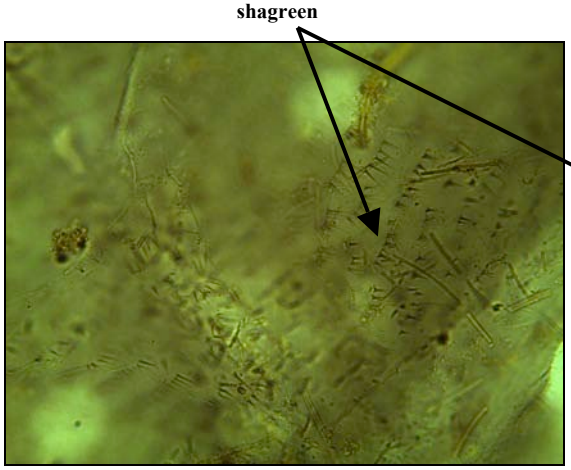

Figure 28. Tergite IV of *Larsia* sp. 1

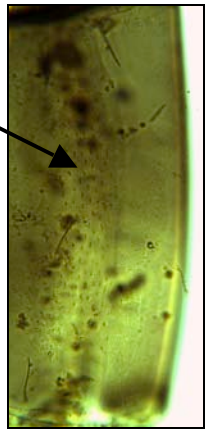
Figure 29. Tergite IV of *Paramerina* sp. 1

6(2'). Segment VII with at least 12 hairlike setae (Fig. 32); thoracic horn with reticulate meshwork (Figs. 5, 30) …….. ***Fittkauimyia***

6'. Segment VII with less than 12 hairlike setae (Figs. 33-34); thoracic horn without reticulate meshwork (Figs. 6, 31) ……..…. 7

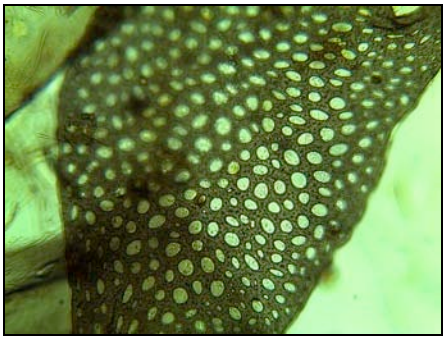

Figure 30. Reticulate meshwork on thoracic horn of *Fittkauimyia crypta*

Figure 31. Thoracic horn of *Procladius bellus*

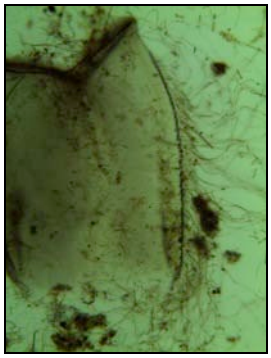

Figure 32. Tergite VII of *Fittkauimyia crypta*

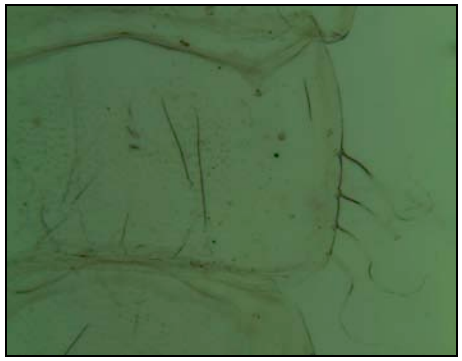

Figure 33. Tergite VII of *Procladius bellus*

Figure 34. Setae on tergite VII of *Coelotanypus* sp. 1

7(6'). Anal lobes more or less quadrate with rounded inner border (Fig. 25), spines along the margin (Fig. 35); thoracic horn dark brown and plastron plate narrower than horn sac (Fig. 31) ……..…… ***Procladius***

7. Anal lobes rounded uniformly with straight inner border and filamentous lateral fringe (Fig. 36); thoracic horn light yellow and plastron plate slightly wider than horn sac (Figs. 6, 37) ……..……..... ***Coelotanypus***

Figure 35. Anal lobe spines of *Procladius bellus*

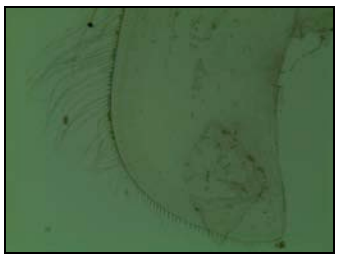

Figure 36. Anal lobe lateral fringe of *Coelotanypus* sp. 1

Figure 37. Thoracic horn of *Coelotanypus* sp. 2

8(1'). Thoracic horns large and ovoid, usually dark and with a conspicuous reticulate meshwork (Figs. 21, 38-39); tergite IV without lateral fringe setae (Figs. 41-42) ……. 9

8'. Thoracic horn smaller and tubular, light and without meshwork (Fig. 40); tergite IV with lateral fringe setae (Fig. 43) ……..…….…… **Unknown Pentaneurini #2**

Figure 38. Thoracic horn of *Ablabesmyia* sp. 1

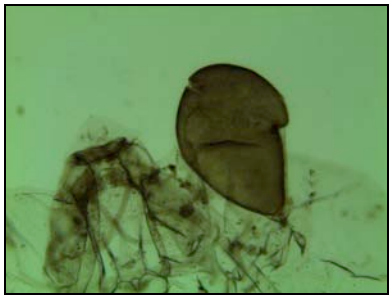

Figure 39. Thoracic horn of Unknown Pentaneurini #1

Figure 40. Thoracic horn of Unknown Pentaneurini #2

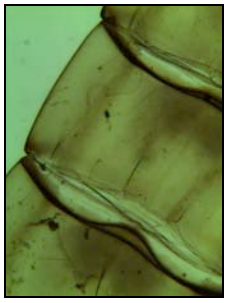

Figure 41. Tergite IV of *Ablabesmyia* sp. 1

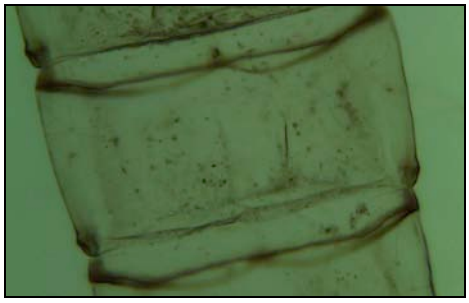

Figure 42. Tergite IV of Unknown Pentaneurini #1

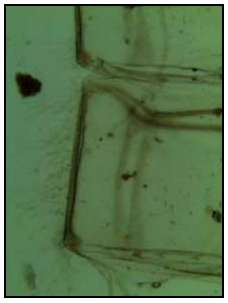

Figure 43. Tergite IV of Unknown Pentaneurini #2

9(8). Meshwork of thoracic horn coarse (Figs. 38, 44); anal lobes short and broad (Figs. 8, 46) ……..……..... ***Ablabesmyia***

9'. Meshwork of thoracic horn usually fine (Figs. 21, 39, 45); anal lobes long and narrow (Figs. 47-48) ……..……...…. 10

Figure 44. Thoracic horn of *Ablabesmyia* sp. 1

Figure 45. Thoracic horn of *Labrundinia* sp. 2

Figure 46. Anal lobes of *Ablabesmyia* sp. 2

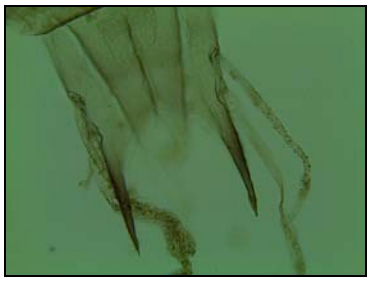

Figure 47. Anal lobes of *Labrundinia* sp. 1

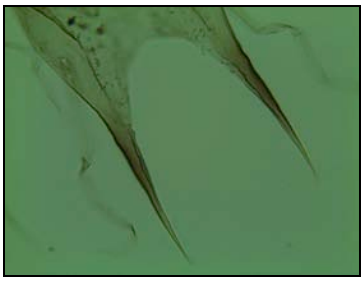

Figure 48. Anal lobes of Unknown Pentaneurini #1

10(9'). Outer border of anal lobes straight with prominent spines below the anal macrosetae (Figs. 47, 49) ……..……. ***Labrundina***

10'. Outer border of anal lobes curved inward apically and without spines below the anal macrosetae (Figs. 48, 50) ……...……..... **Unknown Pentanuerini #1**

Figure 49. Anal lobe of *Labrundinia* sp. 1

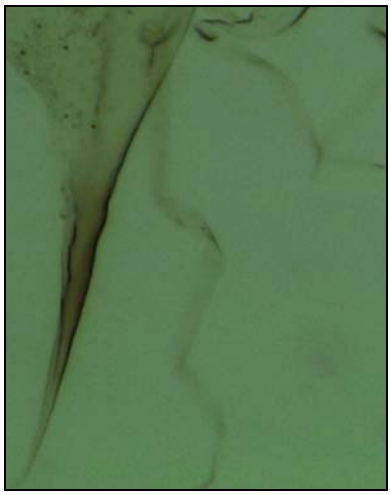

Figure 50. Anal lobe of Unknown Pentaneurini #1

KEY TO *ABLABESMYIA* SPECIES

1. Anal lobe outer border slightly concave and spinose in the apical 1/3, inner border more or less convex, and anal lobe points slightly divergent (Fig. 51) ……. ***Ablabesmyia* sp. 1**

1'. Anal lobe outer border very concave in the apical 1/3, inner border very convex, and anal lobe points very divergent (Fig. 52) ……..…. ***Ablabesmyia* sp. 2**

Figure 51. Anal lobe of *Ablabesmyia* sp. 1

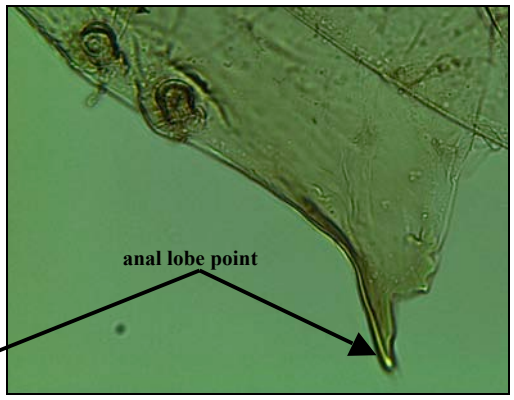

Figure 52. Anal lobe of *Ablabesmyia* sp. 2

NOTES ON *ABLABESMYIA* SPECIES

Ablabesmyia sp. 1

Locality: Laguna del Tortuguero 1, 2 & 3

Thorax: Thoracic horn like Fig. 5.1 A (Wiederholm 1986), apical nipple of thoracic horn short (Figs. 38, 44); 9 tubercles on thoracic comb; wings pads with M absent, like *A. janata* var. I (Roback 1985)

Abdomen: Shagreen on tergites I-VIII made up of short simple spines (Fig. 5.1 F, Wiederholm 1986); anal lobes with outer border spines (Fig. 5.1 H Wiederholm 1986) (Figs. 8, 51); O & D setae on tergite VII and tergite VII don't match *A. janata* var. I (Roback 1985)

Ablabesmyia sp. 2

Locality: Laguna del Tortuguero 2

Thorax: Both thoracic horns missing

Abdomen: Inner border of anal lobe swollen medially; anal lobe points very divergent; tergites VII, VIII, and anal lobes like *A. peleensis*, except this specimen doesn't have small spikes (Figs. 46, 52) (Roback 1985)

ADDITIONAL REFERENCE

Roback, S.S., 1985. The immature chironomids of the eastern United States VI. Pentaneurini – Genus *Ablabesmyia*. Proceedings of the Academy of Natural Sciences of Philadelphia 137: 153-212.

KEY TO *COELOTANYPUS* SPECIES

1. Thoracic horn about 5x as long as broad (Fig. 6); tergite VII with 8 LS setae (Figs. 34, 53) ……..……...…… ***Coelotanypus* sp. 1**

1'. Thoracic horn about 4x as long as broad (Fig. 37); tergite VII with 9 LS setae (Fig. 54) ……..……...…… ***Coelotanypus* sp. 2**

Figure 53. Tergite VII LS setae of *Coelotanypus* sp. 1

Figure 54. Tergite VII LS setae of *Coelotanypus* sp. 2

NOTES ON *COELOTANYPUS* SPECIES

Coelotanypus sp. 1

Locality: Laguna del Tortuguero 1, 2, & 3

Thorax: Thoracic horn pale (like Fig. 5.9 A, Wiederholm 1986)

Comments: Close to *C. tricolor*, around 5 mm long exuviae

Coelotanypus sp. 2

Locality: Laguna del Tortuguero 3

Thorax: Thoracic horn larger than *Coelotanypus* sp. 1, smaller neck, and horn sac fills more of the lumen than *Coelotanypus* sp. 1

ADDITIONAL REFERENCES

Roback, S.S. 1974. The immature stages of the genus *Coelotanypus* (Chironomidae; Tanypodinae: Coelotanypodini) in North America. Proceedings of the Academy of Natural Sciences of Philadelphia. 126: 9-19.

NOTES ON *DJALMABATISTA* SPECIES

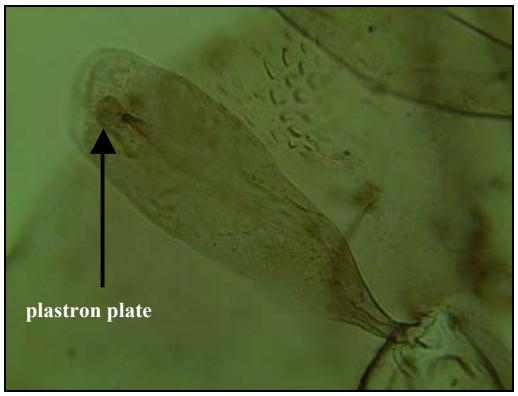

Figure 55. Thoraic horn of *Djalmabatista* sp. 1

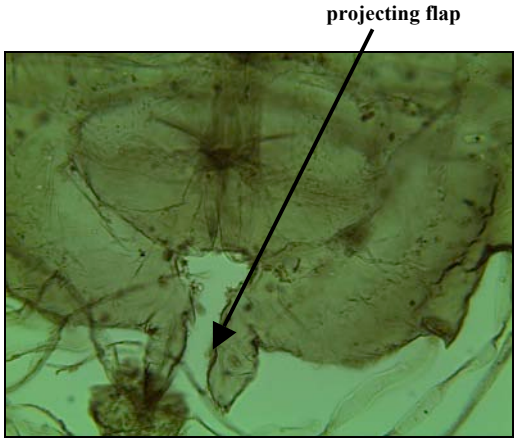

Figure 56. Anal lobes of *Djalmabatista* sp. 1

Djalmabatista sp. 1

Locality: Laguna del Tortuguero 1 & 2

Thorax: Thoracic horn very pale brown and small plastron plate (Fig. 55)

Abdomen: Anal lobe different than *D. pulcher*, distal 1/3 concave with a short projecting flap; anal lobe point more bulbous (Figs. 22, 56) (Roback 1978)

ADDITIONAL REFERENCES

Roback, S. S., & K. J. Tennessen. 1978. The immature stages of *Djalmabatista pulcher* [=*Procladius (Calotanypus) pulcher* (Joh.)]. Proceedings of the Academy of Natural Sciences of Philadelphia 130: 11-20.

NOTES ON *FITTKAUIMYIA* SPECIES

Figure 57. Tergite V of *Fittkauimyia crypta*

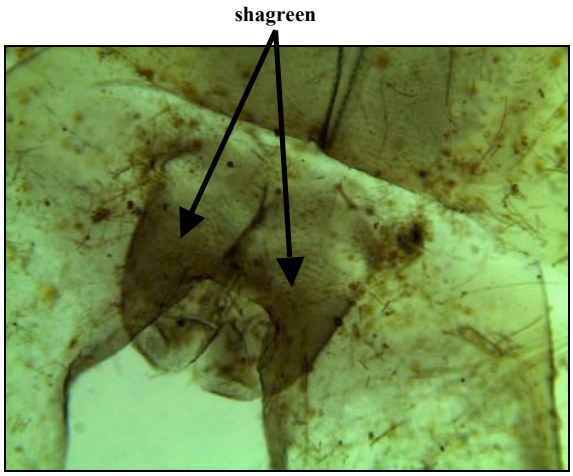

Figure 58. Male genitalia of *Fittkauimyia crypta*

Fittkauimyia crypta Serrano & Nolte, 1996

Locality: Quebrada

Thorax: Missing right thoracic horn; left horn large, flattened with perforations, narrow at the base; oval plastron plate (Figs. 7, 30)

Abdomen: Segments II-VII with lateral fringe setae (Fig. 32); segment VIII half the size of segment VII; shagreen present but covered by debris; D1 setae on segments III-VII robust and arising from sclerotized tubercles (Fig. 58); around 16 LS setae on tergite VIII like *F. crypta*; shagreen present on tergites II-VII and genitalia of anal lobes, like *F. crypta* (Fig. 59) (Serrano & Nolte 1996a)

ADDITIONAL REFERENCE

Serrano, M. A. S. and Nolte, U. 1996a. A sit-and-wait predatory chironomid from tropical Brazil - *Fittkauimyia crypta* sp. n. (Diptera: Chironomidae).- Entomologica Scandinavica 27: 251-258.

KEY TO *LABRUNDINIA* SPECIES

1. Respiratory atrium of thoracic horn with elongate preapical groove (Fig. 60); anal lobes 4x as long as wide, unscelortized anal lobe points with long outer border spines (Fig. 63) ……..…… ***Labrundinia* sp. 2**

1'. Respiratory atrium of thoracic horn ovoid (Fig. 59), or club shaped (Fig. 61); anal lobes 5x as long as wide; sclerotized anal lobe points with short outer border spines (Figs. 62, 64) ……..……..…. 2

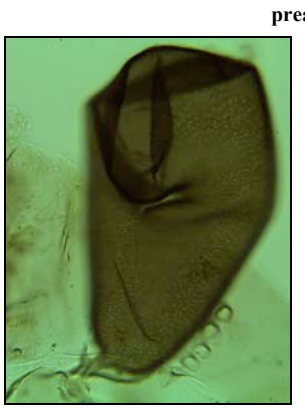

Figure 59. Thoracic horn of *Labrundinia* sp. 1

Figure 60. Thoracic horn of *Labrundinia* sp. 2

Figure 61. Thoracic horn of *Labrundinia* sp. 3

Figure 62. Anal lobes of *Labrundinia* sp. 1

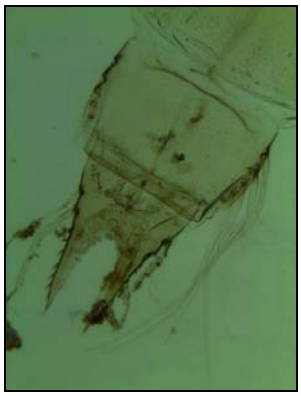

Figure 63. Anal lobes of *Labrundinia* sp. 2

Figure 64. Anal lobes of *Labrundinia* sp. 3

2(1'). Respiratory atrium of thoracic horn ovoid, without distinct neck or plastron plate (Fig. 59); exuviae light brown (Fig. 62) …..…… ***Labrundinia* sp. 1**

2'. Respiratory atrium of thoracic horn club-shaped, distinct neck and plastron plate (Fig. 61); exuviae dark brown (Fig. 64) ……...…… ***Labrundinia* sp. 3**

NOTES ON *LABRUNDINIA* SPECIES

Labrundinia sp. 1

Locality: Laguna del Tortuguero 1 & 2

Thorax: Both thoracic horns present, dark outline and small plastron plate (5.20 A, Wiederholm 1986) and close to *L.* sp. 10 (Fig. 66, Roback 1987); around 5 thoracic comb tubercles visible

Abdomen: Segment I missing, sparse shagreen on tergites II-VIII, spines on long anal lobe but not as conspicuous at (Figs. 5.20 H-I, Wiederholm 1986)

Labrundinia sp. 2

Locality: Laguna del Tortuguero 2

Thorax: Only right thoracic horn present (Fig. 5.20 C, Wiederholm 1986); horn sac occupies less of the lumen (Fig. 62, Roback 1987)

Abdomen: Anal lobe overall lighter color than *Labrundinia* sp. 1 and sp. 3 with conspicuous external spines (Fig. 63)

Comments: Close to *L.* sp. 3 near *virescens* (Roback 1987)

Labrundinia sp. 3

Locality: Laguna del Tortuguero 2 & Quebrada

Thorax: thoracic horn very dark and spinose; horn sac filling most of lumen; conspicuous, small plastron plate (Fig. 61)

Abdomen: External conspicuous spines on outside of dark anal lobe (Fig. 64)

ADDITIONAL REFERENCE

Roback, S.S., 1987. The immature chironomids of the eastern United States IX. Pentaneurini – genus *Labrundinia* with the Description of some Neotropical material. Proceedings of the Academy of Natural Sciences of Philadelphia 139: 159-209.

NOTES ON *LARSIA* SPECIES

Figure 65. Thoracic horn of *Larsia* sp. 1

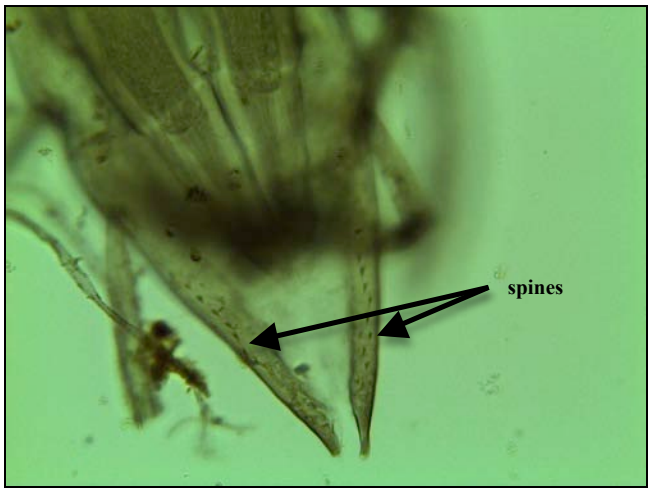

Figure 66. Anal lobes of *Larsia* sp. 1

Larsia sp. 1

Locality: Quebrada

Thorax: Thoracic horn visible under tissues of head of adult, respiratory atrium without distinct central duct (Figs. 19, 65); thoracic horn most similar to *Larsia gelhausi* (Fig. 7, Oliveira & Silva 2011)

Abdomen: Scar on tergite I, segment VII with 4 LS setae, segment VIII with 5 LS setae, longer than broader anal lobe, adhesive sheath macrosetae (Fig. 23), medial border with spines on anal lobes (Fig. 66)

ADDITIONAL REFERENCE

Oliveira, C.S.N. and F.L. Da Silva, 2011. Two new species of *Larsia* Fittkau, 1962 (Diptera Chironomonidae: Tanypodinae) from Neotropical region, with a checklist of *Larsia* species of the world. Zootaxa, 2786: 27-41.

NOTES TO *PARAMERINA* SPECIES

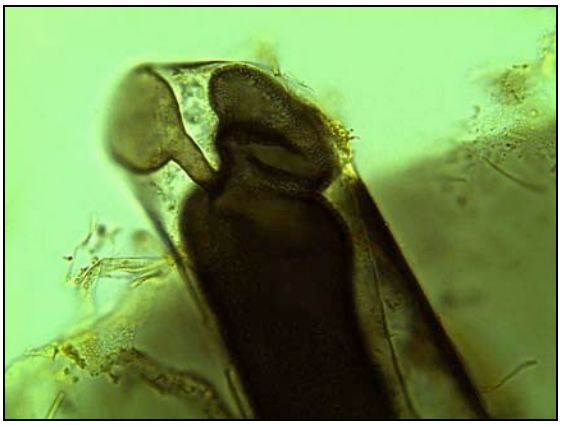

Figure 67. Thoracic horn of *Paramerina* sp. 1

Paramerina sp. 1

Locality: Quebrada

Thorax: Long neck and small corona (Fig. 5.28 C, Wiederholm 1986) (Figs. 5, 67); thoracic comb with 12 spines

Abdomen: No inner border spines on anal lobes (Fig. 26)

ADDITIONAL REFERENCE

Sublette, J.E. & Sasa, M. 1994. Chironomidae collected in Onchocerciasis endemic areas of Guatemala (Insecta, Diptera). Spixiana Supplement 20: 1-60.

NOTES ON *PROCLADIUS* SPECIES

Procladius (*Psilotanypus*) *bellus* Loew, 1866

Locality: Laguna del Tortuguero 1, 2, & 3

Abdomen: Light scar on tergite I, small triangular shaped shagreen present on tergites II-VIII (Fig. 5.33 F, Wiederholm 1986), 4 LS setae on tergite VII (Fig. 33), 5 LS on tergite VIII, 2 macrosetae on anal lobe and external spines like *Procladius bellus* (Figs. 25, 35)

Comments: *Psilotanypus* subgenus group, most similar to *Procladius bellus* var. 3 (Roback 1980)

ADDITIONAL REFERENCE

Roback, S.S., 1980. The immature chironomids of the eastern United States IV. Tanypodinae – Procladiinae. Proceedings of the Academy of Natural Sciences of Philadelphia 132: 1-63.

NOTES ON UNKNOWN PENTANEURINI GENERA

Unknown Pentaneurini #1

Locality: Laguna del Tortuguero 2

Thorax: Horn sac filling the entire lumen, similar to *Ablabesmyia* (Fig. 39)

Abdomen: Tergite I with much darker scar than other *Labrundinia*; anal lobe 3x as long as broad, similar to *Labrundinia*; longer and curved inward and without external spines (Figs. 48, 50)

Unknown Pentaneurini #2

Locality: Laguna del Tortuguero 3

Thorax: Thoracic horn pale and slender, like *Rheopelopia*, but wider than Fig. 5.36 A & B (Wiederholm 1986) (Fig. 40); plastron plate and thoracic comb absent; rounded spines along median suture

Abdomen: Tergite I without median scar; dense covering of tuberculate on shagreen I-IV (Fig. 43); many more L setae on tergite IV (unlike Fig. 5.36 E, Wiederholm 1986)*;* apex of abdomen missing

Comments: Represented by 1 specimen

Unknown Pentaneurini #3

Locality: Quebrada

Thorax: Thoracic horn dark brown and slender with apical setae similar to *Monopelopia* (Fig. 5.25 C, Wiederholm 1986) (Fig. 20); thoracic comb present

KEY TO GENERA OF ORTHOCLADIINAE PUPAE

1. Anal lobes with full or partial fringe of setae (Figs. 11, 68-69) …… 2

1’. Anal lobes without a fringe of setae (Figs. 13, 70) ……..….. 4

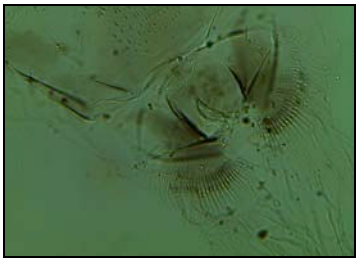

Figure 68. Anal lobes of *Corynoneura* sp. 1

Figure 69. Anal lobes of *Nanocladius minimus*

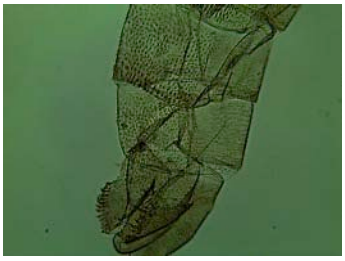

Figure 70. Anal lobes of Unknown Orthocladiinae #1

2(1). Thoracic horn present (Figs. 14, 71) ……..…. ***Nanocladius***

2’. Thoracic horn absent ……..….. 3

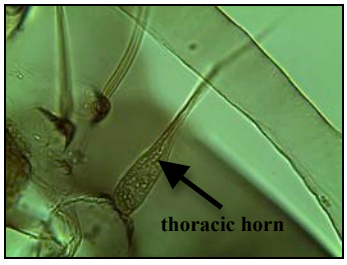

Figure 71. Thoracic horn of *Nanocladius minimus*

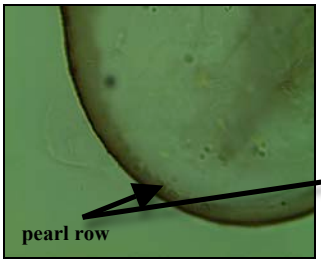

Figure 72. Wing sheath of *Corynoneura* sp. 1

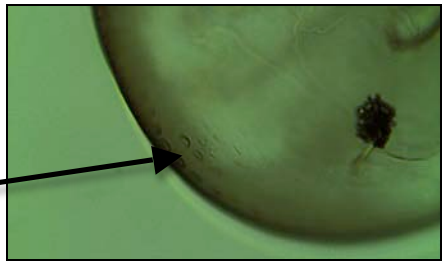

Figure 73. Wing sheath of *Corynoneura* sp. 2

3(2’). Wing sheaths with pearl rows (Figs. 72-73) ……...……. ***Corynoneura***

3’. Wing sheaths without pearl rows ……..……. ***Thienemanniella***

4(1'). Anal lobes with 3 terminal or lateral anal macrosetae, either hair-like (Figs. 13, 74), or spine-like (Fig. 75) ……..…….. 5

4'. Anal lobes without 3 terminal or lateral anal macrosetae, but rather conspicuous spines along lateral border of lobes (Fig. 76) …… **Unknown Orthocladiinae #1**

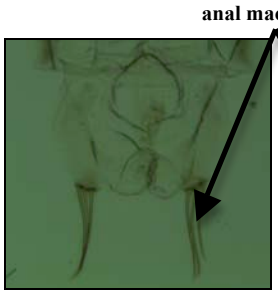

Figure 74. Anal lobes of *Cricotopus* sp. 2

Figure 75. Anal lobes of Unknown Orthocladiinae #2

Figure 76. Anal lobes of Unknown Orthocladiinae #1

Figure 77. Tergites III-V of *Cricotopus* sp. 1

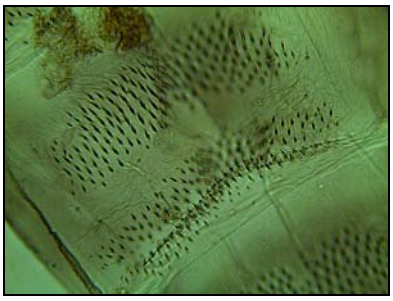

Figure 78. Tergites IV of *Cricotopus* sp. 1

Figure 79. Tergites II-V of Unknown Orthocladiinae #2

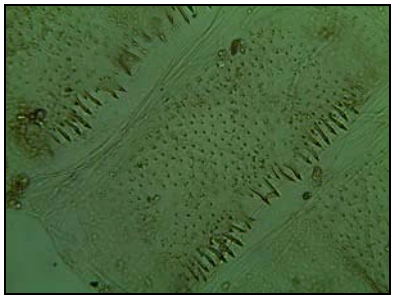

Figure 80. Tergites IV of Unknown Orthocladiinae #2

5(4). Anal lobes with 3 terminal hair-like anal macrosetae (Fig. 74); tergites IV sometimes with light continuous shagreen and anterior and/or posterior bands of shagreen, but no posterior row of long spines (Figs. 77-78) ……..….. ***Cricotopus***

5'. Anal lobes with 3 lateral spine-like anal macrosetae (Fig. 75); tergites IV with continuous shagreen and posterior row of long spines (Figs. 79-80) ……..…… **Unknown Orthocladiinae #2**

KEY TO *CORYNONEURA* SPECIES

1. Wing sheaths with dark pigmentation (Figs. 81-82); tergites III-VII with light (Fig. 85) or dark (Fig. 84) median shagreen ……..……..……. 2

1'. Wing sheaths with light pigmentation (Fig. 83); tergites III-VII with light median shagreen and dark posterior row of spines ……..…….. ***Corynoneura* sp. 3**

Figure 81. Wing sheaths of *Corynoneura* sp. 1

Figure 82. Wing sheaths of *Corynoneura* sp. 2

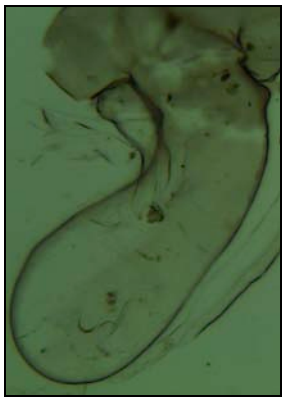

Figure 83. Wing sheaths of *Corynoneura* sp. 3

Figure 84. Lower tergites of *Corynoneura* sp. 1

Figure 85. Lower tergites of *Corynoneura* sp. 2

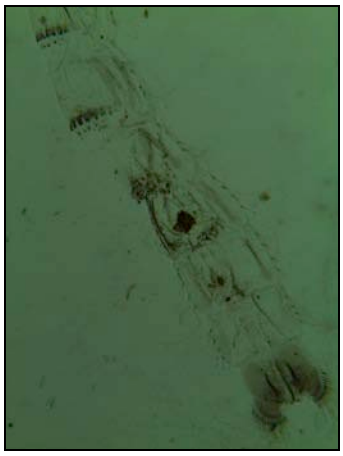

Figure 86. Lower tergites of *Corynoneura* sp. 3

2(1). Wing sheaths with 1 row of pearls (Fig. 72); tergites with light brown pleural pigmentation and dense shagreen covering entire segment on tergites III-VII (Fig. 84) …… ***Corynoneura* sp. 1**

2'. Wing sheaths with 4 rows of pearls (Fig. 73); tergites with dark brown pleural pigmentation and light shagreen constricted to median 1/3 of segment on tergites III-VII (Fig. 85) ……..…… ***Corynoneura* sp. 2**

NOTES ON *CORYNONEURA* SPECIES

Corynoneura sp. 1

Locality: Laguna del Tortuguero 2 & 3

Head: Frontal setae present on frontal apotome

Thorax: One row of pearls on wing sheaths (Fig. 72)

Abdomen: Tergite I bare; tergite II with sparse median shagreen; tergites III-VII with dense median shagreen; tergite VIII with sparse median shagreen; anal lobe with sparse shagreen; anal fringe incomplete and only occupying the distal 1/2 to 2/3 of the anal lobe (Figs. 68, 84)

Corynoneura sp. 2

Locality: Laguna del Tortuguero 2 & 3

Head: Frontal setae present on frontal apotome

Thorax: Four rows of pearls on wing sheaths (Fig. 73)

Abdomen: Darker plueral area than sp.1; tergite I bare; tergite II with very sparse patch of shagreen on the posterior; tergites III-anal lobe shagreen constricted to median area (only covering 1/3 of segment); anal fringe incomplete and only occupying the distal 1/2 to 2/3 of the anal lobe (Fig. 85)

Corynoneura sp. 3

Locality: Quebrada

Head: Frontal setae absent

Thorax: Two rows of pearls on wing sheaths

Abdomen: Lateral view of abdomen; tergite II-VII with darker posterior row of spines than sp. 1 and sp. 2; anal lobe fringe incomplete and only occupying the distal 1/2 to 2/3 of the anal lobe (Fig. 86)

Comments: Represented by one specimen

ADDITIONAL REFERENCES

Roback, S.S. & Coffman, W.P. 1983. Results of the Catherwood Bolivian-Peruvian Altiplano expedition Part II. Aquatic Diptera including montane Diamesinae and Orthocladiinae (Chironomidae) from Venezuela. Proceedings of the Academy of Natural Sciences of Philadelphia 135: 9–79.

Sublette, J.E. & Sasa, M. 1994. Chironomidae collected in Onchocerciasis endemic areas of Guatemala (Insecta, Diptera). Spixiana Supplement 20: 1-60.

Wiedenbrug, S & Trivinho-Strixino, S. 2011. New species of the genus *Corynoneura* Winnertz (Diptera, Chironomidae) from Brazil. Zootaxa 2822: 1-40.

KEY TO *CRICOTOPUS* SPECIES

1. Frontal setae located on prefons (Figs. 88-89) ……... 2

1'. Frontal setae located on frontal apotome (Fig. 87) …….. ***Cricotopus* sp. 1**

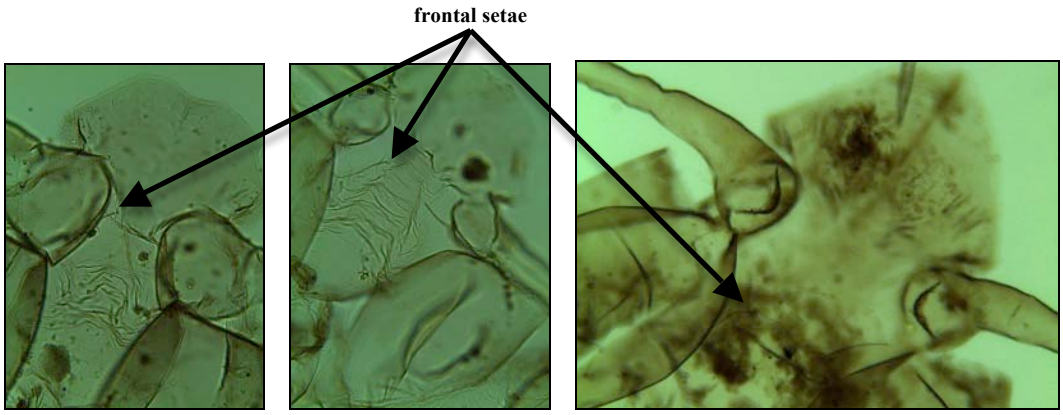

Figure 87. Frontal apotome of *Cricotopus* sp. 1

Figure 88. Frontal apotome of *Cricotopus* sp. 2

Figure 89. Frontal apotome of *Cricotopus* sp. 3

2(1). Anterior band of shagreen on tergites rectangular and anterior and posterior bands distinctly divided (Fig. 90); male antennal sheaths very short (Fig. 92) ... ***Cricotopus* sp. 2**

2'. Anterior band of shagreen on tergites crescent-shaped and anterior and posterior bands undivided (Fig. 91); male antennal sheaths regular size ……. ***Cricotopus* sp. 3**

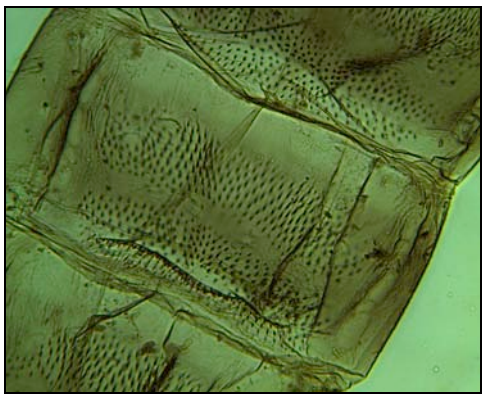

Figure 90. Tergite IV of *Cricotopus* sp. 2

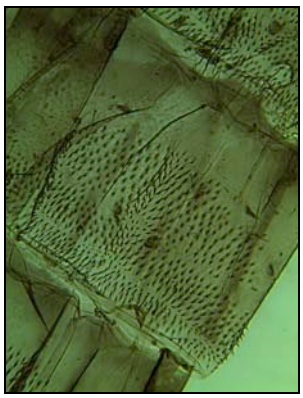

Figure 91. Tergite IV of *Cricotopus* sp. 3

Figure 92. Antennal sheaths of *Cricotopus* sp. 2

NOTES ON *CRICOTOPUS* SPECIES

Cricotopus sp. 1

Locality: Laguna del Tortuguero 1, 2, 3 & Quebrada

Head: Frontal setae on frontal apotome (like Fig. 9.13 B, Wiederholm 1986) (Fig. 87)

Abdomen: Abdomen looks like subgenus *Cricotopus*; tergite I with light shagreen; pedes spurii B present on tergites II and III; tergite II with median shagreen and dark; continuous hook row on projecting flap (1/2 width); tergites III-VI with thick anterior band and thinner posterior band of shagreen (not reaching lateral edge); tergite VII, VIII, and anal lobe with anterior median light shagreen (Figs. 77-78)

Cricotopus sp. 2

Locality: Laguna del Tortuguero 2 & 3

Head: Frontal setae on prefons (like Fig. 9.13 A, Wiederholm 1986) (Fig. 88); male antennal sheath shorter than usual (Fig. 92)

Abdomen: Tergites II-VI with dense anterior and posterior shagreen (rectangular-shaped) and gap between patches; tergite II with dark hook row (1/2 width) (Fig. 90)

Cricotopus sp. 3

Locality: Laguna del Tortuguero 1& 2

Head: Frontal setae on prefons (like Fig. 9.13 A, Wiederholm 1986) (Fig. 89)

Abdomen: Tergite I with light shagreen; tergite II with continuous, dark hook row (3/4 width); tergite II-VI with anterior crescent shaped shagreen and posterior band of shagreen; tergite VII and VIII with anterior light patches of shagreen (Fig. 91)

ADDITIONAL REFERENCES

Roback, S.S. & Coffman, W.P. 1983. Results of the Catherwood Bolivian-Peruvian Altiplano expedition Part II. Aquatic Diptera including montane Diamesinae and Orthocladiinae (Chironomidae) from Venezuela. Proceedings of the Academy of Natural Sciences of Philadelphia 135: 9–79.

Simpson, K.W., Bode, R.W. & Albu, P. 1983. Keys for the genus *Cricotopus* adapted from Revison der Gattung *Cricotopus* van der Wulp und ihrer Verwandten (Diptera, Chironomidae) by M. Hirvenoja. New York State Museum, The University of the State of New York, Albany, NY. Bulletin 450

Sublette, J.E. & Sasa, M. 1994. Chironomidae collected in Onchocerciasis endemic areas of Guatemala (Insecta, Diptera). Spixiana Supplement 20: 1-60.

KEY TO *NANOCLADIUS* SPECIES

1. Thoracic horn elongate and tapering to a point (Fig. 93); long frontal setae on pronounced cephalic tubercles (Fig. 95); tergites V-VI with anterior bands of long spines (Fig. 97) ……...…… ***Nanocladius* (*Nanocladius*) *minimus***

1'. Thoracic horn broad and rounded (Fig. 94); long frontal setae on small, rounded cephalic tubercles (Fig. 96), tergites V-VI without anterior bands of long spines (Fig. 98) ……..……..……. ***Nanocladius* sp. 1**

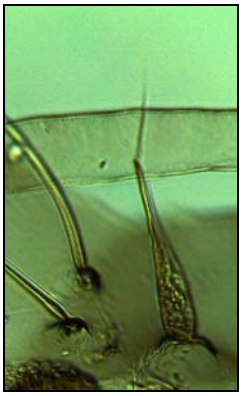

Figure 93. Thoracic horn of *Nanocladius minimus*

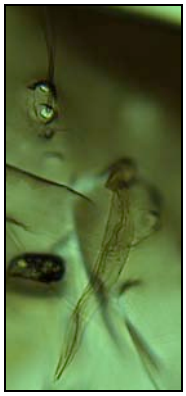

Figure 94. Thoracic horn of *Nanocladius* sp.1

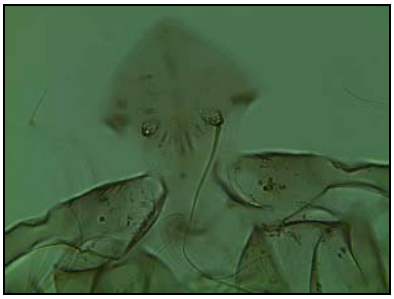

Figure 95. Frontal apotome of *Nanocladius minimus*

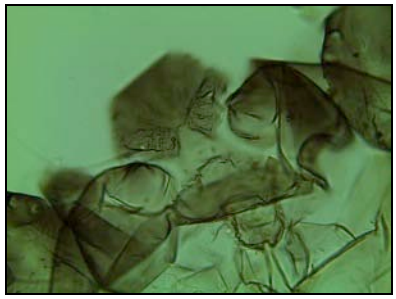

Figure 96. Frontal apotome of *Nanocladius* sp. 1

Figure 97. Lower tergites of *Nanocladius minimus*

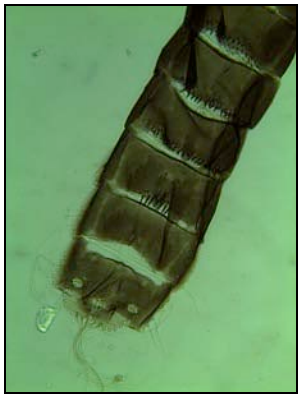

Figure 98. Lower tergites of *Nanocladius* sp. 1

NOTES ON *NANOCLADIUS* SPECIES

Nanocladius (*Nanocladius*) *minimus*

Locality: Laguna del Tortuguero 1, 2 & 3

Head: Long frontal setae on prominent cephalic tubercle (like Fig. 9.37 A, Wiederholm 1986) (Fig. 95)

Thorax: Thoracic horn elongate and tapering to a point with spines (Fig. 9.37 B, Wiederholm 1986) (Fig. 93)

Abdomen: Tergite IV with weak median patch of shagreen; tergites V-VI with posterior band of long spines and strong median patch of shagreen; row of spinules on integument IV/V broadly interrupted; around 14 setae in anal fringe (Fig. 97)

Nanocladius sp. 1

Locality: Quebrada

Head: Long frontal setae on small, rounded tubercle (Fig. 96)

Thorax: Thoracic horn broad and rounded (like Fig. 9.37 C, Wiederholm 1986) (Fig. 96)

Abdomen: Darker pigmentation of segments than *N. minimus*, no median patches of shagreen on tergites IV-V; anal lobe folded under segment VIII (Fig. 98)

ADDITIONAL REFERENCE

Sæther, O.A., 1977. Taxonomic studies on Chironomidae: *Nanocladius*, *Pseudochironomus*, and the *Harnischia* complex. Bulletin of the Fisheries Research Board of Canada. Bulletin 196.

KEY TO *THIENEMANNIELLA* SPECIES

1. Dark pigmentation on pleural area of segments and anal lobes; tergites II-VIII with dark median shagreen; anal lobes with ½ anal fringe (Fig. 99) …. ***Thienemanniella* sp. 1**

1'. Light pigmentation on pleural area of segments and anal lobes; tergites II-VIII with light median shagreen; anal lobes with ¾ anal fringe (Fig. 100) ……. ***Thienemanniella* sp. 2**

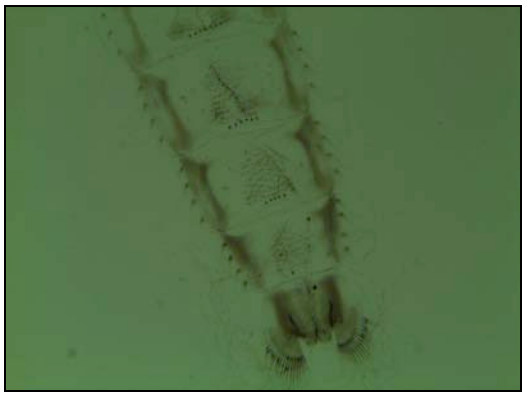

Figure 99. Lower tergites of *Thienemanniella* sp. 1

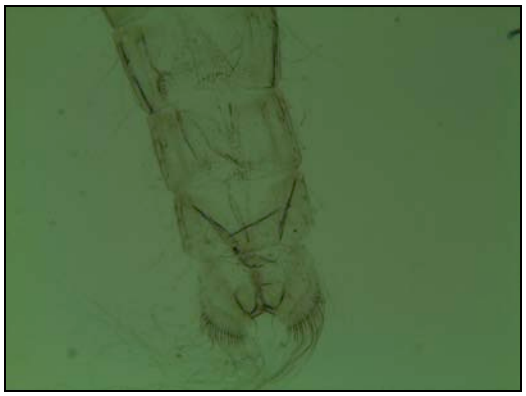

Figure 100. Lower tergites of *Thienemanniella* sp. 2

NOTES ON *THIENEMANNIELLA* SPECIES

Thienemanniella sp. 1

Locality: Laguna del Tortuguero 3

Abdomen: No shagreen on tergites I; very light shagreen on tergite II; shagreen on tergites III-VIII and anal lobe; fine spinules and small posterior hook row on tergite III; tergites IV-VIII with coarse shagreen; tergites IV-VII with posterior spines; segments III-VIII with 4 thick L setae; anal lobes with ½ anal fringe; dark pigmentation on pleural area of abdomen and anal lobe (Fig. 99)

Comments: Represented by one specimen; close to *T. sanctivincenta* (Saether 1981)

Thienemanniella sp. 2

Locality: Laguna del Tortuguero 2 & 3

Abdomen: Damaged abdomen; no shagreen on tergite I; tergite II-VIII and anal lobe with light shagreen; tergites V-VIII with 4 LS setae; anal lobes with ¾ anal fringe (Fig. 100)

ADDITIONAL REFERENCE

Sæther, O.A. 1981. Orthocladiinae (Chironomidae: Diptera) from the British West Indies with descriptions of *Antillocladius* n. gen., *Lipurometriocmemus* n. gen., *Compterosmittia* n. gen. and *Diplosmittia* n. gen. Entomologica Scandinavica, Supplement 16: 1-46.

NOTES TO UNKNOWN ORTHOCLADIINAE GENERA

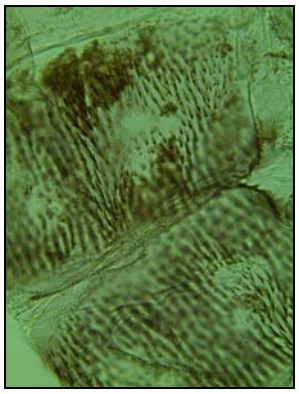

Figure 101. Tergites II-III of Unknown Orthocladiinae #1

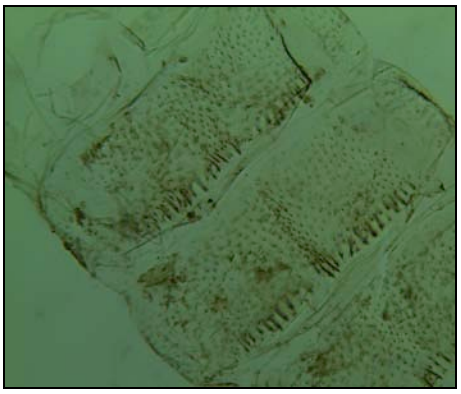

Figure 102. Tergites II-III of Unknown Orthocladiinae #2

Unknown Orthocladiinae #1

Locality: Laguna del Tortuguero 1 & 2

Abdomen: Partial lateral slide mount; dense spines on tergites I-VIII (Fig. 101) and anal lobes; no anal fringe or macrosetae; no lateral setae; anal lobes with large spines on lateral side (increase from interior or posterior) (Fig. 76)

Comments: Close to *Gymnometriocnemus*

Unknown Orthocladiinae #2

Locality: Laguna del Tortuguero 2

Abdomen: 3 lateral spine-like anal macrosetae on anal lobes (Fig. 75); posterior spines on tergites II-VIII (Figs. 79-80, 102)

Comments: Represented by 1 specimen; somewhat resembling *Eukiefferiella* and *Pseudorthocladius*

KEY TO TRIBES OF CHIRONOMINAE PUPAE

1. Thoracic horn unbranched (Figs. 10, 17, 103); wing sheaths almost always with nose (Fig. 106) …… ***Tanytarsini***

1'. Thoracic horn with at least two branches (Figs. 9, 18, 104-105); wing sheaths almost always without nose ….....…….. 2

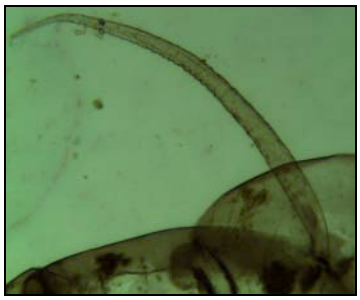

Figure 103. Thoracic horn of *Tanytarsus* sp. 1

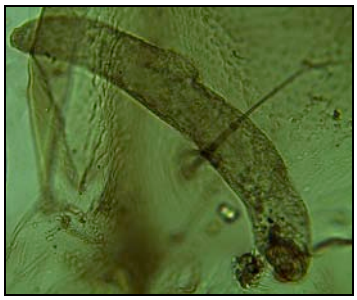

Figure 104. Thoracic horn of *Pseudochironomus richardsoni*

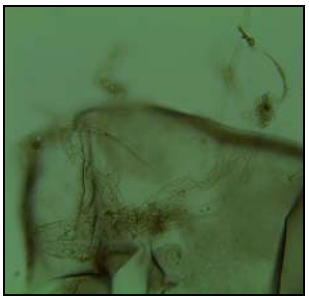

Figure 105. Thoracic horn of *Paratendipes* sp. 7

2(1'). Thoracic horn with two short, plump, apically rounded branches (Fig. 104) ……. ***Pseudochironomini***

2'. Thoracic horn with more than two slender, apically pointed branches (Figs. 9, 18, 105) …… ***Chironomini***

KEY TO GENERA OF CHIRONOMINI PUPAE

1. Hook row on posterior margin of segment 2 distinctly interrupted (Figs. 106-107) … 2

1'. Hook row on posterior margin of segment 2, at most, very narrowly interrupted (Figs. 108-109) ……. 5

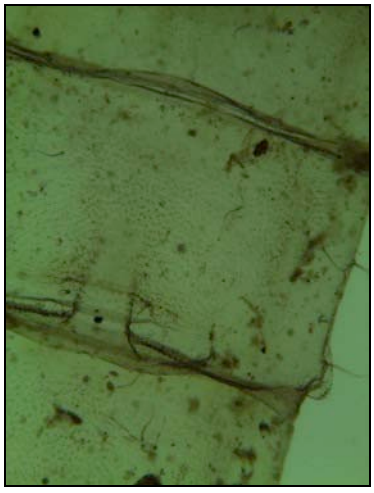

Figure 106. Tergite II of *Cryptochironomus* sp. 2

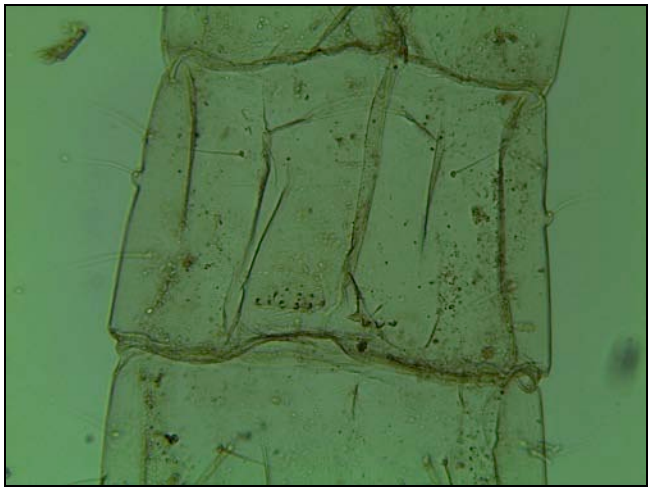

Figure 107. Tergite II of *Cryptotendipes* sp. 1

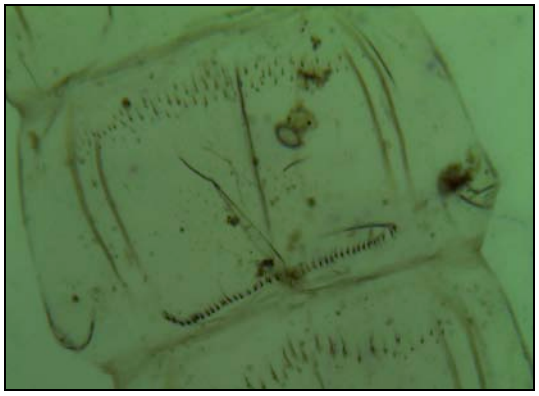

Figure 108. Tergite II of *Polypedilum* sp. 1

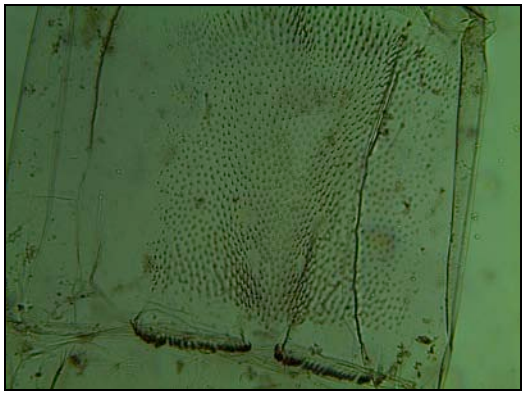

Figure 109. Tergite II of *Stenochironomus* sp. 5

2(1). Thoracic horn exceptionally long (Fig. 110) ……..…… ***Cryptotendipes***

2'. Thoracic horn not as long as above (Figs. 9, 111-112) ……..…….. 3

Figure 110. Thoracic horn of *Cryptotendipes* sp. 1

Figure 111. Thoracic horn of *Cryptochironomus* sp. 2

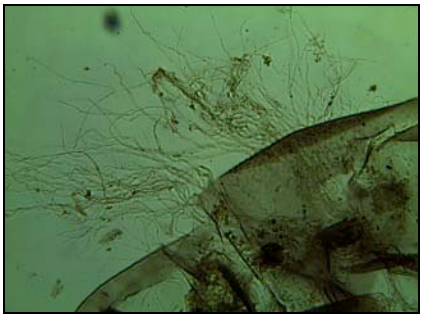

Figure 112. Thoracic horn of *Harnischia* sp. 1

3(2'). Tergite VI with posteromedian mound of spines (Figs. 113-114) ….. ***Cladopelma***

3'. Tergite VI without such a mound of spines ……...…….. 4

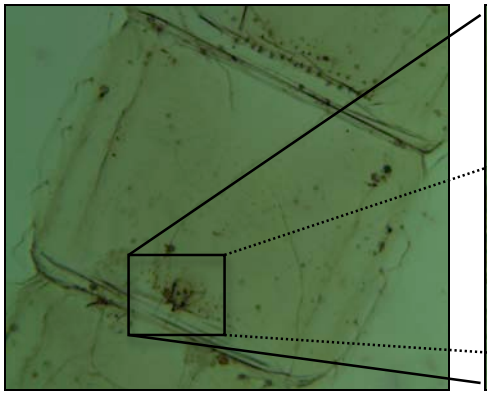

Figure 113. Tergite VI of *Cladopelma* sp. 1

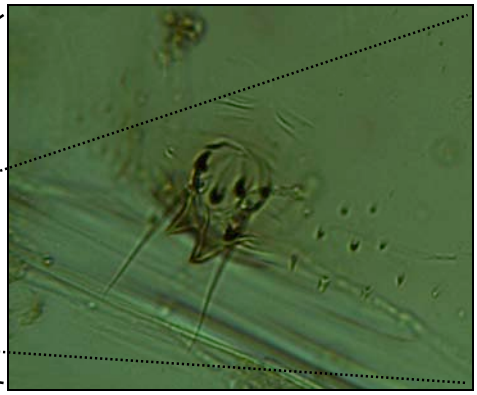

Figure 114. Tergite VI of *Cladopelma* sp. 1

4(3’). Anal segment with forked, posteromedian process (Fig. 115); frontal apotome often with ornate cephalic tubercles (Figs. 116-117); tergite IV with single row of short posterior spines (Fig. 118) ……..……..……..… ***Cryptochironomus***

4’. Anal segment without forked, posteromedian process; cephalic tubercles, when present, never ornate; tergite IV with multiple rows of long posterior spines (Fig. 119) …… ***Harnischia***

Figure 115 Anal segment of *Cryptochironomus* sp. 4

Figure 116. Cephalic tubercle of *Cryptochironomus* sp. 3

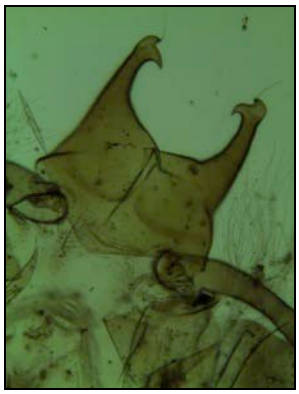

Figure 117. Cephalic tubercle of *Cryptochironomus* sp. 4

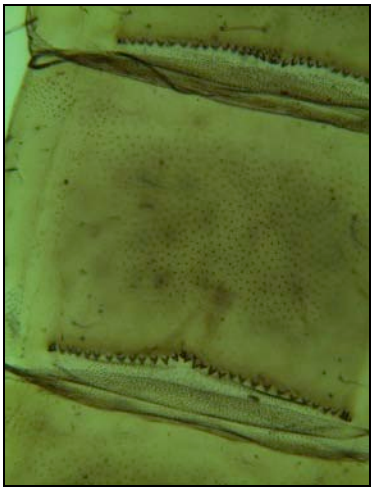

Figure 118. Tergite IV of *Cryptochironomus* sp. 4

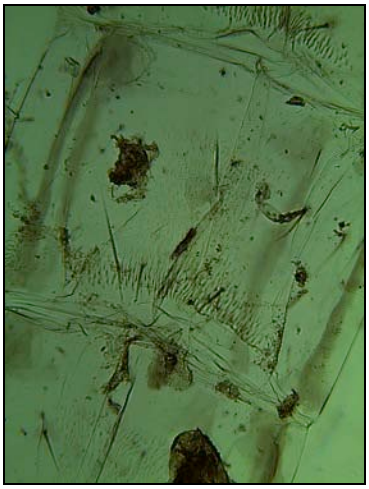

Figure 119. Tergite IV of *Harnischia* sp. 1

5(1’). Caudolateral margin of segment VIII sometimes without a spines or with a spine or group of spines (Figs. 120-121) ……..…..….. 7

5’. Caudolateral margin of segment VIII always without spines (Figs. 122-123) ……..... 6

Figure 120. Tergite VIII of *Goeldichironomus* sp. 1

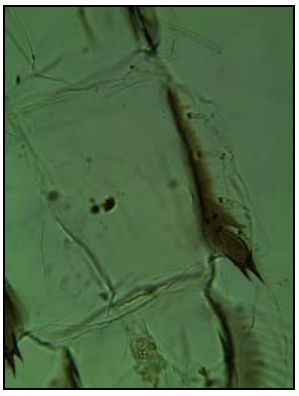

Figure 121. Tergite VIII of *Polypedilum* sp. 11

Figure 122. Tergite VIII of *Saetheria* nr *tylus*

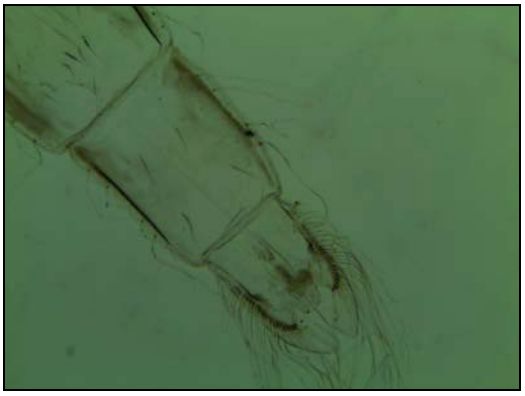

Figure 123. Tergite VIII of Unknown Chironomini #3

6(5’). Tergite II with continuous hook row on projecting flap; tergite III with posterior rows of triangular spines, with a yellow base with dark brown tips (Fig. 124) ……... ***Saetheria***

6’. Tergite II with interrupted hook row and posterior row of triangular dark brown spines; tergite III also with posterior row of triangular dark brown spines (Fig. 125) ……..…. **Unknown Chironomini #3**

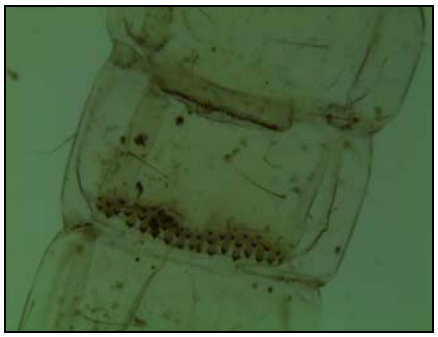

Figure 124. Tergites II-III of *Saetheria* nr. tylus

Figure 125. Tergites II-III of Unknown Chironomini #3

7(5). Cephalic tubercles absent (Figs. 126-127) ……..….. 8

7’. Cephalic tubercles present (Figs. 128-129) …… 12

Figure 126. Frontal apotome of *Nilothauma* sp. 1

Figure 127. Frontal apotome of *Stenochironomus* sp. 5

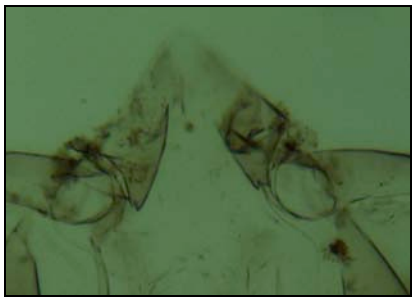

Figure 128. Frontal apotome of *Paralauterborniella nigrohalteralis*

Figure 129. Frontal apotome of *Polypedilum* sp. 4

8(7). Thoracic horn with about 6 slender branches (Fig. 130); two anterolateral patches and one median patch of shagreen on tergite VIII (Fig. 131) .....……. ***Nilothauma***

8’. Thoracic horn with more than 20 fine braches; no to continuous and dense shagreen on tergite VIII ……..…….. 9

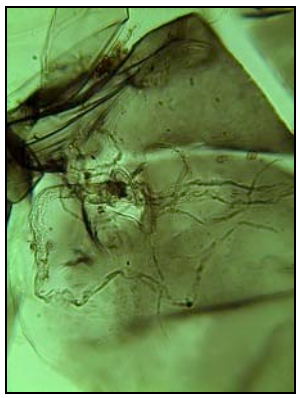

Figure 130. Thoracic horn of *Nilothauma* nr *reissi* var. 2

Figure 131. Tergite VIII of *Nilothauma* nr *reissi* var. 2

9(8’). Thoracic horn with several fine branches and one simple, spinose branch (Figs. 18, 132); frontal apotome with a pair of large swollen mounds (Fig. 127) ……..…...…….. 10

9’. Thoracic horn with fine branches only; frontal apotome with a pair of small swollen mounds (Fig. 133) ……..... 11

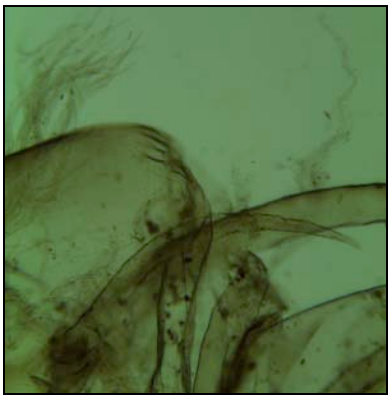

Figure 132. Thoracic horn of *Stenochironomus* sp. 1

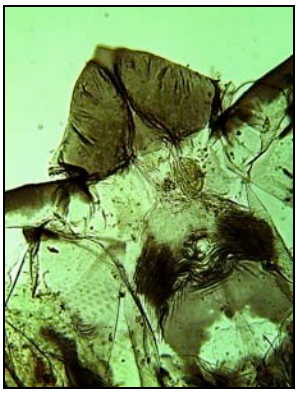

Figure 133. Frontal apotome of Unknown Chironomini #1

10(9). Shagreen absent on tergites VII and VIII or restricted to anterolateral regions (Fig. 134) ……..…….……. ***Stenochironomus***

10’. Shagreen present on tergites VII and VIII on posterior regions (Fig. 135) ……..…… ***Xestochironomus***

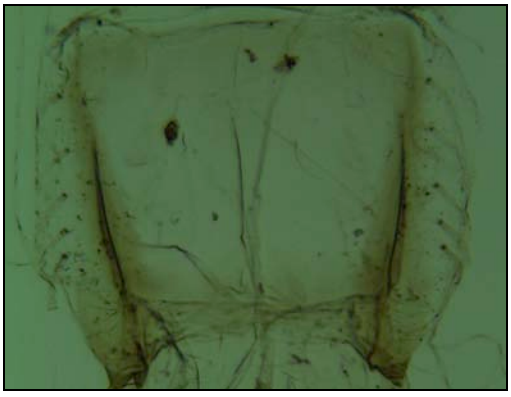

Figure 134. Tergite VIII of *Stenochironomus* sp. 1

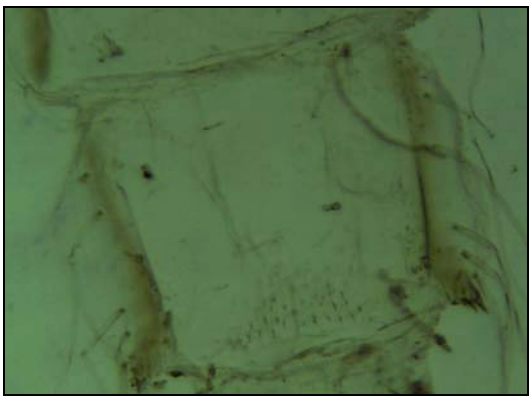

Figure 135. Tergite VIII of *Xestochironomus subletti*

11(9’). Dense, continuous shagreen on tergite VIII; dark brown recurved anal claw (Fig. 136) ……..…….. **Unknown Chironomini #1**

11’. Light, anterolateral shagreen on tergite VIII; yellow recurved anal claw (Fig. 137) …….. **Unknown Chironomini #2**

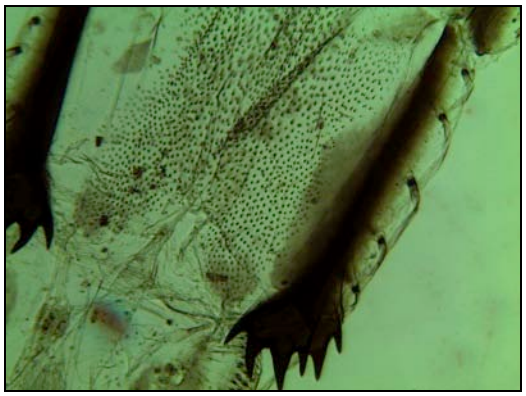

Figure 136. Tergite VIII of Unknown Chironomini #1

Figure 137. Tergite VIII of Unknown Chironomini #2

12(7'). Cephalic tubercles truncate and with a cluster of spinules (Fig. 138) ……..…...… ***Endotribelos***

12'. Cephalic tubercles not truncate and without spinules …….. 13

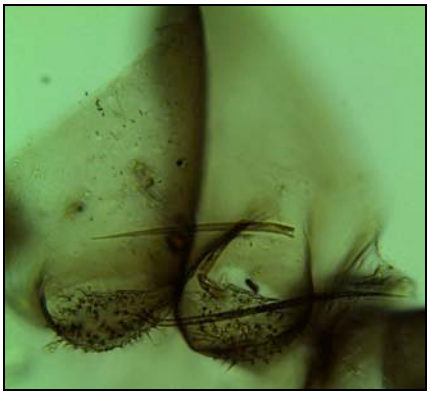

Figure 138. Cephalic tubercles of *Endotribelos* sp.1

13(12'). Tergites II-VI with paired groups of spines (Fig. 139); thoracic horn with 4 thick branches (Fig. 140) ……. ***Zavreliella***

13'. Tergites II-VI without paired groups of spines; thoracic horn with more than 4 branches ……...…… 14

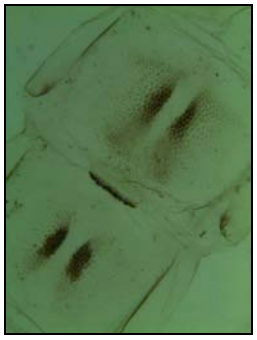

Figure 139. Tergites II-III of *Zavreliella* sp.1

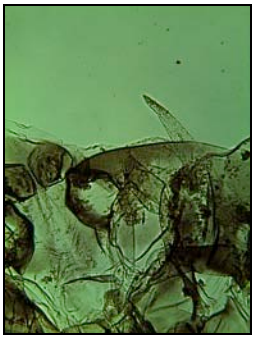

Figure 140. Thoracic horn of *Zavreliella* sp.1

14(13’). Thoracic horn plumose with more than 20 fine branches (Fig. 141) …… 15

14’. Thoracic horn with less than 20 coarse branches (Figs. 142) ……...… 18

Figure 141. Thoracic horn of Unknown Chironomini #4

Figure 142. Thoracic horn of *Polypedilum* sp. 1

15(14). Segment VIII with a singular, large spine (Fig. 143); conjunctives III/IV and IV/V each with a short, slender L seta (Fig. 146) ……..…..… ***Chironomus***

15’. Segment VIII without spines (Fig. 144) or at least 2 separate spines (Fig. 145); conjunctives III/IV and IV/V each without L seta (Fig. 147) ……..…… 16

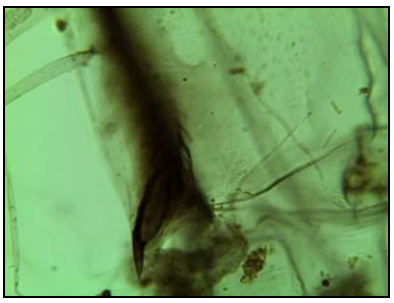

Figure 143. Anal spur of *Chironomus* sp. 1

Figure 144. Segment VIII of *Parachironomus* sp. 1

Figure 145. Anal comb of *Goeldichironomus* sp. 4

Figure 146. Conjunctive III/IV of *Chironomus* sp. 1

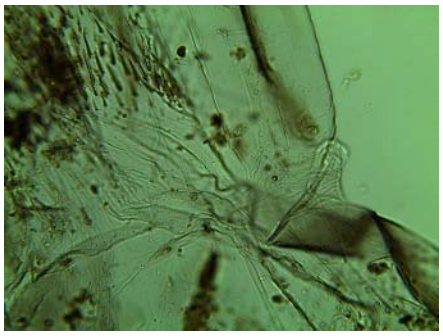

Figure 147. Conjunctive III/IV of *Goeldichironomus* sp. 5

16(15’). Tergite VI with posteromedian spinose swelling (Fig. 148) ….. ***Parachironomus***

16’. Tergite VI without posteromedian spinose swelling ……...……. 17

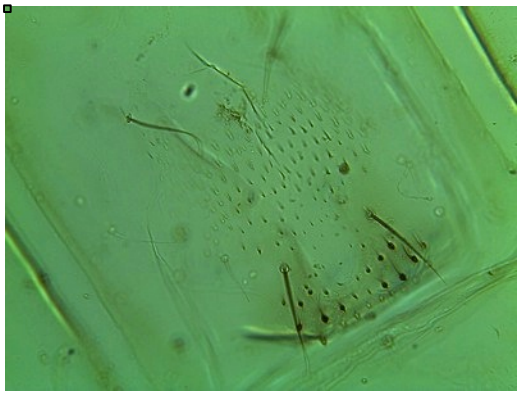

Figure 148. Tergite VI of *Parachironomus* nr. *cayapo*

17(16’). Tergite VIII with 4 LS setae; median pair of shagreen bands; dark brown pigmentation across entire segment (Fig. 149) ….……..…… **Unknown Chironomini #4**

17’. Tergite VIII with 5 LS setae; anterolateral pair of shagreen bands; dark brown pigmentation on anterior or lateral portions of segment (Figs. 150-151) …… ***Goeldichironomus***

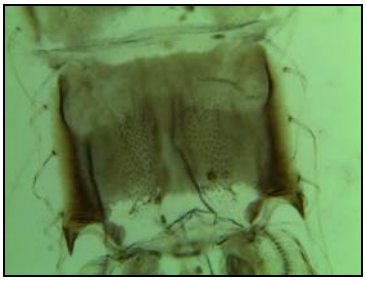

Figure 149. Tergite VII of Unknown Chironomini #4

Figure 150. Tergite VII of *Goeldichironomus* sp. 4

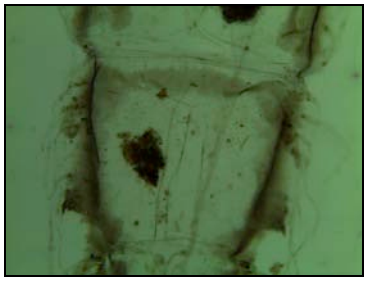

Figure 151. Tergite VII of *Goeldichironomus* sp. 5

18(14’). Cephalic tubercles long and slender with 2 apical spinules; frontal setae long and slender (Fig. 152); tergites IV-VIII with 4 LS setae ……..…. ***Paralauterborniella***

18’. Cephalic tubercles variable from absent to long and slender; frontal setae absent to long (Figs. 153-154); tergite IV with 0-3 LS setae and tergites V-VIII with 3-5 LS setae ……..…….. 19

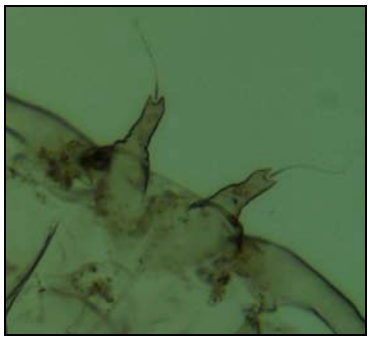

Figure 152. Cephalic tubercles of *Paralauterborniella nigrohalteralis*

Figure 153. Cephalic tubercles of *Polypedilum* sp. 5

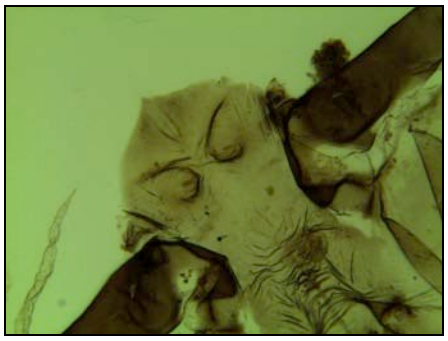

Figure 154. Cephalic tubercles of *Paratendipes* sp. 1

19(18'). Tergites II-VI with continuous shagreen in square or hourglass shape (Figs. 155-156); tergite V-VI with 4 LS setae ……..……...…. 20

19'. Tergites II-VI with anterior band of shagreen mostly separate from remaining shagreen (Fig. 157); tergites V-VI with 3 LS setae ……. ***Polypedilum***

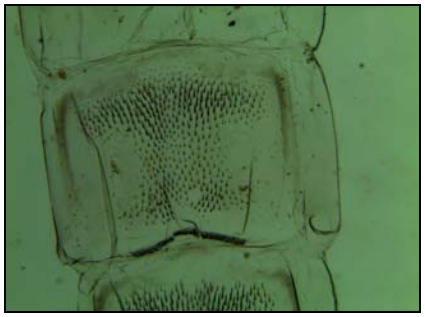

Figure 155. Tergite II of *Paratendipes* sp. 3

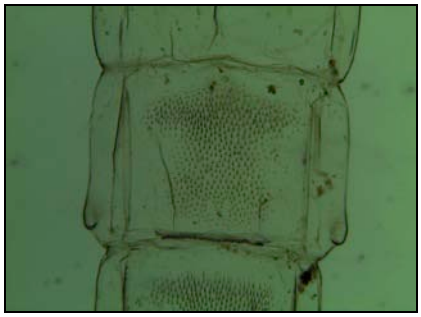

Figure 156. Tergite II of *Beardius* sp. 1

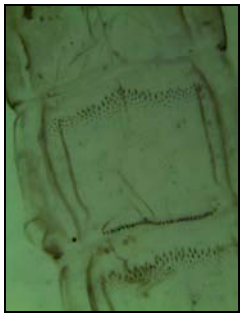

Figure 157. Tergite II of *Polypedilum* sp. 5

20(19). Tergite VIII with 4-7 dark spines along the lateral edge and one small dark anal spur on posterolateral corner (Figs. 158-159) ……..…….…… ***Beardius***

20'. Tergites VIII without dark spines along lateral edge and variable anal spur or comb (Figs. 160-161) ……..……...…….. ***Paratendipes***

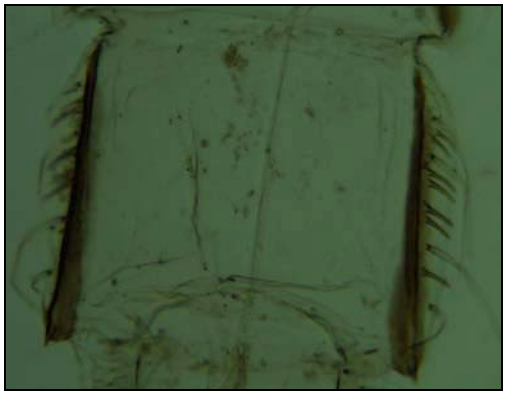

Figure 158. Tergite VIII of *Beardius* sp. 1

Figure 159. Tergite VIII of *Beardius* sp. 1

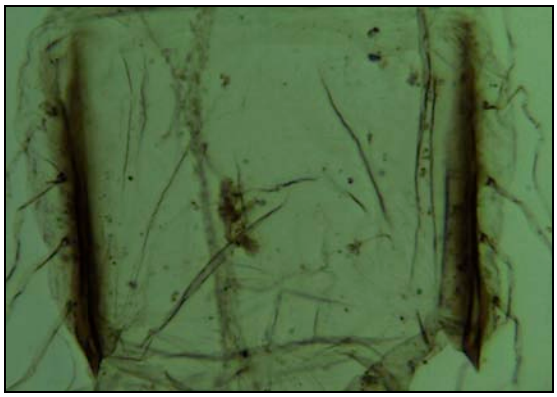

Figure 160. Tergite VIII of *Paratendipes* sp. 3

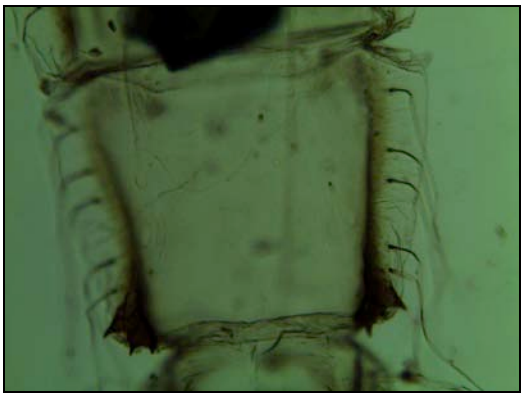

Figure 161. Tergite VIII of *Paratendipes* sp. 1

NOTES ON *BEARDIUS* SPECIES

Beardius sp. 1

Locality: Laguna del Tortuguero 1, 2, 3 & Quebrada

Head: Cephalic tubercles small and apically pointed; frontal setae present

Thorax: Basal ring with 1 tracheal branch

Abdomen: Lateral view of abdomen; tergite I bare; tergite II with dense median shagreen with continuous hook row (1/2 width) (Fig. 156); pedes spurii A and B present; tergites III-VI with median shagreen; tergite VII with anterior circular shagreen; tergite VII and VIII bare; 4 LS setae on tergites VI-VII; around 6 small, dark spines along pluera and one dark anal spur; at least 4 LS setae on tergite VIII (every other pattern of spine and LS setae) (Figs. 158-159), anal lobe fringe 3/4 complete

Comments: Originally described as an unknown Chironomini; appears close to *Beardius cristhinae* (Trivinho-Strixino & Siqueira 2007).

ADDITIONAL REFERENCES:

Reiss, F. and J.E. Sublette. 1985. *Beardius* new genus with notes on additional Pan-American taxa (Diptera, Chironomidae). Spixiana Supplement 11: 179-193.

Trivinho-Strixino, S. and T. Siqueira. 2007. New species of *Beardius* Reiss et Sublette, 1985 (Diptera: Chironomidae) from southeastern Brazil. In: T. Andersen (ed.). Contributions to the Systematics and Ecology of Aquatic Diptera- A tribute to Ole A. Saether. The Caddis Press. p 281-286.

KEY TO *CHIRONOMUS* SPECIES

1. Anal spur slightly longer and dark brown; anal lobe fringe dark brown (Fig. 162); cephalic tubercles with bulbous base and arched apex (Fig. 164) …..… ***Chironomus sp. 1***

1'. Anal spur slightly shorter and light brown; anal lobe fringe light brown (Fig. 163); cephalic tubercles bulbous base and tubular apex (Fig. 165) ……. ***Chironomus sp. 2***

Figure 162. Tergite VIII and anal lobes of *Chironomus* sp. 1

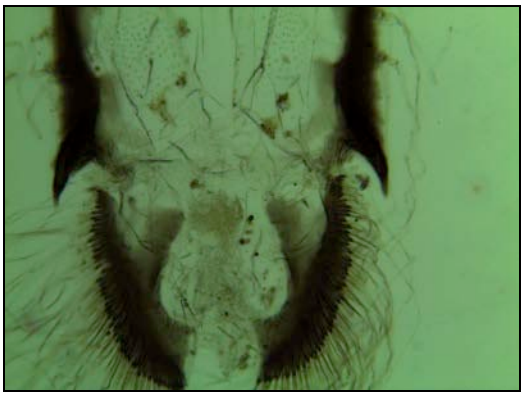

Figure 163. Tergite VIII and anal lobes of *Chironomus* sp. 2

Figure 164. Cephalic tubercles of *Chironomus* sp. 1

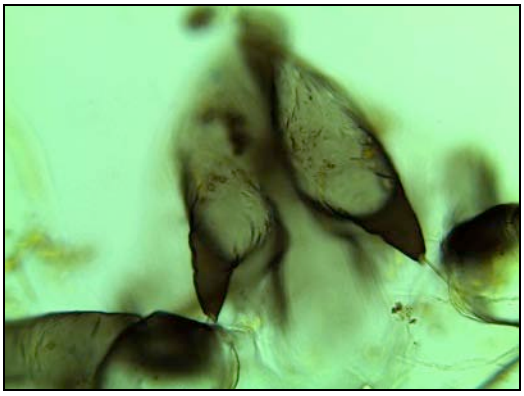

Figure 165. Cephalic tubercles of *Chironomus* sp. 2

NOTES ON *CHIRONOMUS* SPECIES

Chironomus sp. 1

Locality: Laguna del Tortuguero 1 & Quebrada

Head: Cephalic tubercles with bulbous base and arched apex (Fig. 164)

Abdomen: Tergite I bare; tergite II with median shagreen and continuous hook row (1/2 width); tergite III-V with median shagreen with a slightly darker posterior; conjunctives III/IV and IV/V with short, slender L setae (Fig. 146); tergite VI with heavier anterior and posterior patches of shagreen; tergite VII with light anterior patches of shagreen; tergite VII with light lateral patches of shagreen; dark anal spur; around 40 anal lobe filaments (Figs. 143, 162)

Chironomus sp. 2

Locality: Laguna del Tortuguero 1, 2 & Quebrada

Head: Cephalic tubercles with bulbous base and tubular apex (Fig. 165)

Abdomen: Anal spur much longer and darker than Chironomus sp. 1, appears close to *Chironomus gigas* (Reiss 1974:); around 45 anal lobe filaments (Fig. 163)

ADDITIONAL REFERENCES

Fittkau, E. J. 1968. *Chironomus streinzkei* n. sp. (Chironomidae, Dipt.), ein neues Laboratoriumstier. Zeitschtift für Morphologie der Tiere 63: 239–250.

Reiss, F. 1974. Vier neue *Chironomus*-Arten (Chironomidae, Diptera) und ihre ökologische Bedeutung für die Benthosfauna zentralamazonischer Seen und Überschwemmungswälder. Amazoniana 5: 3–23.

NOTES ON *CLADOPELMA* SPECIES

Cladopelma sp. 1

Locality: Laguna del Tortuguero 2

Head: Cephalic tubercles rounded with terminal point (like Fig. 10.8 B, Wiederholm 1986); thoracic horn plumose

Thorax: Medially restricted basal ring; granulose thorax

Abdomen: Tergite I with medial row of spines; tergite II anterior row of spines (wider than tergite I) and medially interrupted hook row; pedes spurii B absent on tergite II; tergites III-VI with posterior, triangular patch of spines; tergite VI with more rounded patch of spines (Figs. 113-114); shagreen on tergites I-VIII; tergite VIII with pale, single thorn-like spur in posterior 1/3; complete anal fringe; doesn't match abdomen of *C. laccophila* (Fig. 10.8, Wiederholm 1986)

KEY TO *CRYPTOCHIRONOMUS* SPECIES

1. Cephalic tubercles unfused at the base (Fig. 166) ……..... ***Cryptochironomus* sp. 2**

1'. Cephalic tubercles fused at the base (Figs. 167-169) ……..……. 2

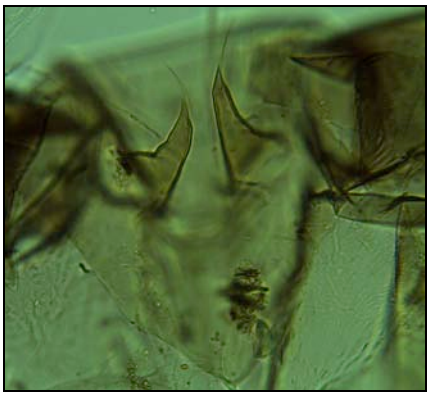

Figure 166. Cephalic tubercles of *Cryptochironomus* sp. 2

Figure 167. Cephalic tubercles of *Cryptochironomus* sp. 1

Figure 168. Cephalic tubercles of *Cryptochironomus* sp. 3

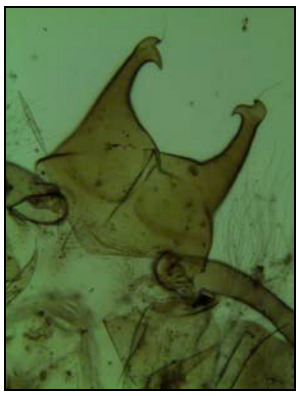

Figure 169. Cephalic tubercles of *Cryptochironomus* sp. 4

2(1'). Undivided arms of cephalic tubercles (Fig. 167), tergites III-VI with double row of posterior spines (Fig. 170) …… ***Cryptochironomus* sp. 1**

2'. Divided arms of cephalic tubercles (Figs. 168-169); tergites III-VI with single row of posterior spines (Fig. 171) ……...….. 3

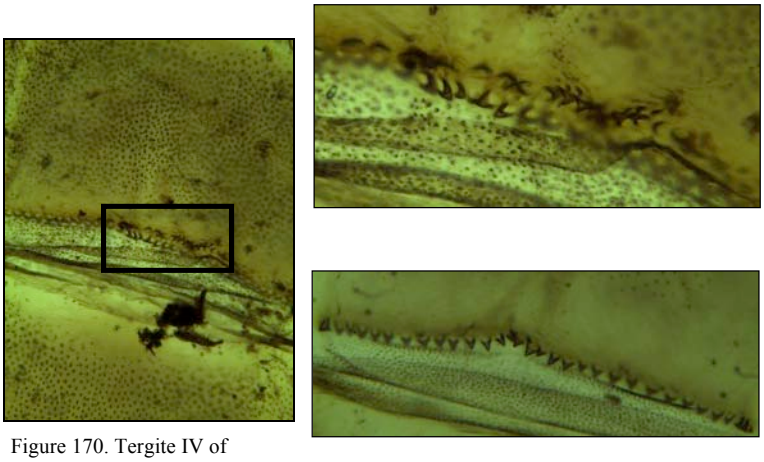

Figure 170. Tergite IV of *Cryptochironomus* sp. 1

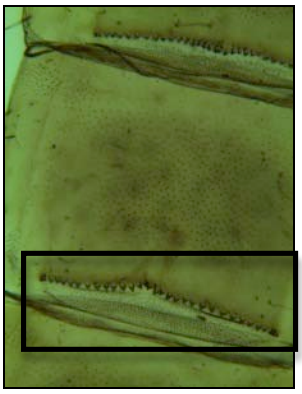

Figure 171. Tergite IV of *Cryptochironomus* sp. 4

3(2'). Divided arms of cephalic tubercles relatively straight, outside arm 2x as long as inside arm (Fig. 168); tergite VI single spine row consisting of a set of 2-3 small spines, a large gap, and another set of 2 small spines (Fig. 173); tergite VII without a small row of spines (Fig. 175) …..……...….. ***Cryptochironomus* sp. 3**

3'. Divided arms of cephalic tubercles curved, outside arm 1/2x as long as inside arm, frontal setae on outside arm (Fig. 169); tergite VI with single row consisting of about 25 small spines (Fig. 174); tergite VII with a small row of spines (Fig. 176) ……...…… ***Cryptochironomus* sp. 4**

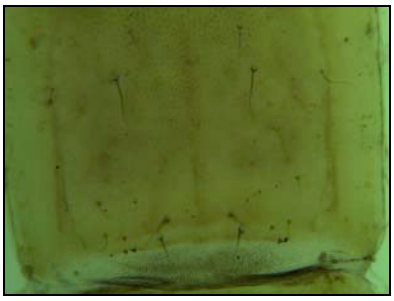

Figure 173. Tergite VI of *Cryptochironomus* sp. 3

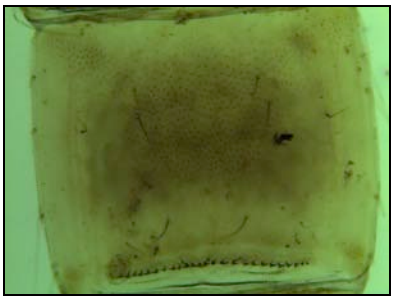

Figure 174. Tergite VI of *Cryptochironomus* sp. 4

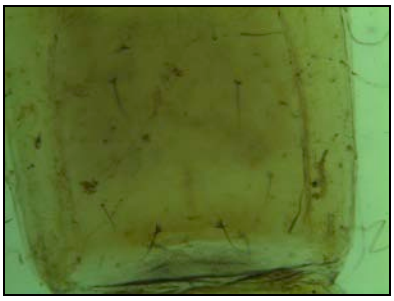

Figure 175. Tergite VII of *Cryptochironomus* sp. 3

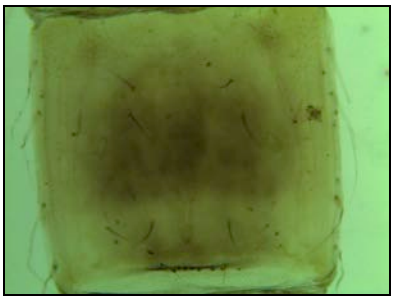

Figure 176. Tergite VII of *Cryptochironomus* sp. 4

NOTES ON *CRYPTOCHIRONOMUS* SPECIES

Cryptochironomus sp. 1

Locality: Laguna del Tortuguero 1, 2 & 3

Head: Large cephalic tubercles fused at the base; arms of cephalic tubercle relatively straight and equal in length; frontal setae present (Fig. 167)

Abdomen: Tergites without reticulations (doesn't match species in Vallenduuk 2004); spinose pedes spurii B on segment II; tergite II with large gap in hook row (Fig. 107); tergites III-VII with two posterior rows of spines (Fig. 170)

Comments: Around 6.5 mm long exuviae

Cryptochironomus sp. 2

Locality: Laguna del Tortuguero 2 & 3

Head: Moderate conical cephalic tubercles that are not fused at the base; frontal setae present (Fig. 166)

Thorax: Thoracic horn plumose (Fig. 111)

Abdomen: Very fine reticulation on tergites; sternite I with 2 spinose anterolateral tubercles; spinose pedes spurii B on segment II; tergite II with gap in hook row (Fig. 106); anal lobe missing

Comments: Light yellow pigmentation; around 4 mm long exuviae, appears to be closest to *C. denticulatus* (Goetghebuer, 1921) (Vallenduuk & Morozova 2004)

Cryptochironomus sp. 3

Locality: Laguna del Tortuguero 1

Head: Large cephalic tubercles fused at base, subdivided arms relatively straight, outside arm 2x as long as the inside arm; frontal setae appears absent (Figs. 116, 168)

Abdomen: Tergites III-VI with single row of posterior spines; tergite VI single spine row consisting of a set of 2-3 small spines, a large gap, and another set of 2 small spines (Fig. 173); tergite VII without a small row of spines (Fig. 175); missing anal lobe

***Cryptochironomus* sp. 4**

Locality: Laguna del Tortuguero 2

Head: Large cephalic tubercles fused at base, subdivided arms curved inward (Fig. 117); frontal setae present on outside arm (Fig. 169)

Abdomen: Tergites III-VI with single row of posterior spines (Figs. 118, 171); tergite VI with single row consisting of about 25 small spines (Fig. 174); tergite VII with a small row of spines (Fig. 176); anal projection longer than *Cryptochironomus* sp. 1 (Fig. 115)

ADDITIONAL REFERENCES

Curry, L.L., 1958. Larvae and pupae of the species *Cryptochironomus* (Diptera) in Michigan. Limnology and Oceanography 3:427-442.

Mason, P.G., 1986. Four new species of the *Cryptochironomus fulvus* (Johannsen) species complex (Diptera: Chironomidae). Entomologica scandanavica 16: 399 413.

Vallenduuk H.J. & E. E. Morozova. 2005. *Cryptochironomus*: An identification key to the larvae and pupal exuviae in Europe. Lautrebornia 55: 1-22.

KEY TO *CRYPTOTENDIPES* SPECIES

1. Segment VIII with singular long, curved, slender spines about 2/3 of the way down lateral margins (Fig. 177) ……...…… ***Cryptotendipes* sp. 1**

1'. Segment VIII with singular long, curved, slender spine about 2/3 of the way down right lateral margin and bifurcated spine on left margin (Fig. 178) ……. ***Cryptotendipes* sp. 2**

Figure 177. Tergite VIII of *Cryptotendipes* sp. 1

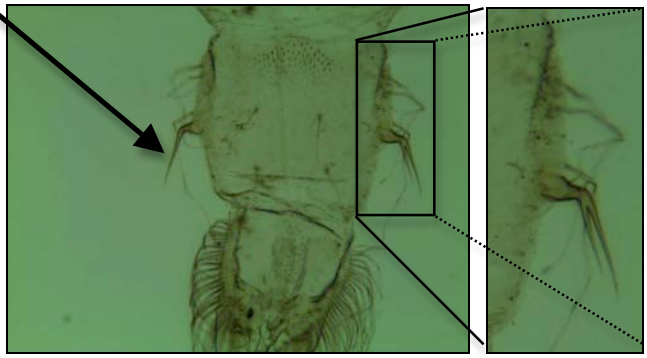

Figure 178. Tergite VIII of *Cryptotendipes* sp. 2

NOTES ON *CRYPTOTENDIPES* SPECIES

Cryptotendipes sp. 1

Locality: Laguna del Tortuguero 1, 2 & 3

Head: Cephalic tubercle similar to 10.13 A (Wiederholm 1986)

Thorax: Thoracic horn similar to 10.13 D (Wiederholm 1986) (Fig. 110)

Abdomen: Tergites V-VIII with shagreen; tergite V-VI with median shagreen patch; tergite VII-VIII anterior band of shagreen; segment VIII with singular long, curved, slender spines about 2/3 of the way down lateral margins (Fig. 177); anal lobe with median shagreen,

Cryptotendipes sp. 2

Locality: Laguna del Tortuguero 1 & 2

Head: Same as *Cryptotendipes* sp. 1

Thorax: Same as *Cryptotendipes* sp. 1

Abdomen: Segment VIII with singular long, curved, slender spine about 2/3 of the way down right lateral margin and bifurcated spine on left margin (Fig. 178)

NOTES ON *ENDOTRIBELOS* SPECIES

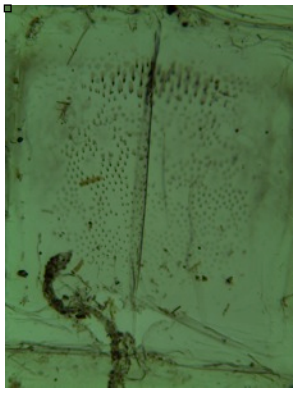

Figure 179. Tergites VI of *Endotribelos* sp. 1

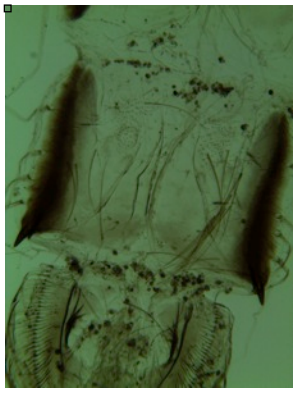

Figure 180. Tergites VIII of *Endotribelos* sp. 1

Endotribelos sp. 1

Locality: Laguna del Tortuguero 1, 2, 3 & Quebrada

Head: Cephalic tubercles truncate with apical patches of spines; frontal setae long with width at least two times diameter of tubercle (like Fig. 93, Grodhaus 1987) (Fig. 138)

Thorax: Thoracic horn with few branches (Fig. 95, Grodhaus 1987)

Abdomen: Conjunctives I/II – IV/V with laterally darkened; tergite II-VI with continuous, median shagreen (Fig. 179); pupal anal lobes (like Fig. 127, Grodhaus 1987); tergite V with 3 LS setae, tergite VI with 3 LS setae, tergite VII with 4 LS setae; tergite VIII with 4 LS setae; brown anal comb with 1 main tooth and 2-3 accessory teeth (Fig. 241) (Fig. 120, Grodhaus 1987)

Comments: Originally described as *Phaenopsectra*

ADDITIONAL REFERENCES

Grodhaus, G., 1987. *Endochironomus* Kieffer, *Tribelos* Townes, *Synendotendipes*, n. gen., and *Endotribelos,* n. gen. (Diptera: Chironomidae) of the Nearctic Region. Journal of the Kansas Entomological Society 60: 167-247.

Roque, F. O. & Trivinho-Strixino, S. 2008. Four new species of *Endotribelos* Grodhaus, a common fallen fruit-dwelling chironomid genus in Brazilian streams (Diptera: Chironomidae: Chironominae). Studies on Neotropical Fauna and Environment 43: 191-207.

KEY TO *GOELDICHIRONOMUS* SPECIES

1. Segment VIII with yellow singular anal spur (Figs. 181-182) ……..…….…. 2

1’. Segment VIII with dark brown anal comb with multiple spines (Figs. 183-185) ……. 3

Figure 181. Tergite VIII of *Goeldichironomus* sp. 1

Figure 182. Tergite VIII of *Goeldichironomus* sp. 2

Figure 183. Tergite VIII of *Goeldichironomus* sp. 3

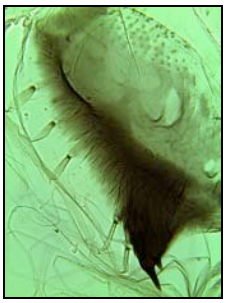

Figure 184. Tergite VIII of *Goeldichironomus* sp. 4

Figure 185. Tergite VIII of *Goeldichironomus* sp. 5

2(1). Segment VIII with 4 LS setae and singular yellow anal spur with minor accessory spine (Fig. 186) ……. ***Goeldichironomus* sp. 1**

2’. Segment VIII with 5 LS setae and singular yellow anal spur without accessory spine (Fig. 187) ……..……. ***Goeldichironomus* sp. 2**

Figure 186. Anal spur of *Goeldichironomus* sp. 1

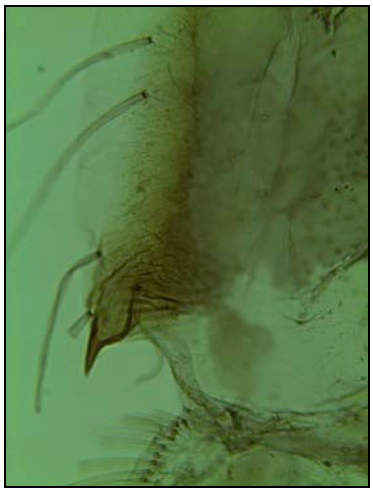

Figure 187. Anal spur of *Goeldichironomus* sp. 2

3(1’). Cephalic tubercles small, light brown (Fig. 188); tergites II-VI with continuous shagreen with dark, long spinules and slightly darker, longer spinules on posterior patches of shagreen (Fig. 191); tergite VIII with dark anterior and lateral pigmentation (Fig. 194) ……...…….... ***Goeldichironomus* sp. 4**

3’. Cephalic tubercles large, dark brown (Figs. 189-190); tergites II-VI with continuous shagreen with light, short spinules and distinct darker, longer spinules on posterior patches of shagreen (Figs. 192-193); tergite VIII with only dark anterior pigmentation (Fig. 196) …… 4

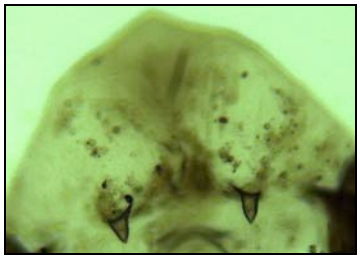

Figure 188. Cepahlic tubercles of *Goeldichironomus* sp. 4

Figure 189. Cephalic tubercles of *Goeldichironomus* sp. 3

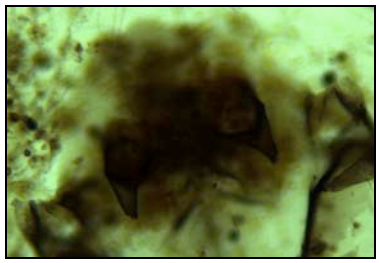

Figure 190. Cephalic tubercles of *Goeldichironomus* sp. 5

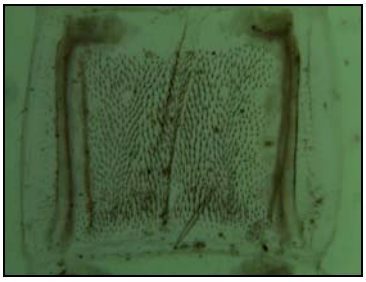

Figure 191. Tergite IV of *Goeldichironomus* sp. 4

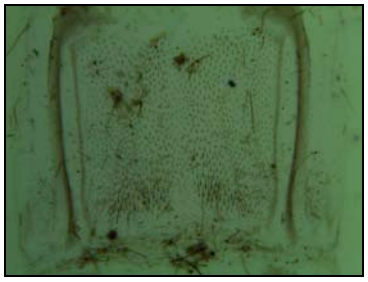

Figure 192. Tergite IV of *Goeldichironomus* sp. 3

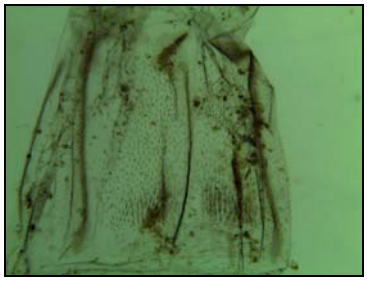

Figure 193. Tergite IV of *Goeldichironomus* sp. 5

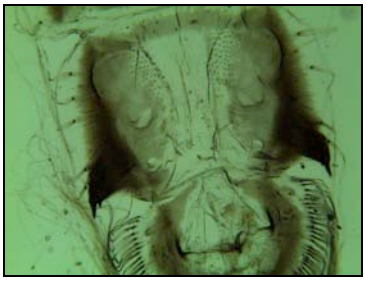

Figure 194. Tergite VIII of *Goeldichironomus* sp. 4

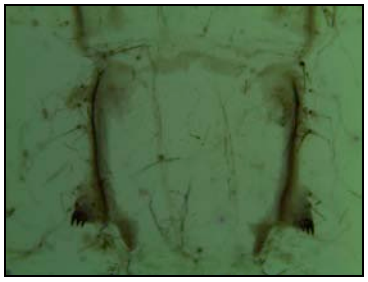

Figure 195. Tergite VIII of *Goeldichironomus* sp. 3

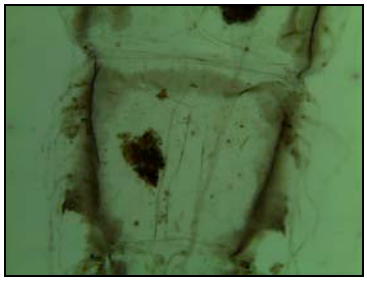

Figure 196. Tergite VIII of *Goeldichironomus* sp. 5

4(3’). Segment VIII with dark, 3-point anal claw (Figs. 183, 195); cephalic tubercles as long as wide (Fig. 189) ……..... ***Goeldichironomus* sp. 3**

4’. Segment VIII with dark, 2-point anal claw (Figs. 185, 196); cephalic tubercles 2x as long as wide (Fig. 190) ……..…… ***Goeldichironomus* sp. 5**

NOTES ON *GOELDICHIRONOMUS* SPECIES

Goeldichironomus sp. 1

Locality: Laguna del Tortuguero 2 & Quebrada

Head: Cephalic tubercle small and pointed with frontal setae

Thorax: Basal ring with 2 semi-circles (medially restricted); upper portion of thorax granulose; 4 dorsocentral setae spaced out between one another

Abdomen: Tergite I bare; tergite II with anterior band of shagreen and medial shagreen and continuous hook row (3/4 width); tergites III-V with dense hourglass shaped shagreen; tergite VI with anterior triangular patch of shagreen; tergite VII with two small patches of anterior shagreen; tergite VIII with two medial bands of shagreen; yellow spur with two minor spines (Figs. 181, 186); complete single row of anal fringe; pedes spurii A & B present; 4 LS setae on tergites V-VII and 4 LS setae on tergite VIII (two setae around anal spur) (Figs. 120, 181, 186); two lateral tubercles on tergite VIII

Comments: Abdomen shagreen and anal spur doesn't match any of the described species

Goeldichironomus sp. 2

Locality: Laguna del Tortuguero 2

Head: Cephalic tubercle small and pointed with frontal setae; very similar to *Goeldichironomus* sp. 1

Abdomen: Can clearly see the 5 LS setae on tergite VIII; LS setae position varies from *Goeldichironomus* sp. 1, single spur with no minor spines (Figs. 182, 187)

Comments: Very different from *G. holoprasinus*, closest to *Goeldichironomus* sp. 1

***Goeldichironomus* sp. 3**

Locality: Quebrada

Head: Cephalic tubercles small, dark and pointed; short frontal setae (Fig. 189)

Thorax: Two medially constricted basal rings (like 10.29 B, Wiederholm 1986)

Abdomen: Brown pigmentation of pleural area; tergite I bare; pedes spurii A & B present; tergite II-VI with continuous shagreen (more anteriorally than posteriorally) but longer spines on posterior (Fig. 192); tergite VII-VIII with two circulular anterior patches of shagreen (abdomen very similar to *G. holoprasinus*); tergites V-VII with 4 LS setae; tergite VIII with 5 LS setae (gap between first 2 and last 3 setae); dark brown, globular 3-point anal claw with some minor spines (Figs. 183, 195)

Comments: Around 6 mm long exuviae, closest to *G. xiborena* (Reiss 1974b, but varies from setal position on tergite VIII)

***Goeldichironomus* sp. 4**

Locality: Laguna del Tortuguero 2

Head: Cephalic tubercles small, light brown

Thorax: Kidney shaped basal ring with two tracheal branches

Abdomen: Tergite I bare; tergite II-VI with dense continuous shagreen (Fig. 191); tergite II with continuous hook row (3/4 width) and pedes spurii B; tergite IV with pedes spurii A; tergites VII and VIII with anterolateral patches of shagreen; no shagreen on anal lobe; 4 LS setae on tergites V-VII; 5 LS on tergite VIII; 2 large dark brown anal spurs (varies from *G. holoprasinus*) (Figs. 145, 150, 184, 194)

Comments: Close to *G. holoprasinus* group, *Chironomus*, and *Einfeldia* species group C

***Goeldichironomus* sp. 5**

Locality: Quebrada

Head: Cephalic tubercles large, dark brown with frontal setae (Fig. 190)

Thorax: Basal ring with 2 tracheal branches, thorax slightly granulose

Abdomen: Tergite I bar; tergite II with dense central shagreen and interrupted hook row on projecting flap (1/2 width); pedes spurii A & B present; tergites III-V with light central shagreen and two posterior dark patches of shagreen (Fig. 193); conjuncties between III/IV and IV/V without L setae (Fig. 147); tergite VI with anterior triangular light shagreen and darker posterior patches; tergites VII and VIII with anterolateral light patches of shagreen; 5 LS setae on tergite VIII; dark two-point spine (Figs. 151, 185, 196)

Comments: Close to *Chironomus* and *Einfeldia* species group C

ADDITIONAL REFERENCE

Reiss, F. 1974. Die in stehenden Gewässern der Neotropis verbreitete Chironomidengattung *Goeldichironomus* Fittkau (Diptera, Insecta). Studies on Neotropical Fauna 9: 85–122.

NOTES ON *HARNISCHIA* SPECIES

Harnischia sp. 1

Locality: Laguna del Tortuguero 1 & 2

Head: Cephalic tubercles bulbous with distal point and frontal setae absent

Thorax: Thoracic horn plumose (Fig. 112); bumps near median suture

Abdomen: Tergite I bare with 4 D setae; tergite II hook row interrupted (but appears connected since it is smashed together on the slide) and median shagreen; tergites III-VI with median shagreen and posterior row of long spines (Fig. 119); tergites III-VI with at least 10 D setae and 3 L setae; tergite IV with pedes spurii A; 4 LS setae on tergite V-VI; 5 LS setae on tergite VII, tergite VIII without anal spur; anal lobes with shagreen

Comments: Represented by two specimens; close to *Harnischia curtilamellata* (Malloch)

KEY TO *NILOTHAUMA* SPECIES

1. Tergite VII with anterior shagreen only (Fig. 197-200) ……...……...…… 2

1'. Tergite VII with anterior and posterior hourglass-shaped shagreen (Fig. 202, 204, 206) ……..…… 3

Figure 197. Tergites VII-VIII of *Nilothauma* nr *reissi* var. 1

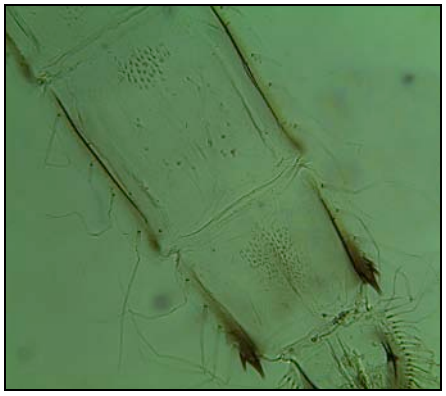

Figure 198. Tergites VII-VIII of *Nilothauma* nr *reissi* var. 2

Figure 199. Tergites VII-VIII of *Nilothauma* nr *reissi* var. 3

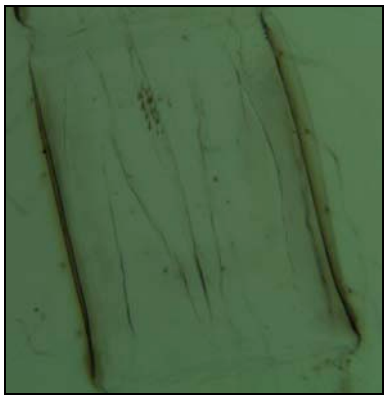

Figure 200. Tergites VII of *Nilothauma* sp. 4

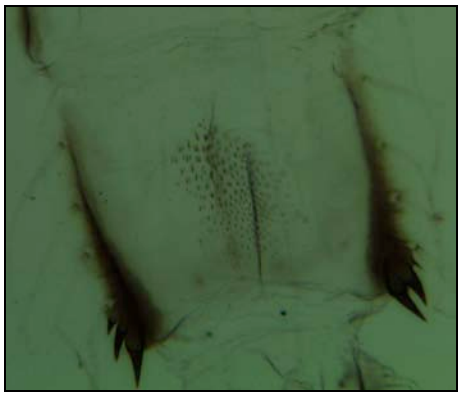

Figure 201. Tergites VIII of *Nilothauma* sp. 4

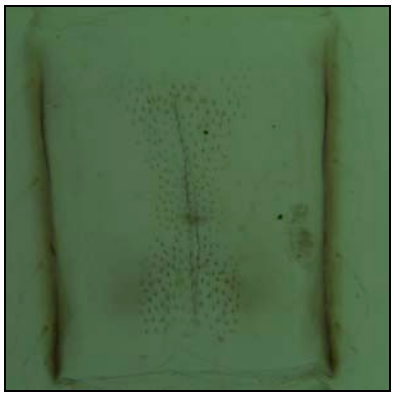

Figure 202. Tergites VII of *Nilothauma* sp. 1

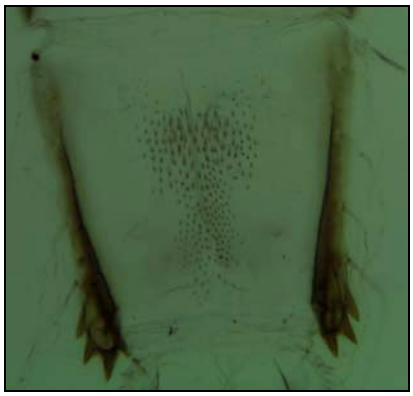

Figure 203. Tergites VIII of *Nilothauma* sp. 1

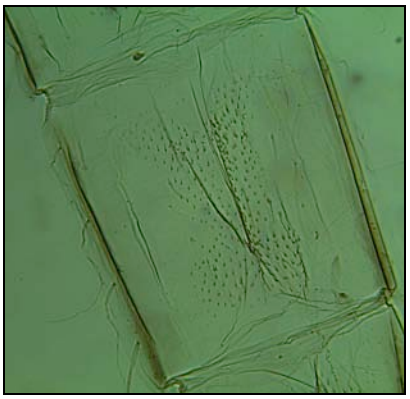

Figure 204. Tergites VII of *Nilothauma* sp. 2

Figure 205. Tergites VIII of *Nilothauma* sp. 2

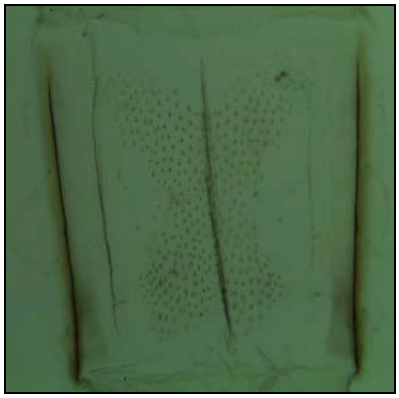

Figure 206. Tergites VII of *Nilothauma* sp. 3

Figure 207. Tergites VIII of *Nilothauma* sp. 3

2(1). Dark brown, 2-3 point anal comb (Fig. 208); dark brown pigmentation of pleural area of tergites (Fig. 212) …… ***Nilothauma* sp. 4**

2'. Yellow to light brown, 2-3 point anal comb (Figs. 209-211); light brown pigmentation of pleural area of tergites (Fig. 213) …….. ***Nilothauma* near *reissi* var. 1, 2, 3**

Figure 208. Anal comb of *Nilothauma* sp. 4

Figure 209. Anal comb of *Nilothauma* nr. *reissi* var. 1

Figure 210. Anal comb of *Nilothauma* nr. *reissi* var. 2

Figure 211. Anal comb of *Nilothauma* nr. *reissi* var. 3

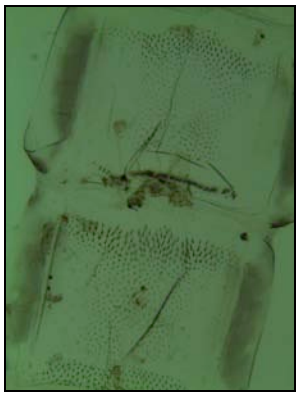

Figure 212. Tergites II-III of *Nilothauma* sp. 4

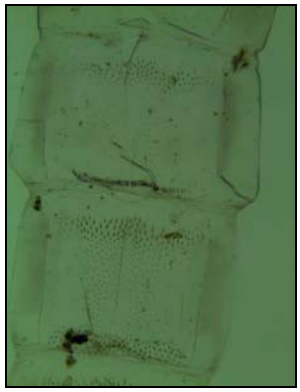

Figure 213. Tergites II-III of *Nilothauma* nr. *reissi* var. 3

3(1'). Tergite VIII with anterior patch of shagreen only (Figs. 205, 207) ……. 4

3'. Tergite VIII with anterior and posterior hourglass-shaped patch of shagreen (Fig. 203) …….. ***Nilothauma* sp. 1**

4(3). Posterior area of tergite VIII with yellow pigmentation; yellow to light brown, 6-point anal claw (Fig. 205) ……...…. ***Nilothauma* sp. 2**

4'. Posterior area of tergite VIII with dark brown pigmentation; dark brown, 5-point anal claw (Fig. 207) ……...…. ***Nilothauma* sp. 3**

NOTES ON *NILOTHAUMA* SPECIES

Nilothauma near *reissi* variation 1 Soponis, 1987

Locality: Laguna del Tortuguero 2

Head: Cephalic tubercle absent, frontal setae present

Thorax: Singular, round basal ring; distinct banded wing sheaths

Abdomen: Tergite I without shagreen; tergites II-VI with hourglass-shaped shagreen; tergite II with continuous hook row (1/2 width); tergite VII with anterior circular patch of shagreen; tergite VIII with anterior patch of shagreen (Fig. 197); yellow, 2-point anal claw (Fig. 209)

Nilothauma near *reissi* variation 2 Soponis, 1987

Locality: Laguna del Tortuguero 1

Thorax: Thoracic horn with six slender branches (Fig. 130)

Abdomen: Tergites similar to *Nilothauma* nr. *reissi* var. 1; tergite VIII with two anterolateral patches and one median patch of shagreen (Fig. 131); yellow anal claw made up of one major spur and 2-3 minor spines in a linear position (Fig. 210)

Nilothauma near *reissi* variation 3 Soponis, 1987

Locality: Laguna del Tortuguero 1

Abdomen: Tergites similar to *Nilothauma* nr. *reissi* var. 1; yellow to light brown 2-3 point anal claw (Fig. 211)

***Nilothauma* sp. 1**

Locality: Laguna del Tortuguero 1 & 2

Head: Cephalic tubercle absent, frontal setae present (Fig. 126)

Thorax: Median suture slightly granulose; distinct banded antennal sheath

Abdomen: Tergite I bare; tergite II-V with continuous dark shagreen; tergite II with hook row, continuous occupying 1/2 width; tergite VI and VII with hourglass shaped shagreen; tergite VII with anterior and posterior shagreen patches or only posterior shagreen patch (Fig. 202); tergite VIII with anterior and posterior shagreen patches (Fig. 203); overall abdomen close to Nilothauma sp. 1 in Mendes & Anderson 2009 (see Figs 75–79), but variation in shagreen pattern and anal comb, yellow to brown, 4-point anal comb (Fig. 203); 4 LS setae on segments V-VIII; complete anal fringe; around 22 taeniae on each anal lobe

***Nilothauma* sp. 2**

Locality: Laguna del Tortuguero 1

Head: Cephalic tubercle absent, frontal setae present

Thorax: 4 dorsocentral setae; 2 precorneal setae; rugulose thorax near median suture; slight protuberance on wing sheath

Abdomen: Pedes spurii B present; tergite II with continuous hook row (1/2 width); tergites II-VI with continuous hourglass-shaped shagreen; tergite VII with anteromedian hourglass-shaped shagreen (Fig. 204); tergite VIII with anteromedian circular-shaped shagreen (Fig. 205); posterior patch of shagreen on tergite VII (unlike *N. reissi*) and only anterior patch of shagreen on tergite VIII (unlike *Nilothauma* sp.1); 4 LS setae on tergites V-VIII; anal comb with 8-10 points (Fig. 205)

***Nilothauma* sp. 3**

Locality: Laguna del Tortuguero 2

Head: Cephalic tubercle absent, frontal setae present

Thorax: 4 dorsocentrals; 2 precorneals; rugulose thorax near median suture; slight protuberance on wing sheath; small singular basal ring

Abdomen: Tergite I without shagreen; tergites II-VII with continuous hourglass-shaped shagreen (Fig. 206); continuous hook row on tergite II (1/2 width); tergite VIII with median circular shagreen (Fig. 207); around 5-pointed dark anal claw; tergite VIII and anal claw different than *Nilothauma* sp. 2

***Nilothauma* sp. 4**

Locality: Laguna del Tortuguero 2

Head: Cephalic tubercle absent, frontal setae present

Thorax: 4 dorsocentrals; 2 precorneals; semi-circular basal ring; distinct banded antennal sheaths

Abdomen: Dark pigmentation of pleural area of tergites; tergite I without shagreen; tergites II-V with hourglass-shaped shagreen (darker anterior and posterior patches); tergite II with continuous hook row (1/2 width); tergite VI one anterior patch and two posterior patches of shagreen; tergite VII one anteromedian patch and two anterolateral patches (Fig. 200); tergite VIII with anteromedian circular patch of shagreen; very dark brown, 3-point anal claw (Fig. 201); complete anal fringe

ADDITIONAL REFERENCES

Adam, J.I. and O.A. Sæther. 1999. Revision of the genus *Nilothauma* Kieffer, 1921 (Diptera: Chironomidae). Entomologica Scandinavica Supplement 56: 1–107.

Mendes, H.F. and T. Andersen. 2009. Neotropical *Nilothauma* Kieffer, 1921, with the description of thirteen new species (Diptera: Chironomidae). Zootaxa 2063: 1-45.

KEY TO *PARACHIRONOMUS* SPECIES

1. Tergite VIII with 5 LS setae (Figs. 214-215) ……..……..…… 2

1’. Tergite VIII with 4 LS setae (Fig. 216) ……. ***Parachironomus* sp. 2**

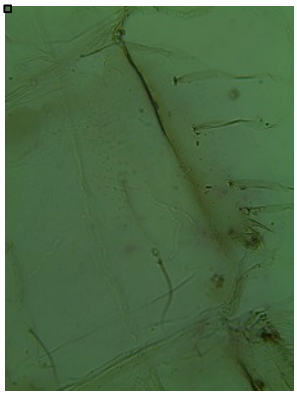

Figure 214. Tergite VIII of *Parachironomus* nr. *cayapo*

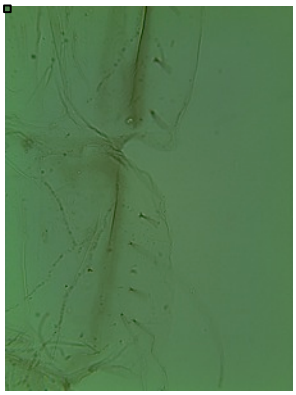

Figure 215. Tergite VIII of *Parachironomus* sp. 1

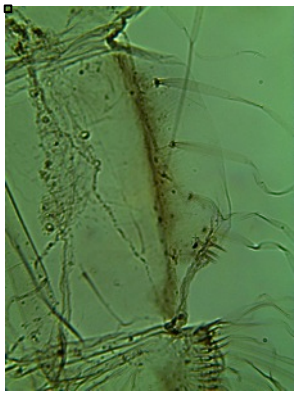

Figure 216. Tergite VIII of *Parachironomus* sp. 2

2(1). Segment VIII with 1 or more small anal spines (Figs. 214, 217-218) ……..… 3

2’. Segment VIII without spines (Fig. 215) ……..... ***Parachironomus* sp. 1**

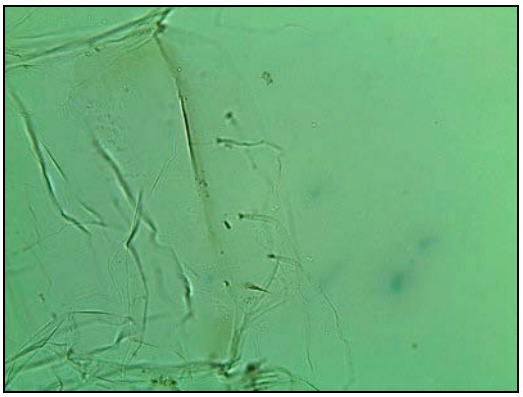

Figure 217. Tergite VIII of *Parachironomus* sp. 3

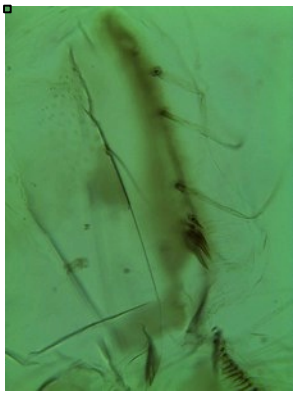

Figure 218. Tergite VIII of *Parachironomus* sp. 4

3(2). Tergite VI with posterior group of small spines on projecting flap (Figs. 219-220) …… 4

3’. Tergite VI with posterior group of distinct, large spines on projecting flap (Fig. 221) …….. ***Parachironomus* sp. 4**

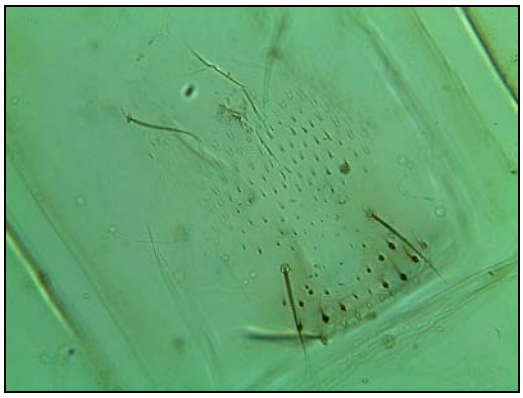

Figure 219. Tergite VI of *Parachironomus* nr. *cayapo*

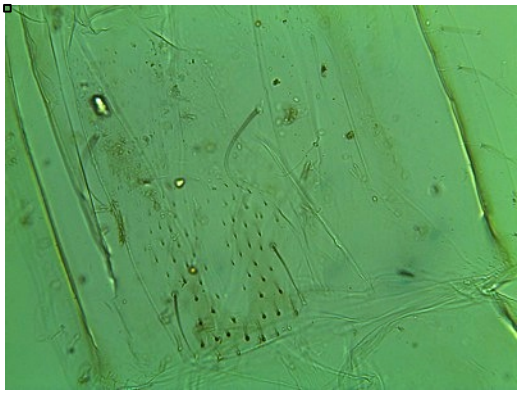

Figure 220. Tergite VI of *Parachironomus* sp. 3

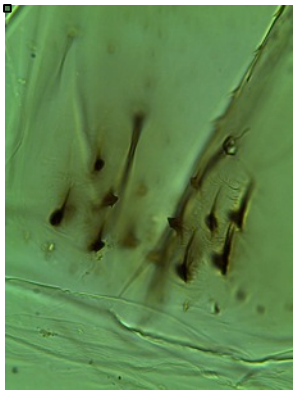

Figure 221. Tergite VI of *Parachironomus* sp. 4

4(3). Tergite II with light median shagreen and no pigmentation (Fig. 222)
…….. ***Parachironomus* nr. *cayapo***

4’. Tergite II with anterior band of small spines and dark brown pigmentation (Fig. 223)
……. ***Parachironomus* sp. 3**

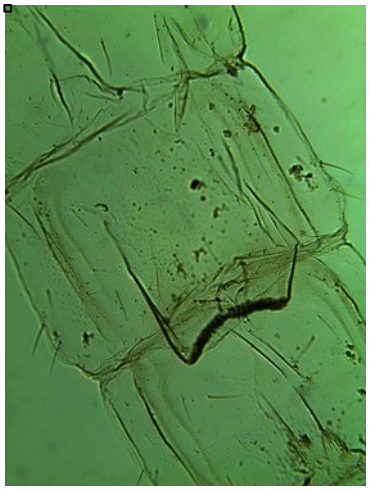

Figure 222. Tergite II of *Parachironomus* nr. *cayapo*

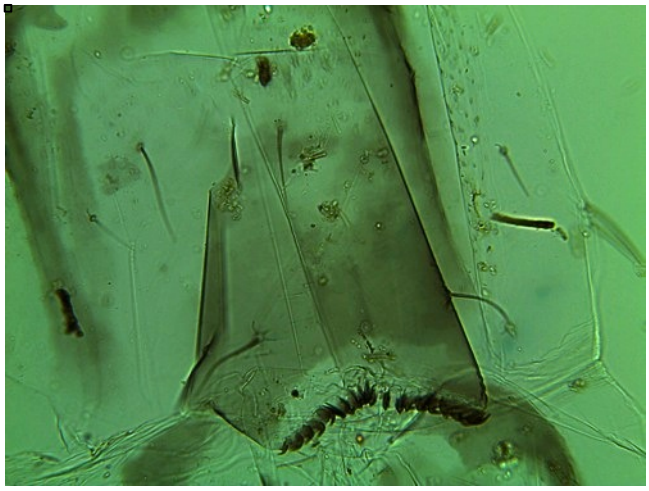

Figure 223. Tergite II of *Parachironomus* sp. 3

NOTES ON *PARACHIRONOMUS* SPECIES

Parachironomus near *cayapo* Spies, Fittkau & Reiss, 1994

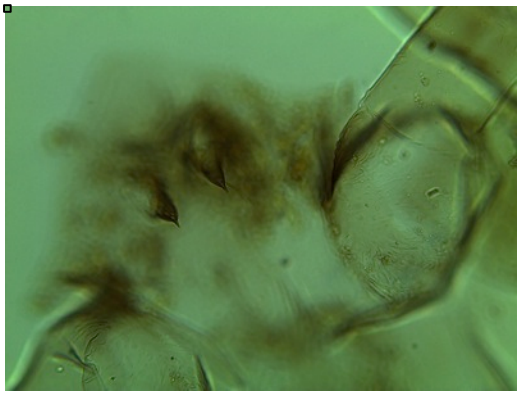

Figure 224. Cephalic tubercles of *Parachironomus* near *cayapo*

Locality: Laguna del Tortuguero 2 & 3

Head: Cephalic tubercles dark colored and conical with apical point and frontal setae (Fig. 224)

Thorax: Dorsocentral setae 1 and 4 much longer and more robust than dorsalcentral setae 2 and 3

Abdomen: Light median shagreen on tergites I-II (unlike *Parachironomus cayapo*); tergite II with continuous hook row (1/3 width) (Fig. 222); tergite VI with posterior group of points on distinct projecting flap (Figs. 148, 219); 5 LS setae and 2-4 point anal comb on tergite VIII (Fig. 214)

Comments: Close to vitiosus group (Wiederholm 1986); see page 7 of Trivinho-Strixino *et al.* 2010 for species description

***Parachironomus* sp. 1**

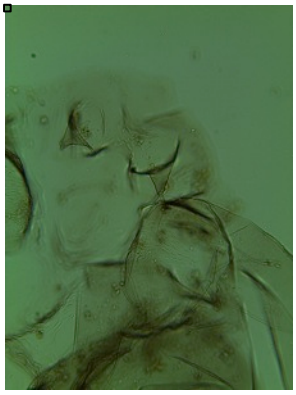

Figure 225. Cephalic tubercles of *Parachironomus* sp. 1

Locality: Laguna del Tortuguero 1

Head: Cephalic tubercles light colored and conical with apical point and frontal setae (Fig. 225)

Thorax: Very well developed prealar tubercles; 4 distanced dorsocentral setae

Abdomen: Tergite I with light median shagreen; tergite II with light median shagreen, posterior continuous hook row (1/2 width) and conspicuous pedes spurii B; tergites III-VI with light median shagreen and dark posterior shagreen; tergite VI with posterior shagreen on projecting flap; tergites VII-VIII with two light patches of anterolateral shagreen; tergite VII without anal claw or spines and 5 LS setae (Figs. 144, 215)

Comments: Close to varus group (Wiederholm 1986)

***Parachironomus* sp. 2**

Locality: Laguna del Tortuguero 1 & 2

Head: Cephalic tubercles light colored, long, and conical with slender frontal setae

Thorax: Rugulose median suture and median thorax; prealar tubercle weakly developed; 4 long spaced out dorsocentral setae

Abdomen: Tergite I appears bare (half missing); tergite II with light median shagreen and light hook row on distinct posterior flap (1/2 width and could be medially interrupted); tergites III-VI with anterior fine and posterior coarse shagreen; pedes spurii B inconspicuous and A well developed; tergite VI with very well developed patch of posterior spines on projecting flap (like Fig. 10.51 D, Wiederholm 1986), tergites V-VI with small spines on the lateral conjunctives; tergites V-VI with lateral spines; tergites VII-VIII with two light anterior patches of shagreen; anal claw made up of many minute, pale spines; 4 LS setae on tergites V-VIII (Fig. 216); single row of complete anal fringe

Comments: Close to species group C Carey Lake, Pa., coll. W.P. Coffman (Wiederholm 1986)

***Parachironomus* sp. 3**

Locality: Quebrada

Head: Cephalic tubercles bulbous and conical with apical point and frontal setae

Abdomen: Tergites I-IV with dark brown pigmentation of pleural area (Fig. 223); sternite II with anterior band of light spines; tergites V-VII with 4 LS setae; tergite VI with small swelling and stronger shagreen in middle near posterior margin but not on distinct projecting flap (Fig. 220); tergite VIII with 5 LS setae and 1 spine on the left side (Fig. 217)

Comments: Close to arcuatus group, but this specimen doesn't have posterior band of colorless spines (Wiederholm 1986)

***Parachironomus* sp. 4**

Locality: Laguna del Tortuguero 1

Head: Cephalic tubercles dark coloration and conical with frontal setae

Thorax: Very well developed prealar tubercle; very granulose median suture area of thorax

Abdomen: No anterior/posterior bands of spines on sternite II; spines on posterior shagreen on tergite VI very dark and thick on projecting flap (Fig. 221); tergite VIII with 5 LS setae and 3-4 pointed (Fig. 218), yellow anal claw with some minor spines

Comments: Represented by 1 specimen; close to vitiosus group, but tergite VI spines don't appear to be on a distinct projecting flap (Wiederholm 1986)

ADDITIONAL REFERENCES

Spies, M., E.J. Fittkau, and F. Reiss. 1994. The adult males of *Parachironomus* Lenz, 1921, from the Neotropical faunal region (Insecta, Diptera, Chironomidae). Spixiana Supplement 20: 61-98.

Trivinho-Strixino, S., F.L. Da Silva, and F.O Roque. 2010. A new species of *Parachironomus* Lenz, 1921 (Diptera: Chironomidae: Chironominae), and description of immature stages of two other species from the Neotropical Region. Zootaxa 2689: 1-14

NOTES ON *PARALAUTERBORNIELLA* SPECIES

Paralauterborniella nigrohalteralis Malloch, 1915

Locality: Laguna del Tortuguero 3

Head: Cephalic tubercles like Fig. 10.53 A (Wiederholm 1986) (Figs. 128, 152)

Thorax: Distinct nace on wing sheathes (most like Fig. 10.53 E); 1 long antepronotal; 2 precorneals and at least 2 dorsocentral setae present; missing paired patches on tergites VII & VIII (Fig. 10.53 G, Wiederholm 1986)

Abdomen: Abdomen like Fig. 10.53 D (Wiederholm 1986); 4 thick & bulbous LS setae on tergites V-VIII; anal comb most like *P. nigrohalteralis* (see Fig. 10.53 I, Wiederholm 1986)

Comments: Previously found in Costa Rica

KEY TO *PARATENDIPES* SPECIES

1. Tergite VIII with 5 LS setae (Fig. 226) ……. 2

1'. Tergite VIII with 4 LS setae (Fig. 227) ……..... 3

Figure 226. Tergites VIII of *Paratendipes* sp. 5

Figure 227. Tergites VIII of *Paratendipes* sp. 2

2(1). Frontal apotome with no to small cephalic tubercles and frontal setae absent (Fig. 228); tergite II with continuous hook row occupying ¼ width of segment (Fig. 230); segment VIII with dark brown, 3-point anal claw (Fig 232) ..……. ***Paratendipes* sp. 1**

2'. Frontal apotome with cephalic tubercles and frontal setae absent (Fig. 229); tergite II with continuous hook row occupying ¾ width of segement (Fig. 231); segment VIII with dark brown, multi-spined anal claw (Fig. 233) ……. ***Paratendipes* sp. 5**

Figure 228. Frontal apotome of *Paratendipes* sp. 1

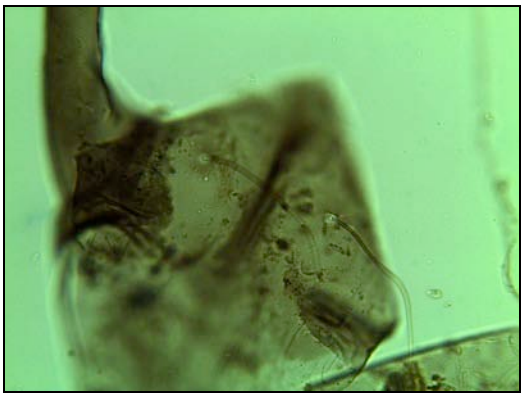

Figure 229. Frontal apotome of *Paratendipes* sp. 5

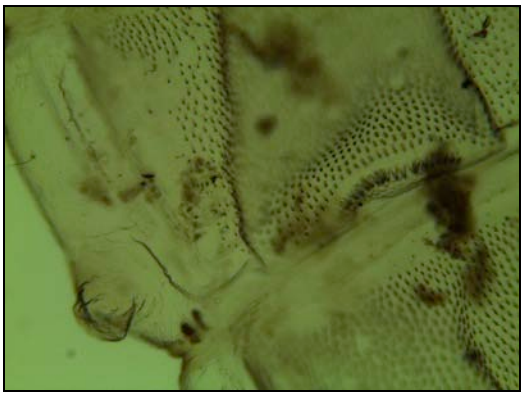

Figure 230. Tergite II of *Paratendipes* sp. 1

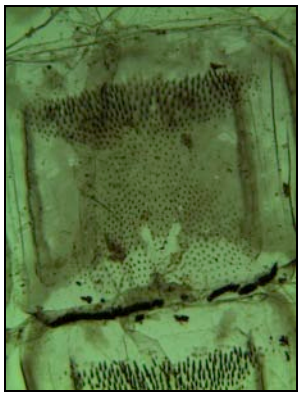

Figure 231. Tergite II of *Paratendipes* sp. 5

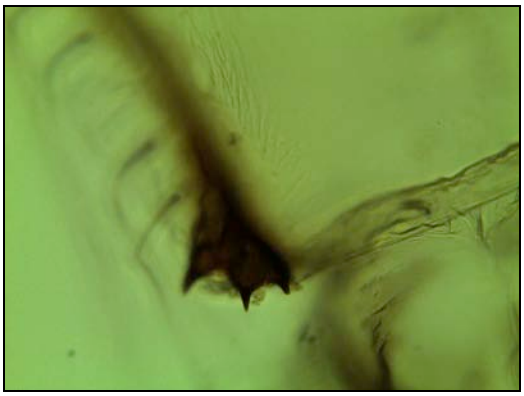

Figure 232. Anal claw of *Paratendipes* sp. 1

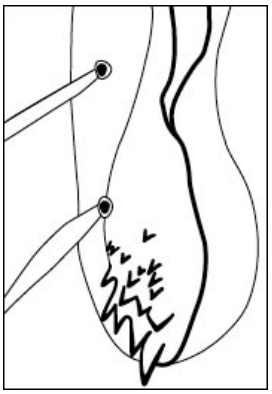

Figure 233. Anal claw of *Paratendipes* sp. 5

3(1'). Tergite V with 3 LS setae (Fig. 234); cephalic tubercles small, dark, and pointed (Fig. 236); dark, singular anal spur (Fig. 237) ……..…. ***Paratendipes* sp. 3**

3'. Tergite V with 4 LS setae (Fig. 235); cephalic tubercles absent; anal claw with multiple spines (Figs. 237-239) ……. 4

Figure 234. Tergite V of *Paratendipes* sp. 3

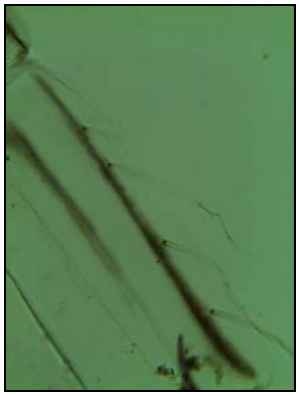

Figure 235. Tergite V of *Paratendipes* sp. 2

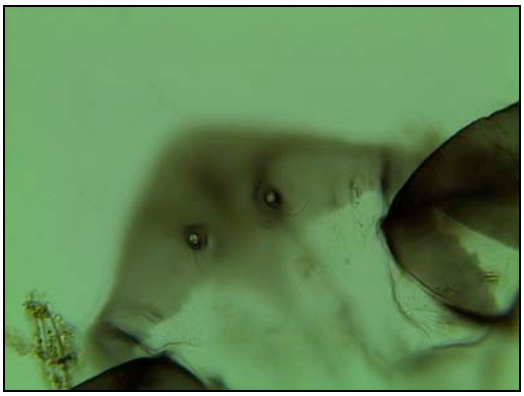

Figure 236. Frontal apotome of *Paratendipes* sp. 3

Figure 237. Anal spur of *Paratendipes* sp. 3

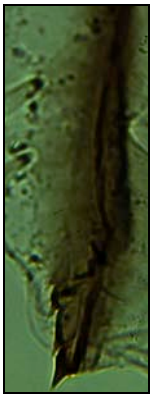

Figure 238. Anal claw of *Paratendipes* sp. 2

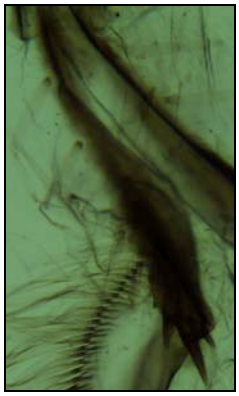

Figure 239. Anal claw of *Paratendipes* sp. 4

4(3'). Conjunctives between tergites III and IV without band of spines, but conjunctive between tergites IV and V with band of spines (Fig. 240); light brown, single anal spur with accessory spines (Fig. 238) ……..…… ***Paratendipes* sp. 2**

4'. Conjunctive between tergites III and IV with band of spines (Fig. 241); dark brown, multi-spine anal claw (Fig. 239) ……..…….. ***Paratendipes* sp. 4**

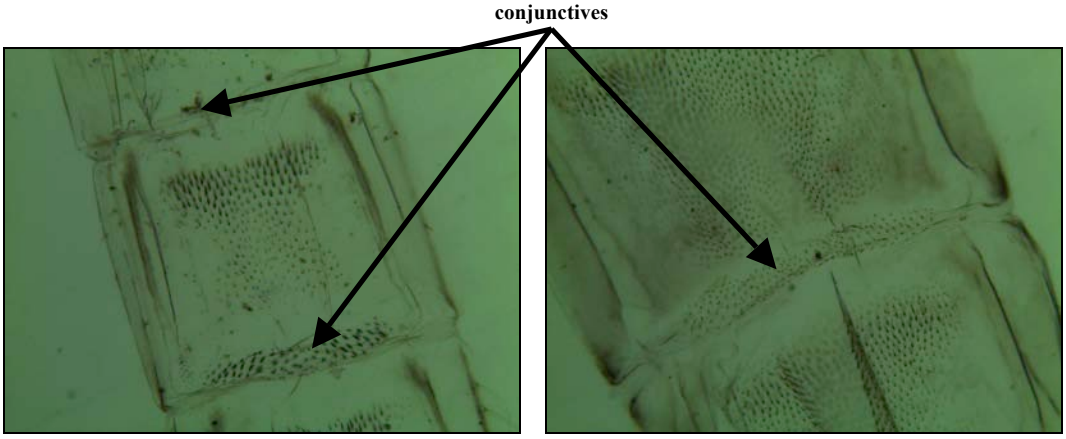

Figure 240. Tergites IV of *Paratendipes* sp. 2

Figure 241. Tergites III and IV of *Paratendipes* sp. 4

NOTES ON *PARATENDIPES* SPECIES

Paratendipes sp. 1

Locality: Laguna del Tortuguero 3

Head: Cephalic tubercles small and bulbous; frontal setae present (Figs. 154, 228)

Thorax: Thoracic horn with eight long, smooth branches; dark oval basal ring; median suture granulose; four dorsocentral setae; two precorneals

Abdomen: Short row of spines on tergite I with around 8-10 spinules; tergites II-VI with dense shagreen (like Fig. 10.58 E, Wiederholm 1986) (Fig. 232); tergite VII with median patch of shagreen; hook row continuous and occupying 1/4 width; pedes spurii A & B present, B very long and prominent; almost complete anal fringe; 4 LS setae on tergite V-VII; 5 LS setae on tergite VIII; brown, 3-point anal claw (Figs. 161, 232)

Comments: Represented by one specimen

Paratendipes sp. 2

Locality: Laguna del Tortuguero 2

Head: Cephalic tubercles absent; frontal setae present

Thorax: Thoracic horn with several branches; 2 precorneal setae; 4 dorsocentral setae

Abdomen: Tergite II with continuous hook row covering 3/4 width; tergites II-VI with hourglass-shaped shagreen (like Fig. 10.57 E, Wiederholm 1986); only band of spines on conjunctive between tergites IV and V (Fig. 240); segments V-VIII with dark abdominal outline; small pedes spurii B; pedes spurii A present; 4 LS setae on segments V-VIII (Figs. 227, 235); dark brown anal spur with one major spine and around 4 minor spines (Fig. 238)

Comments: Represented by two specimens; appears close to *Beardius* sp. B from Jacobsen and Perry (2000)

***Paratendipes* sp. 3**

Locality: Laguna del Tortuguero 1, 2 & 3

Head: Cephalic tubercles dark brown, small, and pointed (Fig. 236)

Thorax: Thoracic horn with several branches; semi-circular basal ring (like Fig. 10.57 D, Wiederholm 1986); 4 conspicuous dorsocentral setae; dark pigmented cephalothorax

Abdomen: Tergite 1 without shagreen; tergites II-VI with hourglass-shaped shagreen; pedes spurii A & B present; 3 LS setae on tergite V (Fig. 234); 4 LS setae on tergites VI-VIII; 1-point dark anal spur (Figs. 160, 237); 3/4 complete anal fringe

Comments: Most common *Paratendipes* species; appears close to *Beardius* sp. B from Jacobsen and Perry (2000)

***Paratendipes* sp. 4**

Locality: Laguna del Tortuguero 2

Head: Cephalic tubercles absent; frontal setae present

Thorax: Small basal ring with one tracheal branch

Abdomen: Tergite II-V with median dense shagreen; tergite II with continuous hook row (3/4 width); Conjunctive between tergites III and IV with band of spines (Fig. 241); conjunctive between tergites IV and V with band of spines; tergite VI with anterior and posterior patch of shagreen; tergite VII and VIII with sparse anterior shagreen; 4 LS setae on tergite V-VIII; 3 dark major points and several minor points in anal claw (Fig. 239); complete anal fringe

Comments: Represented by one specimen

***Paratendipes* sp. 5**

Locality: Laguna del Tortuguero 1

Head: Cephalic tubercles absent, frontal setae present (Fig. 229)

Abdomen: Tergite II with dark hourglass-shaped shagreen (darker anterior band) and continuous hook row (3/4 width, appears to be damaged and partially missing) (Fig. 231); only single band of spines on conjunctives between tergites IV and V; tergites V-VII with 4 LS setae; tergite VIII with 5 LS setae (Fig. 226); 1 dark anal spur and many small accessory spines (Fig. 233)

Comments: Represented by one specimen

ADDITIONAL REFERENCES

Hayford, B.L. 1998. A systematic revision of *Paratendipes* (Diptera: Chironomidae) with special emphasis on the evolution of thermophily. Unpublished PhD thesis.

Jacobsen, R. E. & Perry, S. A. 2000. A review of *Beardius* Reiss & Sublette, with description of a new species from Everglades National Park (Insecta, Diptera, Chironomidae). Spixiana 23: 129-144.

KEY TO *POLYPEDILUM* SPECIES

1. Cephalic tubercles present and large (Fig. 242-243) ……. 2

1’. Cephalic tubercles absent or small (Fig. 244) …….. 3

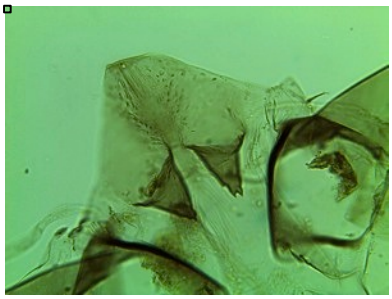

Figure 242. Frontal apotome of *Polypedilum* sp. 2

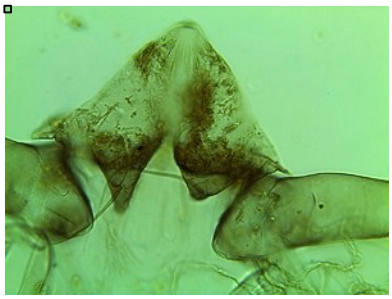

Figure 243. Frontal apotome of *Polypedilum* sp. 4

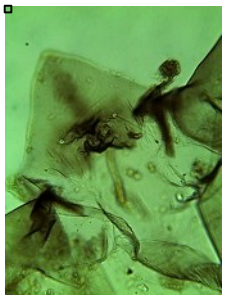

Figure 244. Frontal apotome of *Polypedilum* sp. 5

2(1). Frontal apotome granulose (Fig. 242); golden anal claw with main spur not reaching past segment VIII into anal lobes (Fig. 245) ……..… ***Polypedilum* sp. 2**

2’. Frontal apotome smooth (Fig. 243); golden anal claw with main spur reaching past segment VIII into anal lobes (Fig. 246) ……..……. ***Polypedilum* sp. 4**

Figure 245. Anal claw of *Polypedilum* sp. 2

Figure 246. Anal claw of *Polypedilum* sp. 4

3(1’). Anal claw with apical and lateral accessory spines (Figs. 247-248) ……..… 4

3’. Anal claw with only apical accessory spines (Figs. 249-250) ……..… 9

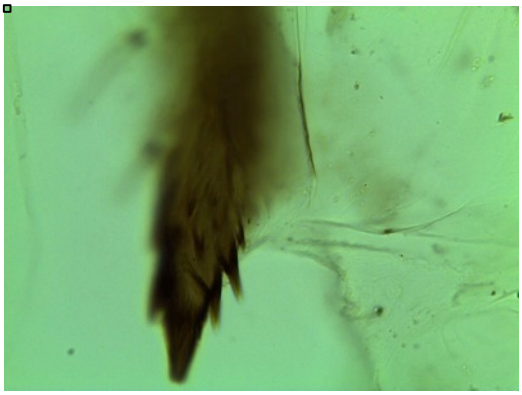

Figure 247. Anal claw of *Polypedilum* sp. 5

Figure 248. Anal claw of *Polypedilum* sp. 8

Figure 249. Anal claw of *Polypedilum* sp. 1

Figure 250. Anal claw of *Polypedilum* sp. 10

4(3). Tergites II-VI with distinct dark anterior band of shagreen (Fig. 251-253) ……. 5

4’. Tergites II-VI with light anterior band of shagreen (Fig. 254-256) ……..... 7

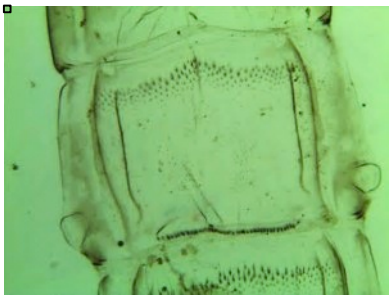

Figure 251. Tergite II of *Polypedilum* sp. 5

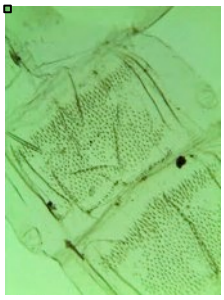

Figure 252. Tergite II of *Polypedilum* sp. 8

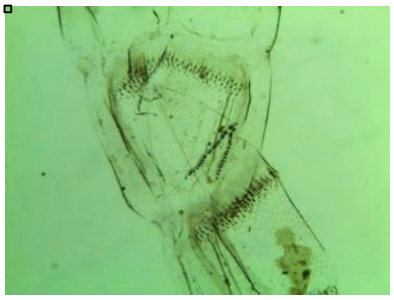

Figure 253. Tergite II of *Polypedilum* sp. 12

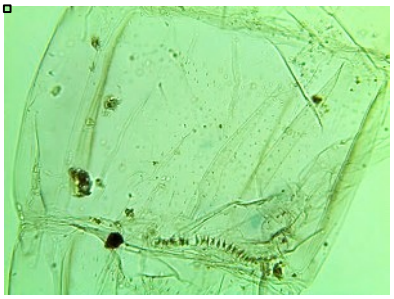

Figure 254. Tergite II of *Polypedilum* sp. 6

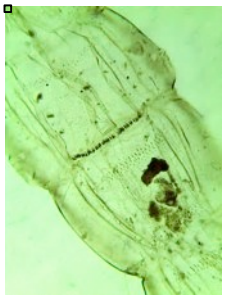

Figure 255. Tergite II-III of *Polypedilum* sp. 7

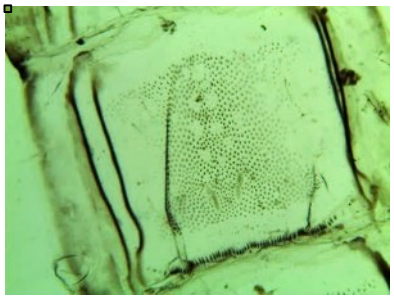

Figure 256. Tergite II of *Polypedilum* sp. 13

5(4). Tergite II with light, sparse median field of shagreen (Figs. 251, 253) ……..……. 6

5'. Tergite II with dark, dense median field of shagreen (Fig. 252) …. ***Polypedilum* sp. 8**

6(5). Tergite VII with light anterolateral patches of shagreen (Fig. 257); each anal lobe with around 30 fringe setae ……..…….. ***Polypedilum* sp. 5**

6'. Tergite VII with dark anterior band of shagreen (Fig. 258); each anal lobe with around 21 fringe setae …….…….. ***Polypedilum* sp. 12**

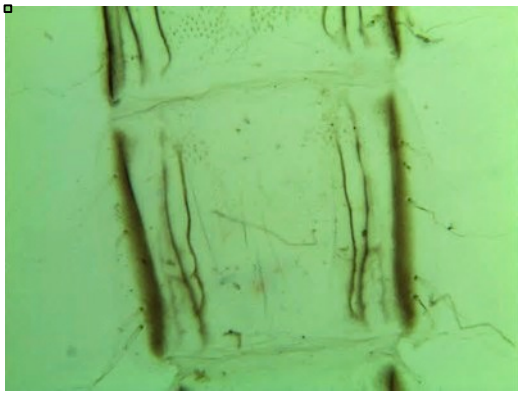

Figure 257. Tergite VII of *Polypedilum* sp. 5

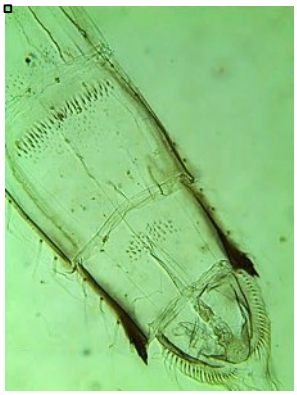

Figure 258. Tergite VII of *Polypedilum* sp. 12

7(4'). Tergites II-VI with light median shagreen without fenestrations (Fig. 254-255); each anal lobe with around 16 fringe setae ……..……..….. 8

7'. Tergites II-VI with dark median shagreen with large fenestrations (Fig. 256); each anal lobe with around 30 fringe setae …….…….. ***Polypedilum* sp. 13**

8(7). Tergite II with continuous, ½ width hook row (Fig. 254); no distinct pigmentation of pleural area of segments ……..……. ***Polypedilum* sp. 6**

8’. Tergite II with continuous, ¾ width hook row (Fig. 255); dark brown pigmentation of pleural area of segments ……..…… ***Polypedilum* sp. 7**

9(3’). Tergite II with anterior band of light, short spines; hook row continuous, ½ width (Figs. 259-260) ……..…… 10

9’. Tergite II with anterior band of dark, long spines; hook row continuous ¾ width (Figs. 261-263) ……....……...……..……..…….. 11

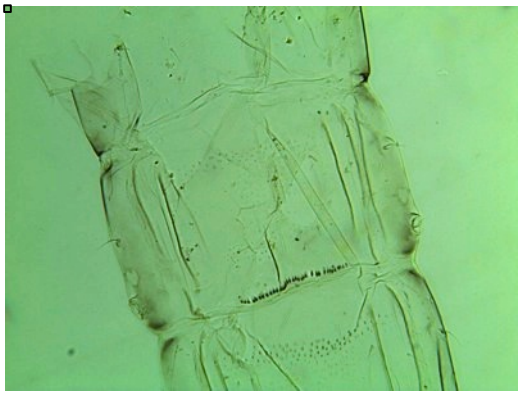

Figure 259 Tergite II of *Polypedilum* sp. 3

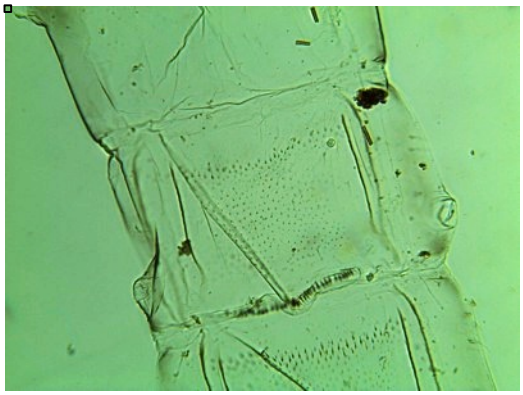

Figure 260. Tergite II of *Polypedilum* sp. 11

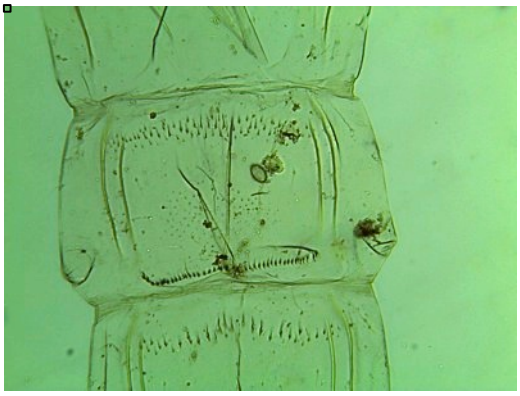

Figure 261. Tergite II of *Polypedilum* sp. 1

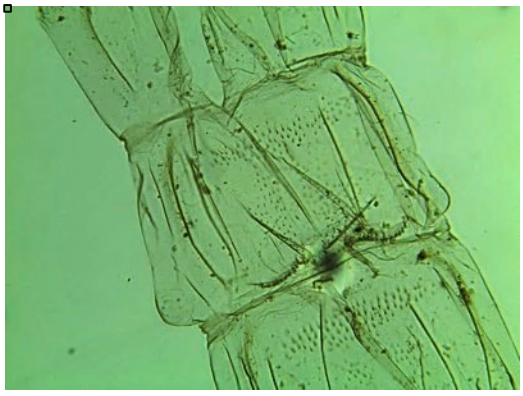

Figure 262. Tergite II of *Polypedilum* sp. 9

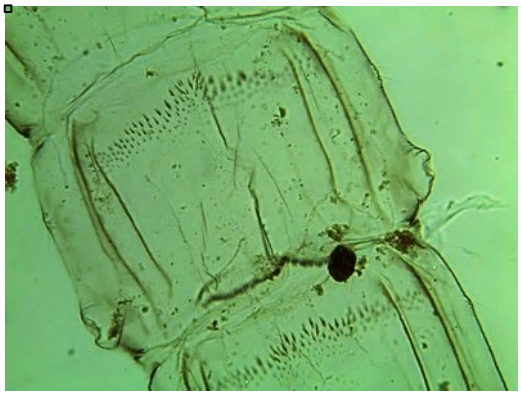

Figure 263. Tergite II of *Polypedilum* sp. 10

10(9). Tergites II-III with light, sparse median shagreen (Fig. 259); light brown anal claw and anal lobes (Figs. 264-265) …… ***Polypedilum* sp. 3**

10'. Tergites II-III with dark, dense median shagreen (Fig. 260); dark brown anal claw and anal lobes (Figs. 266-267) …….. ***Polypedilum* sp. 11**

Figure 264. Lower tergites of *Polypedilum* sp. 3

Figure 265. Anal claw of *Polypedilum* sp. 3

Figure 266. Lower tergites of *Polypedilum* sp. 11

Figure 267. Anal claw of *Polypedilum* sp. 11

11(9’). Tergites III-IV with single anterior row of long spines (Figs. 268-269) ……..……. 12

11’. Tergites III-IV with multiple anterior rows of short spines (Fig. 270) ……..…...……...…. ***Polypedilum* sp. 9**

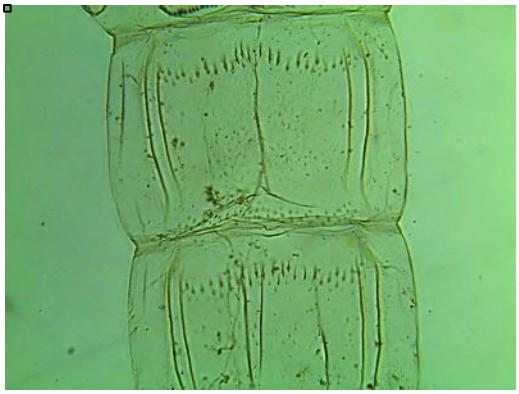

Figure 268. Tergites III-IV of *Polypedilum* sp. 1

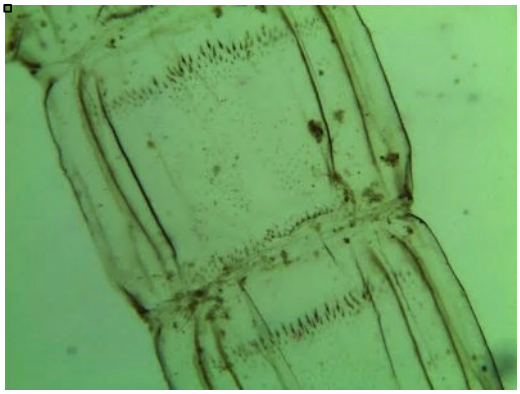

Figure 269. Tergites III-IV of *Polypedilum* sp. 10

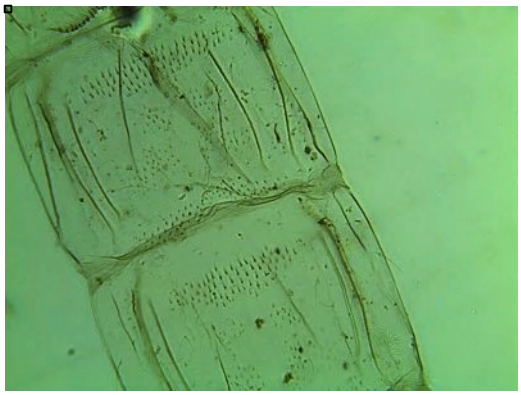

Figure 270. Tergites III-IV of *Polypedilum* sp. 9

12(11). Anal claw yellow, 3-point (Fig. 249); nose present …..…… ***Polypedilum* sp. 1**

12’.; Anal claw brown with one major spur and minor apical accessory spines (Fig. 250); nose absent ……..……..……...…… ***Polypedilum* sp. 10**

NOTES ON *POLYPEDILUM* SPECIES

Polypedilum sp. 1

Locality: Laguna del Tortuguero 1, 2, 3 & Quebrada

Head: Cephalic tubercles absent; long frontal setae

Thorax: Thoracic horn with less than 20 branches (Fig. 142); wing sheaths with nose

Abdomen: Abdomen most like Fig. 10.61 E (Wiederholm 1986); tergite II-VI with dark anterior band of spines (single row of spines), tergite II-V with median light shagreen; tergite II with continuous, ¾ width hook row (Figs. 108, 261, 268); pedes spurii A and B present; conjunctives between tergites III-VI with band of shagreen; tergites VII and VIII with anterolateral patches of shagreen; segment VIII with 3-4 point golden anal claw (Fig. 249); complete anal fringe with 20 setae; tergites V-VI with 3 LS setae; tergites VII-VIII with 4 LS setae

Comments: Closest to *Polypedilum* sp. 9 and sp. 10; around 4 mm long exuviae; keys to *P. (Polypedilum) illinoense*, but lighter median shagreen pattern on tergites II-IV than Fig. 90 (Maschwitz and Cook 2000); anal spur close to *Polypedilum (Tripodura) epomis* (see Figs. 170-172, Sublette & Sasa 1994)

Polypedilum sp. 2

Locality: Laguna del Tortuguero 1 & 2

Head: Cephalic tubercles large, dark brown with 3 points; long frontal setae; frontal apotome granulose (Fig. 242)

Thorax: Wing sheaths with nose

Abdomen: Tergite I bare; tergites II-VI with anterior bands of shagreen; tergite II with median shagreen and continuous, ¾ width hook row; pedes spurii A and B present; conjunctives between tergites IV and V with band of shagreen; tergites V-VI with posterior patches of shagreen; tergite VII-VIII with anterolateral patches of shagreen; segment VIII with larger, multi-pointed golden anal claw (similar to Fig. 35, Maschwitz and Cook 2000) (Fig. 245); complete anal fringe with 27 setae

Comments: Closest to *Polypedilum* sp. 4; around 4 mm long exuviae; keys to *Polypedilum (Tripodura) digitifer*, but there is variation in the median shagreen on tergites II-V, none is visible in this specimen (see Fig. 38, Maschwitz and Cook 2000)

***Polypedilum* sp. 3**

Locality: Laguna del Tortuguero 2

Head: Cephalic tubercles small; long frontal setae

Thorax: Wing sheaths with nose

Abdomen: Light, sparse median shagreen on tergites II-VI (Figs. 155, 259); conjunctives between tergites III and IV with band of shagreen; tergite VIII with small, dark anal claw (Fig. 265); anal lobes with complete anal lobe fringe with around 30 setae (Fig. 264)

Comments: Closest to *Polypedilum* sp. 11; keys to *Polypedilum (Uresipedilum) aviceps* (see Fig. 51, Maschwitz and Cook 2000)

***Polypedilum* sp. 4**

Locality: Laguna del Tortuguero 1 & 2

Head: Frontal apotome smooth (Figs. 129, 243); cephalic tubercles large, dark brown; frontal setae present

Thorax: Wing sheaths with nose

Abdomen: Tergites III-VI with no median shagreen; conjunctive between tergites III and IV without band of shagreen; conjunctive between tergites IV and V with band of shagreen; golden, 3-4 point anal claw (Fig. 246); complete anal lobe fringe with around 30 setae

Comments: Closest to *Polypedilum* sp. 2; keys to *Polypedilum (Uresipedilum) aviceps*, but appears to have more median shagreen on tergite II (see Fig. 51, Maschwitz and Cook 2000)

***Polypedilum* sp. 5**

Locality: Laguna del Tortuguero 1, 2, 3 & Quebrada

Head: Cephalic tubercles absent; frontal setae present (Figs. 153, 244)

Thorax: Wing sheaths without nose

Abdomen: Tergite II with dark anterior band of shagreen, light median shagreen, and ¾ width, continuous hook row (Figs. 157, 251); tergites II-VI with median shagreen with fenestrations; conjunctives between tergites III and IV with band of shagreen; space between posterior patches of shagreen on tergite IV and V; tergite VII with light anterolateral patches of shagreen (Fig. 257); segment VIII with darker brown spine with smaller spines along armature and one strong spine toward tip (Fig. 247); complete anal lobe fringe with around 30 setae

Comments: Closest to *Polypedilum* sp. 8 and sp. 12; keys to *Polypedilum (Polypedilum) nubeculosum*, but specimen differs in the shape and point of the anal spur (see Figs. 103-104, Maschwitz and Cook 2000)

***Polypedilum* sp. 6**

Locality: Laguna del Tortuguero 2 & 3

Head: Cephalic tubercles absent; frontal setae present

Thorax: Wing sheaths without nose

Abdomen: Tergites II-VI with light anterior band of shagreen; sparse median shagreen on tergites II-VI (Fig. 254); conjunctive between tergites III and IV with band of shagreen; dark anal claw with many spines; complete anal lobe fringe with around 16 setae

Comments: Closest to *Polypedilum* sp. 7 and sp. 13; less than 4 mm long; keys to *Polypedilum (Pentapedilum) tritum*, but varies in tergite II-VI and number of LS setae on anal lobes (tergites II–VI without strong, prominent anterior row of spines like Oyewo & Saether 2008 or Fig. 36, Maschwitz and Cook 2000)

***Polypedilum* sp. 7**

Locality: Laguna del Tortuguero 2 & Quebrada

Head: Cephalic tubercles small and bulbous; long frontal setae present

Thorax: Wing sheaths without nose

Abdomen: Tergite I bare; tergite II-VI with light anterior band of shagreen and light median shagreen; tergite II with ½ width, continuous hook row (Fig. 255); pedes spurii A and B present; conjunctive between tergites III and IV with band of shagreen; tergite VII with anterior and posterior shagreen; dark anal comb; complete anal lobe fringe with around 16 setae

Comments: Closest to *Polypedilum* sp. 6 and sp. 13; around 3 mm long exuviae; keys to *Polypedilum (Tripodura) scalaenum*, but differs in the anal spur (Fig. 39, Maschwitz and Cook 2000)

***Polypedilum* sp. 8**

Locality: Laguna del Tortuguero 1, 2 & 3

Head: Cephalic tubercles small and bulbous; long frontal setae present

Thorax: Wing sheaths without nose

Abdomen: Shagreen on tergites II-VIII; tergites II-VI with dark, dense anterior band of shagreen; tergite II with dark, dense median field of shagreen (Fig. 252); conjunctives between tergites III and IV with band of shagreen; tergites V-VI with 3 LS setae; tergites VII-VIII with 4 LS setae; segment VIII with darker brown anal claw (Fig. 248); complete anal lobe fringe with around 30 setae

Comments: Closest to *Polypedilum* sp. 5 and sp. 12; *Polypedilum* subgenus; close to *Polypedilum (Polypedilum) laetum*, but appears to be distinction in the anal spur (Fig. 98, Maschwitz and Cook 2000)

***Polypedilum* sp. 9**

Locality: Laguna del Tortuguero 1 & 2

Head: Cephalic tubercles absent; frontal setae present

Thorax: Wing sheaths with nose

Abdomen: Tergites II-VI with anterior row of spines (multiple rows of spines) (Fig. 270); tergite II with anterior band of dark, long spines; ¾ width, continuous hook (Fig. 262); segment VIII with golden anal claw; complete anal lobe fringe with around 25 setae

Comments: Closest to *Polypedilum* sp. 1 and sp. 10; *Polypedilum* subgenus

***Polypedilum* sp. 10**

Locality: Laguna del Tortuguero 2

Head: Cephalic tubercles absent; frontal setae present

Thorax: Wing sheaths without nose

Abdomen: Tergite II with anterior band of dark, long spines; hook row continuous ¾ width (Fig. 263); tergites III-IV with single anterior row of long spines (Fig. 269); band of light anterior shagreen on tergite VIII; anal claw made up of singular dark spine and apical and lateral accessory spines (Fig. 250)

Comments: Closest to *Polypedilum* sp. 1 and sp. 9; around 4mm long exuviae; keys to *Polypedilum (Pentapedilum)* tritum, but varies in tergite VIII shagreen (Oyewo & Saether 2008) and *Polypedilum (Polypedilum) prolixipartum*, but varies in shagreen pattern (Fig. 137, Maschwitz and Cook 2000)

***Polypedilum* sp. 11**

Locality: Quebrada

Head: Cephalic tubercles absent; frontal setae present

Thorax: Wing sheaths without nose

Abdomen: Tergites II-III with dark, dense median shagreen; tergite II with anterior band of shagreen light and made up of short spines and ½ width, continuous hook row (Fig. 260); dark brown anal claw and anal lobes (like Fig. 40 I Oyewo & Saether 2008) (Figs. 121, 266-267)

Comments: Closest to *Polypedilum* sp. 3; close to *Polypedilum (Pentapedilum) uncinatum* (see Fig. 40 Oyewo & Saether 2008), but varies in the shagreen pattern on tergites II-VI (see Fig. 40 B)

***Polypedilum* sp. 12**

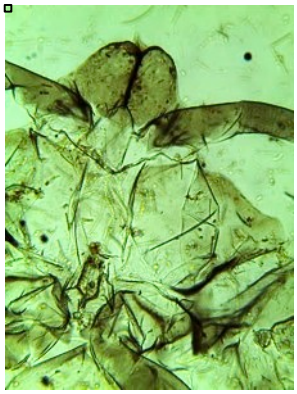

Figure 271. Frontal apotome of *Polypedilum* sp. 12

Locality: Quebrada

Head: Cephalic tubercles absent; frontal setae present; frontal apotome rounded, cone-like (most closely resembles *Polypedilum* subgenus *Cerobregma,* Sæther & Sundal 1999) (Fig. 271)

Thorax: Wing sheaths without nose

Abdomen: Tergites II-VIII with very dark anterior bands of shagreen; tergites II-VI with median shagreen; tergite II with continuous 3/4 width hook row; pedes spurii A & B present (Fig. 253); conjunctives between tergites III/IV and IV/V with band of shagreen; tergite VII with dark anterior band of shagreen; smaller spines on dark anal claw (somewhat close to Polypedilum sp. 5); tergites V-VIII with 3, 3, 4, 4 LS setae pattern; complete anal lobe fringe with 21 setae (Fig. 258)

Comments: Closest to *Polypedilum* sp. 5 and sp. 8

***Polypedilum* sp. 13**

Locality: Laguna del Tortuguero 2

Head: Cephalic tubercles absent; frontal setae present

Thorax: Wing sheaths without nose

Abdomen: Tergites II-VI with light anterior band of shagreen and dark median shagreen with large fenestrations (Fig. 256); dark pleural lines; conjunctive between tergites III and IV with band of shagreen; tergites II-VI with extensive shagreen and large fenestrations; complete anal lobe fringe with 30 setae

Comments: Closest to *Polypedilum* sp. 6 and sp. 7; around 6 mm long exuviae; keys to *Polypedilum* (*Polypedilum*) tuberculum, but doesn't match shagreen pattern on tergites II-VI (Maschwitz and Cook 2000)

ADDITIONAL REFERENCES

Maschwitz, D.E. and E.F. Cook, 2000. Revision of the Nearctic species of the genus *Polypedilum* Kieffer (Diptera: Chironomidae) in the subgenera *P.* (Polypedilum) Kieffer and *P.* (Uresipedilum) Oyewo and Sæther. Ohio Biological Survey, Ohio State University.

Oyewo, E.A. and O.A. Sæther. 2008. Revision of *Polypedilum* (Pentapedilum) Kieffer and Ainuyusurika Sasa et Shirasaki (Diptera: Chironomidae). Zootaxa: 1953, 1–145.

Sæther, O.A. and A. Sundal. 1999. *Cerobregma*, a new subgenus of *Polypedilum* Kieffer, with a tentative phylogeny of subgenera and species groups within *Polypedilum* (Diptera: Chironomidae). Journal of the Kansas Entomological Society 71: 315-382.

Saether, O, A., Andersen, T., Pinho, L.C., Mendes, H.F. 2010: The problems with *Polypedilum* Kieffer (Diptera: Chironomidae), with the description of *Probolum* subgen. n.. Zootaxa, 2497: 1–36.

Soponis, A.R. and K.W. Simpson. 1992. *Polypedilum digitifer* Townes and *Polypedilum griseopunctatum* (Malloch) (Diptera, Chironomidae): Redescription of adult males with a description and separation of the immature stages. Netherlands Journal of Aquatic Ecology 26: 203–213.

Sublette, J.E. and M. Sasa. 1994. Chironomidae collected in Onchocerciasis endemic areas of Guatemala (Insecta, Diptera). Spixiana Supplement 20: 1-60.

Vårdal, H., Bjørlo, A. and O.A. Sæther. 2002. Afrotropical *Polypedilum* subgenus Tripodura, with a review of the subgenus (Diptera: Chironomidae). Zoologica Scripta 31: 331-402.

NOTES ON *SAETHERIA* SPECIES

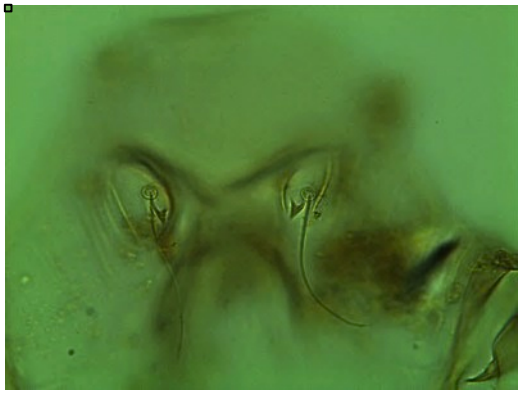

Figure 272. Cephalic tubercles of *Saetheria* nr. *tylus*

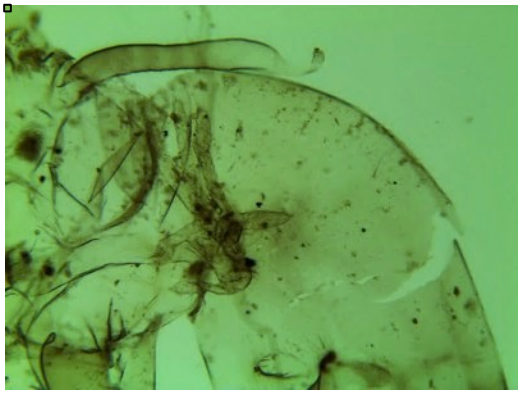

Figure 273. Thoracic horn of *Saetheria* nr. *tylus*

Saetheria near *tylus* Townes, 1945

Locality: Laguna del Tortuguero 2

Head: Cephalic tubercles small and apically pointed; long frontal setae present (Fig. 272)

Thorax: Thoracic horn made up of thick, branches (differs from generic description, Wiederholm 1986) (Fig. 273)

Abdomen: Tergite II with continuous hook row on projecting flap; tergite III with posterior rows of triangular spines, with a yellow base with dark brown tips (Fig. 124); caudolateral margin of segment VIII without spines (Fig. 122); tergites V-VIII with 4 LS setae

Comments: Represented by 1 specimen; closest to Unknown Chironomini #3; around 3.5 mm long exuviae

ADDITIONAL REFERENCE

Jackson, G.A. 1977. Nearctic and Palaearctic *Paracladopelma* Harnisch and *Sætheria* n. gen. (Diptera: Chironomidae). Journal of the Fisheries Research Board of Canada. 34: 1321-1359.

KEY TO *STENOCHIRONOMUS* SPECIES

1. Tergite II with posterior hook row restricted to medial portion of tergite (Fig. 274-275); tergites VII-VIII with at least some shagreen (Figs. 277-278); subgenus *Petalopholeus* ……...….. 2

1'. Tergite II with posterior hook row extending to lateral margins of tergite (Fig. 276); tergites VII-VIII without shagreen (Fig. 279-280); subgenus *Stenochironomus* ……...….. 3

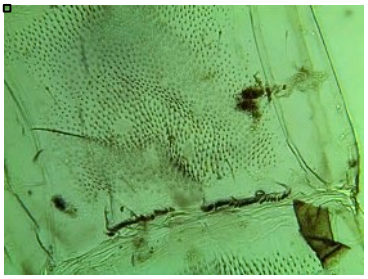

Figure 274. Tergite II of *Stenochironomus* sp. 5

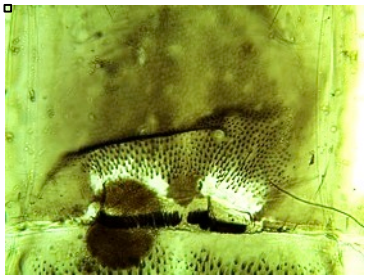

Figure 275. Tergite II of *Stenochironomus quadrinotatus*

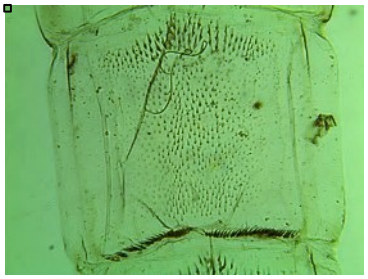

Figure 276. Tergite II of *Stenochironomus* sp. 1

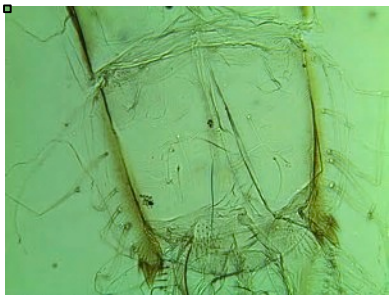

Figure 277. Tergite VIII of *Stenochironomus* sp. 5

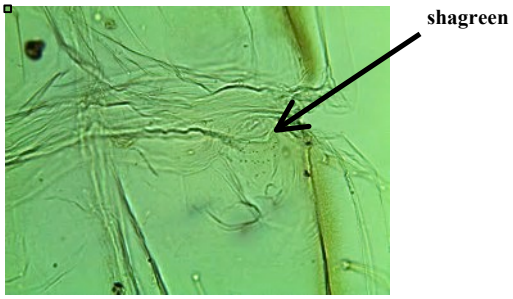

Figure 278. Tergite VIII of *Stenochironomus* sp. 5

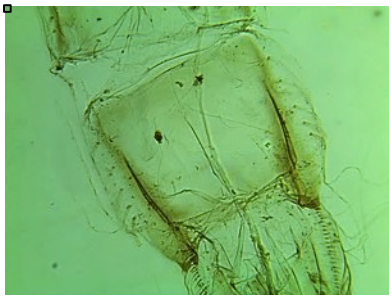

Figure 279. Tergite VIII of *Stenochironomus* sp. 1

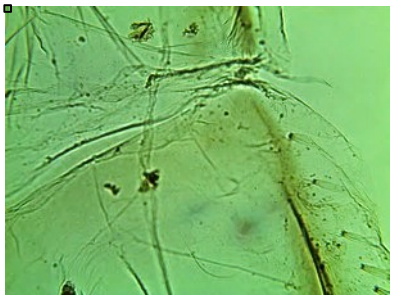

Figure 280. Tergite VIII of *Stenochironomus* sp. 1

2(1). Tergite II hooklets on hook row very long (Fig. 275); yellow, 3-point anal claw, all points equal in length (Fig. 281) ……. ***Stenochironomus (Petalopholeus) quadrinotatus***

2'. Tergite II hooklets on hook row short (Fig. 274); yellow, 5-point anal claw, middle point longer in length than posterior points (Fig. 282) ……..…… ***Stenochironomus* sp. 5**

Figure 281. Anal claw of *Stenochironomus quadrinotatus*

Figure 282. Anal claw of *Stenochironomus* sp. 5

3(1'). Male genital sheaths ending before anal lobes (Fig. 283); tergite V with continuous, dense shagreen (Fig. 285); anal claw very large and bulbous with at least 8 points (Fig. 289) ……..……..…….... ***Stenochironomus* sp. 2**

3'. Male genital sheaths extending beyond anal lobes (Fig. 284); tergite V with discontinuous, sparse spines or shagreen (Figs. 286-289); anal claw large with 2-4 points (Figs. 290-292) ……...…… 4

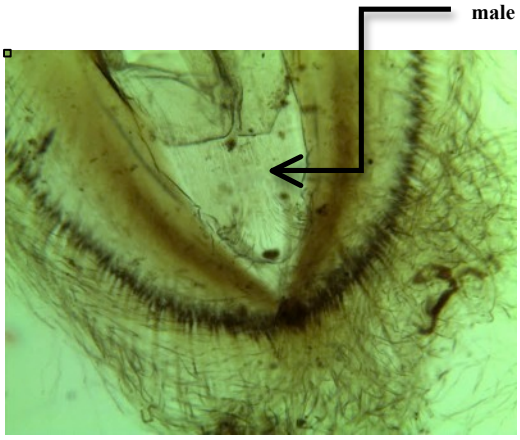

Figure 283. Anal lobes of *Stenochironomus* sp. 2

Figure 284. Anal lobes of *Stenochironomus* sp. 4

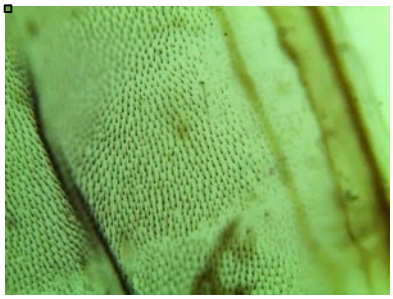

Figure 285. Tergite V of *Stenochironomus* sp. 2

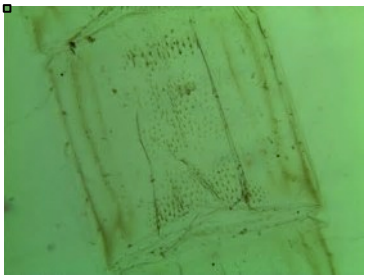

Figure 286. Tergite V of *Stenochironomus* sp. 1

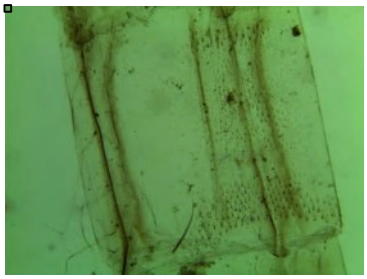

Figure 287. Tergite V of *Stenochironomus* sp. 3

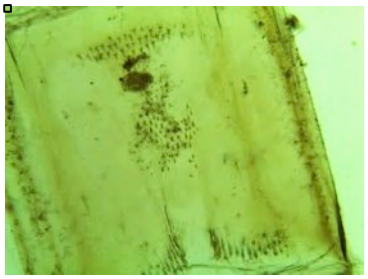

Figure 288. Tergite V of *Stenochironomus* sp. 4

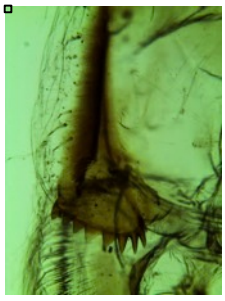

Figure 289. Anal claw of *Stenochironomus* sp. 2

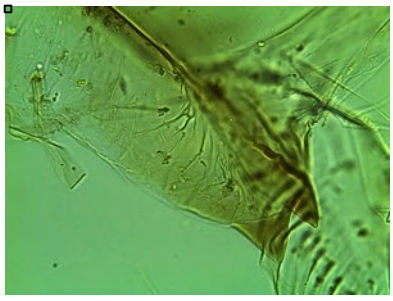

Figure 290. Anal claw of *Stenochironomus* sp. 1

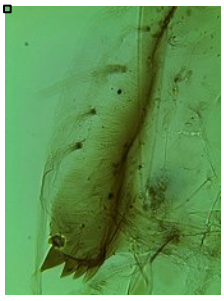

Figure 291. Anal claw of *Stenochironomus* sp. 3

Figure 292. Anal claw of *Stenochironomus* sp. 4

4(3'). Tergite II with dark band of thick, long anterior spines (Fig. 293); tergite V with median patch of spines (Fig. 288); around 10 mm long exuviae
..... **_Stenochironomus_ sp. 4**

4'. Tergite II with dark band of thin, short anterior spines (Figs. 276, 294); tergite V with median patch of shagreen (Figs. 286-287); around 5 mm long exuviae …… 5

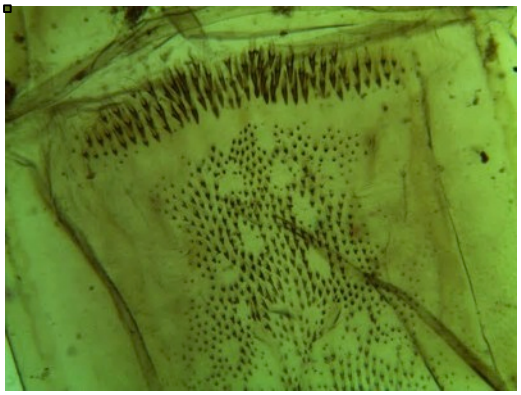

Figure 293. Tergite II of *Stenochironomus* sp. 4

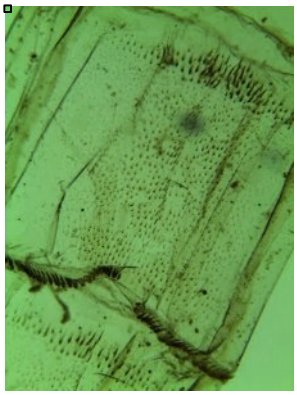

Figure 294. Tergite II of *Stenochironomus* sp. 3

5(4'). Segment VIII with yellow, thick, 2-point anal claw (Fig. 290)
…… ***Stenochironomus* sp. 1**

5'. Segment VIII with yellow, thick, 3-4 point anal claw (Fig. 291)
…… ***Stenochironomus* sp. 3**

NOTES ON *STENOCHIRONOMUS* SPECIES

Stenochironomus (*Petalopholeus*) *quadrinotatus* Borkent, 1984

Locality: Laguna del Tortuguero 2

Abdomen: Tergite I bare; tergite II with posterior hook row restricted to medial portion of tergite; tergite II hooklets on hook row very long (Fig. 275); tergite VI with thick band of posterior shagreen; anterior and median shagreen very light; no shagreen on tergite VII; light anterolateral shagreen on tergite VIII; anal lobe with two patches of shagreen; yellow, 3-point anal claw, all points equal in length, somewhat like *Stenochironomus* sp. 3 (Fig. 281)

Comments: Closest to *Stenochironomus* sp. 5; around 6 mm long exuviae; Borket 1984 documented species in Costa Rica

Stenochironomus sp. 1

Locality: Laguna del Tortuguero 1 & 2

Thorax: Thoracic horn with several fine branches and one simple, spinose branch (Figs. 18, 132)

Abdomen: Tergite I bare; tergites II-V dense shagreen; posterior corners of segments II-IV not brown; tergite II with dark band of thin, short anterior spines; tergite II with posterior hook row extending to lateral margins of tergite, medial interruption of hook row (Fig. 276); tergite V with median patch of shagreen (Fig. 286); tergite VI with darker, posterior patch of shagreen, lack anterior shagreen row; tergites VII-VIII without shagreen (Figs. 134, 279-280); segment VIII with yellow, thick, 2-point anal claw (Fig. 290)

Comments: Closest to *Stenochironomus* sp. 3; part of *Stenochironomus* subgenus; around 5 mm long exuviae

Stenochironomus sp. 2

Locality: Laguna del Tortuguero 2

Abdomen: Tergite I with median, light shagreen; tergites II-V with dense, uniform shagreen; tergite II with posterior hook row extending to lateral margins of tergite; tergite V with continuous, dense shagreen (Fig. 285); tergite VI with anterior and posterior patches of shagreen, tergites VII-VIII without shagreen; two anterior patches of shagreen on anal lobe; male genital sheaths ending before anal lobes (Fig. 283); anal claw very large and bulbous with at least 8 points (Fig. 289)

Comments: Represented by 1 specimen; around 10 mm long exuviae; part of *Stenochironomus* subgenus; somewhat close to *Stenochironomus* near species "Peru", but varies from description of anal claw (Borkent 1984)

Stenochironomus sp. 3

Locality: Laguna del Tortuguero 1, 2 & 3

Abdomen: Tergite II with posterior hook row extending to lateral margins of tergite and dark band of thin, short anterior spines (Fig. 294); tergite V with median patch of shagreen (Fig. 287); tergites VII-VIII without shagreen; segment VIII with yellow, thick, 3-4 point anal claw (Fig. 291); male genital sheaths extending beyond anal lobes

Comments: Closest to Stenochironomus sp. 1; around 5 mm long exuviae; part of *Stenochironomus* subgenus

Stenochironomus sp. 4

Locality: Laguna del Tortuguero 2 & 3

Abdomen: Tergite II with dark band of thick, long anterior spines and posterior hook row extending to lateral margins of tergite (Fig. 293); tergite V with median patch of spines (Fig. 288); tergites VII-VIII without shagreen; yellow, 3-4 point anal claw (Fig. 292); male genital sheaths extending beyond anal lobes (Fig. 284)

Comments: Closest to *Stenochironomus* sp. 1 and sp. 3; around 11 mm long exuviae; part of *Stenochironomus* subgenus

Stenochironomus sp. 5

Locality: Laguna del Tortuguero 1 & 2

Head: Cephalic tubercles absent (Fig. 127)

Abdomen: Tergite II with posterior hook row restricted to medial portion of tergite; hook row ½ width with medial interruption and short hooklets (Fig. 274); tergite II-V with continuous shagreen; tergite VI with median shagreen; tergite VII bare, tergite VIII anterolateral patches of shagreen (Figs. 277-278); yellow, 5-point anal claw, middle point longer in length than posterior points (Fig. 282); anal lobe with anterolateral patches of shagreen

Comments: Closest to *Stenochironomus (Petalopholeus) quadrinotatus*; around 6 mm long exuviae; close to *S. totifuscus*, but doesn't match tergite VIII (Borkent 1984)

ADDITIONAL REFERENCE

Borkent, A. 1984. The systematics and phylogeny of the *Stenochironomus* complex (*Xestochironomus*, *Harrisius*, and *Stenochironomus*) (Diptera: Chironomidae). Memoirs of the Entomological Society of Canada. No. 128.

KEY TO *XESTOCHIRONOMUS* SPECIES

1. Anal claw yellow, small and with several small, thin points (Fig. 295)

…… ***Xestochironomus subletti***

1'. Anal claw light brown, moderate and with 4-6 points (Fig. 296)

…… ***Xestochironomus* sp. 1**

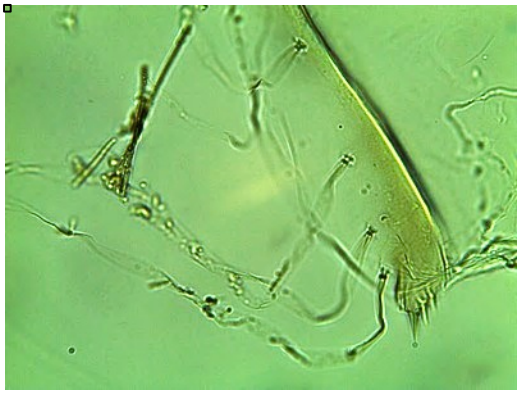

Figure 295. Anal claw of *Xestochironomus subletti*

Figure 296. Anal claw of *Xestochironomus* sp. 1

NOTES ON *XESTOCHIRONOMUS* SPECIES

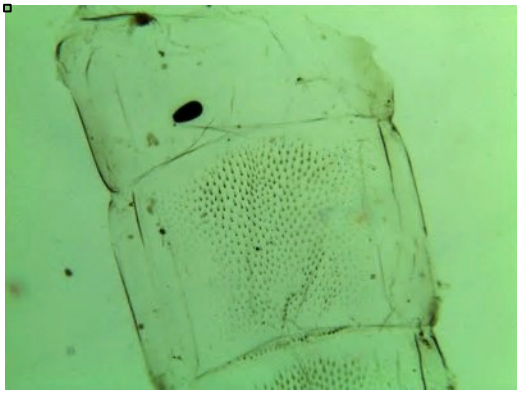

Figure 297. Tergite II of *Xestochironomus subletti*

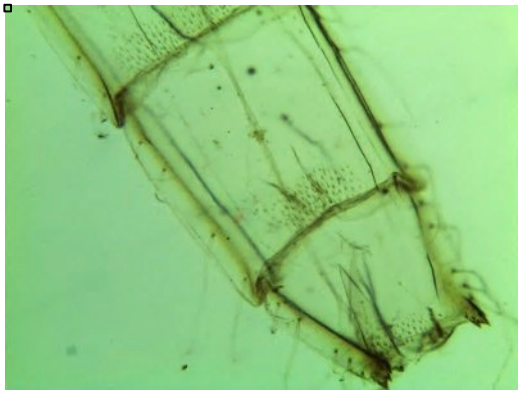

Figure 298. Tergites VII-VIII of *Xestochironomus* sp. 1

Xestochironomus subletti Borkent, 1984

Locality: Laguna del Tortuguero 1 & 3

Abdomen: Tergite II with continuous hook row (1/2 width) (Fig. 297); tergites VII & VIII with posterior shagreen patches; anal lobes with two patches of shagreen; one major spur with 5-6 minor spines on anal claw (Fig. 295); tergite V with 3 LS setae; tergites VII-VIII with posterior shagreen (Fig. 135); tergite VI-VII with 4 LS setae; tergite VIII with 5 LS setae

Comments: Represented by 2 specimens

***Xestochironomus* sp. 1**

Locality: Laguna del Tortuguero 3

Abdomen: Tergite I no shagreen; tergites II-V with continuous, uniform shagreen; tergite II with continuous hook row (1/2 width); pedes spurii A and B absent; tergite VI with hourglass-shaped shagreen; tergites VII & VIII with thick posterior patches of shagreen (Fig. 298); anal comb with one spur and many minor spines (Fig. 296); tergites V-VII with 4 LS setae; tergite VIII with 5 LS setae

Comments: Represented by 1 specimen; apex of abdomen missing in voucher specimen

ADDITIONAL REFERENCE

Borkent, A. 1984. The systematics and phylogeny of the *Stenochironomus* complex (*Xestochironomus*, *Harrisius*, and *Stenochironomus*) (Diptera: Chironomidae). Memoirs of the Entomological Society of Canada. No. 128.

KEY TO *ZAVRELIELLA* SPECIES

1. Anal claw small, brown with many small spines (Fig. 299); dark brown pigmentation of median and pleural areas of segments II-VI (Fig. 301); anal lobes dark brown pigmentation (Fig. 303) …… ***Zavreliella* nr. *marmorata***

1'. Anal claw small, yellow with 2 main spurs and many small spines (Fig. 300); light brown pigmentation of median areas of segments II-VI (Fig. 302); anal lobes light brown pigmentation (Fig. 304) …… ***Zavreliella* sp. 1**

Figure 299. Anal claw of *Zavreliella* nr. *marmorata*

Figure 300. Anal claw of *Zavreliella* sp. 1

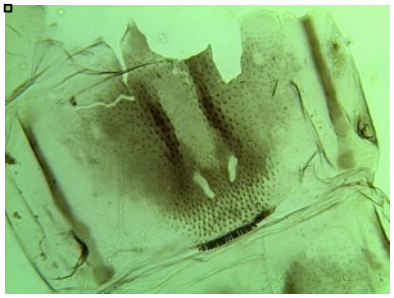

Figure 301. Tergite II of *Zavreliella* nr. *marmorata*

Figure 302. Tergite II of *Zavreliella* sp. 1

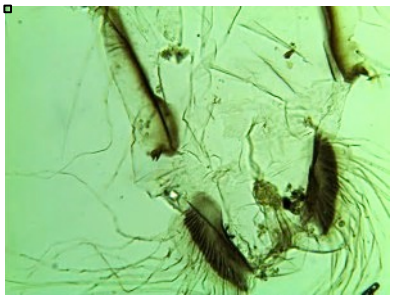

Figure 303. Anal lobes of *Zavreliella* nr. *marmorata*

Figure 304. Anal lobes of *Zavreliella* sp. 1

NOTES ON *ZAVRELIELLA* SPECIES

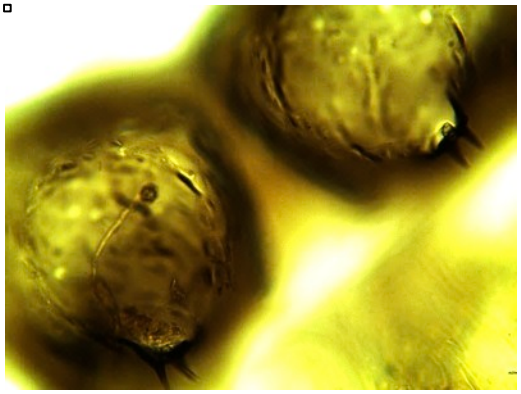

Figure 305. Cephalic tubercles of *Zavreliella* nr. *marmorata*

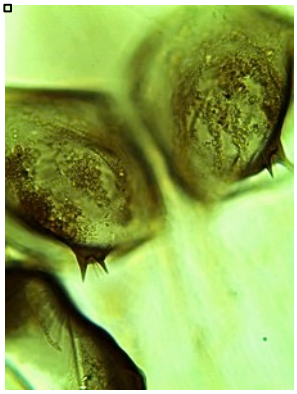

Figure 306. Cephalic tubercles of *Zavreliella* sp. 1

Zavreliella near *marmorata* van der Wulp, 1859

Locality: Laguna del Tortuguero 3

Head: Cephalic tubercles with bulbous base and bifurcated apical tips, frontal setae absent (Fig. 305)

Thorax: Thoracic horn with four thick branches (Fig. 140)

Abdomen: Shagreen and dark paired median patches of tergites II-IV (Fig. 139); dark brown pigmentation of median and pleural areas of segments II-VI (Fig. 301); tergites VII & VIII with posterior shagreen patches; two patches of shagreen on anal lobes; anal claw small, brown with many small spines (Fig. 299); tergite V with 3 LS setae; tergite VI-VII with 4 LS setae; tergite VIII with 5 LS setae; anal lobes dark brown pigmentation (Fig. 303)

Comments: Represented by one specimen

***Zavreliella* sp. 1**

Locality: Laguna del Tortuguero 2 & 3

Head: Cephalic tubercles with bulbous base and bifurcated apical tips, frontal setae present (Fig. 306)

Abdomen: Shagreen and dark paired median patches on tergites II-VI; light brown pigmentation of median areas of segments II-VI (Fig. 302); light anterolateral patches of shagreen on tergites VII-VIII; at least 6 D setae on tergite VII and 4 D setae on tergite VIII; ventral tubercle sheath between tergite VII and VIII; anal claw small, yellow with 2 main spurs and many small spines, like *Zavreliella junki* (Reiss 1990) (Fig. 300); anal lobes light brown pigmentation (Fig. 304)

Comments: Represented by two specimens

ADDITIONAL REFERENCE

Reiss, F. 1990. Revision der Gattung *Zavreliella* Kieffer, 1920 (Diptera, Chironomidae). Spixiana 13: 83-115.

NOTES ON UNKNOWN CHIRONOMINI GENERA

Unknown Chironomini #1

Locality: Laguna del Tortuguero 2

Head: Swollen frontal apotome similar to *Endochironomus*, but no conspicuous frontal setae (Fig. 133)

Thorax: Blunt nase similar to *Paralauterborniella* (Fig. 10.54 F, Wiederholm 1986); dark pigmentation of wing sheaths

Abdomen: Pedes spurii A & B present; tergite VIII with shagreen similar to *Endochironomus* (Fig. 10.21 A Wiederholm 1986), segment VIII with anal claw bending in towards segment with at least 14 points (Fig. 136); 4 LS on tergites V-VII; 5 LS on tergite VIII

Comments: Closest to Unknown Chironomini #2; around 5 mm long exuviae

Unknown Chironomini #2

Locality: Laguna del Tortuguero 1 & 2

Abdomen: Tergite II with continuous hook row; pedes spurii A & B present; lighter anterior band of shagreen on tergite VII; lighter anterolateral patches of shagreen on tergite VIII; segment VIII with anal claw bending in towards segment (Fig. 137)

Comments: Closest to Unknown Chironomini #1

Unknown Chironomini #3

Locality: Laguna del Tortuguero 1

Thorax: Pale brown coloration; small protuberance on wing sheath; 4 dorsocentrals (thorax matches *Saetheria*)

Abdomen: Tergite II with interrupted hook row; two dark rows of spines on tergites II-IV (tergite IV smaller, about ½ size, and lighter color) (Fig. 125); tergite V with two light colored rows of spines (~1/3 size of tergites II & III); pedes spurii A & B absent; shagreen present on tergites I-VII; no anal comb; 4 LS setae on tergites V-VIII; shagreen and spine pattern on tergites I-VIII doesn't match *Saetheria* (Fig. 123)

Comments: Closest to *Saetheria*

Unknown Chironomini #4

Locality: Laguna del Tortuguero 2

Head: Cephalic tubercles large and pointed; frontal setae present

Thorax: Thoracic horn plumose (Fig. 141); circular basal ring; granulose thorax; 4 dorsocentral setae (D1 and D2 separated with distance)

Abdomen: Very dark abdomen; tergite I with light shagreen and scales; tergites II-V with dense, dark shagreen (somewhat hourglass-shaped); tergite II hook row continuous (3/4 width); pedes spurii A & B large and conspicuous; conjunctives between tergites III/IV and IV/V with double row of small spines; tergite VI with triangular-shaped shagreen (denser anteriorally) and scales; scales similar to abdomen of *Robackia* (Fig. 10.69, Wiederholm 1986); tergite VII with two anterior patches of shagreen and scales (Fig. 149); tergite VIII with two medial bands of shagreen and scales; large 1-point yellow anal spur; complete anal fringe, 4 LS setae on tergites V-VII; 3 LS setae on tergite VIII

Comments: Closest to *Goeldichironomus*

KEY TO *PSEUDOCHIRONOMUS* SPECIES

1. Segment VIII with 5 LS setae (Figs. 307-308) …….. 2

1'. Segment VIII with 6 LS setae (Fig. 309) ……..……. ***Pseudochironomus* sp. 2**

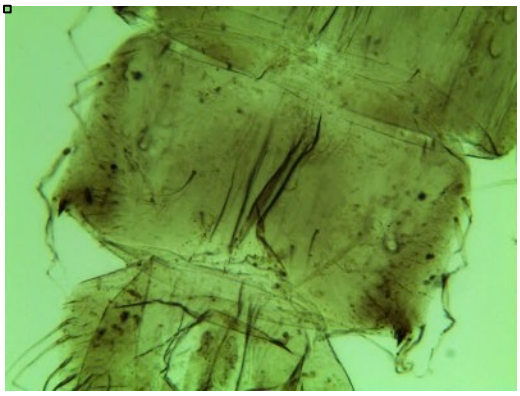

Figure 307. Segment VIII of *Pseudochironomus richardsoni*

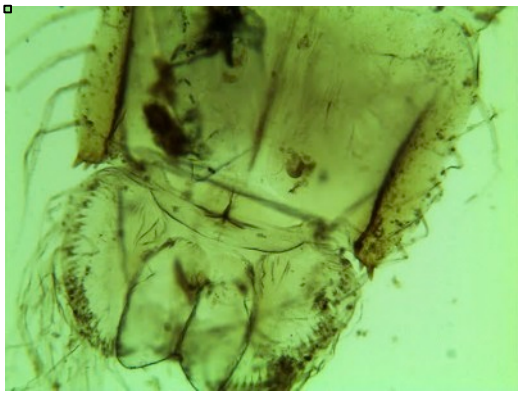

Figure 308. Segment VIII and anal lobes of *Pseudochironomus* sp. 1

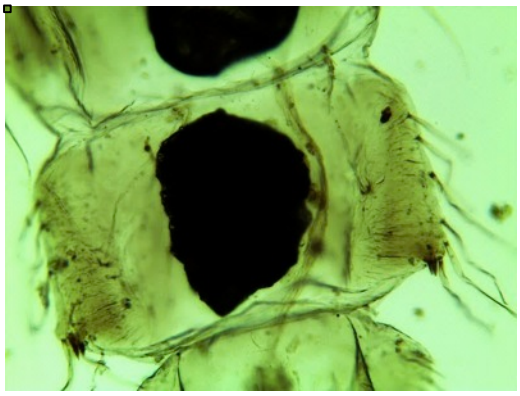

Figure 309. Segment VIII of *Pseudochironomus* sp. 2

Figure 310. Anal lobes of *Pseudochironomus richardsoni*

2(1). Anal lobe fringe with more than 20 setae on each side (Fig. 308)
……..… ***Pseudochironomus* sp. 1**

2'. Anal lobe fringe with less than 10 setae on each side (Fig. 310)
……..…….. ***Pseudochironomus richardsoni***

NOTES ON *PSEUDOCHIRONOMUS* SPECIES

Pseudochironomus richardsoni Malloch, 1915

Locality: Laguna del Tortuguero 1, 2 & 3

Abdomen: Overall abdomen like Fig. 10.67 C (Wiederholm 1986); sternite I with light median shagreen; tergite II with strong anterior band of shagreen and continuous hook row (1/2 width); tergites III-IV with strong anterior and posterior band of shagree; tergites V-VI with anterior drop shaped patch of shagreen and light posterior shagreen; tergite IV with dark anterior band of color; tergites VII-VIII with anterior median circle of shagreen; several small dark spines (like Fig. 10.66 F, Wiederholm 1986); tergite V with 3 LS setae; tergites VI-VII with 4 LS setae; tergite VIII with 5 LS setae (Fig. 307); anal lobe fringe with around 8 setae per lobe (Fig. 310)

Comments: Closest to *Pseudochironomus* sp. 1; most common *Pseudochironomus* species

Pseudochironomus sp. 1

Locality: Laguna del Tortuguero 1

Abdomen: Overall dark coloration of abdomen; no shagreen on tergite I; tergites II-VI with complete light shagreen and stronger anterior bands of shagreen; tergite II with continuous hook row (2/3 width); tergite VII with anterior band of shagreen; tergite VIII with two posterolateral patches of shagreen; yellow, 3-point anal claw; complete anal fringe with around 30 setae per lobe (much more setae than *Pseudochironomus* sp. 1); tergite V with 3 LS setae; tergites VI-VII with 4 LS setae; tergite VIII with 5 LS setae (Fig. 308)

Comments: Closest to *Pseudochironomus richardsoni;* represented by 1 specimen; close to *Pseudochironmus prasinatus* (Staeger, 1839), but doesn't match anal comb (Wiederholm 1986)

***Pseudochironomus* sp. 2**

Locality: Laguna del Tortuguero 2

Abdomen: Tergite V with 3 LS; tergites VI-VII 4 LS; tergite VIII with 6 LS setae; segment VIII with 2 major spines and several small spines (Fig. 309); anal lobe fringe with around 8 setae per lobe

Comments: Represented by 1 specimen; close to *Pseudochironomus richarsoni*, except segment VIII with 6 LS setae and anal claw differs (Wiederholm 1986)

ADDITIONAL REFERENCE

Sæther, O.A. 1977. Taxonomic studies on Chironomidae: *Nanocladius*, *Pseudochironomus*, and the *Harnischia* complex. Bulletin of the Fisheries Research Board of Canada. Bulletin 196.

KEY TO GENERA OF TANYTARSINI PUPAE

1. Thoracic horn with long chaetae (Fig. 311) ……. ***Cladotanytarsus***

1'. Thoracic horn bare (Fig. 312) or with small spines (Fig. 313) …..……. 2

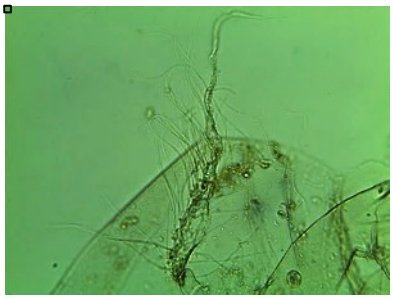

Figure 311. Thoracic horn of *Cladotanytarsus* sp. 1

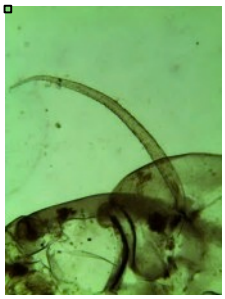

Figure 312. Thoracic horn of *Tanytarsus* sp. 1

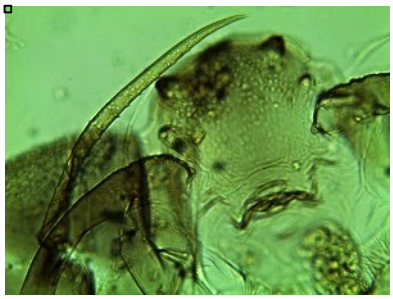

Figure 313. Thoracic horn of Unknown Tanytarsini #1

2(1'). Thoracic horn bare (Fig. 312) ……..…… 3

2'. Thoracic horn with small spines (Fig. 313) ……..…… 4

3(2). Segment VIII with anal spur (Fig. 314); tergites II-V with dark, paired point patches (Fig. 317) ……..…. ***Rheotanytarsus***

3'. Segment VIII with anal claw (Figs. 315-316); tergites II-V vary from bare, to paired point patches, to bands of spines (Figs. 318-319) ……..…… ***Tanytarsus***

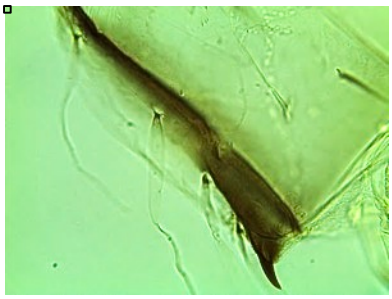

Figure 314. Segment VIII of *Rheotanytarsus* sp. 1

Figure 315. Segment VIII of *Tanytarsus* sp. 1

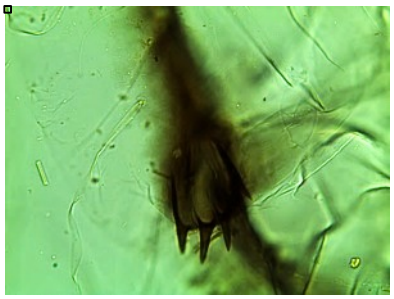

Figure 316. Segment VIII of *Tanytarsus* sp. 3

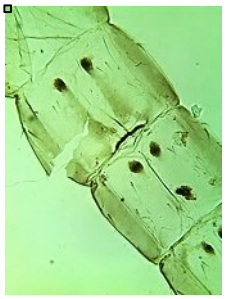

Figure 317. Tergites II-III of *Rheotanytarsus* sp. 1

Figure 318. Tergites II-III of *Tanytarsus* sp. 6

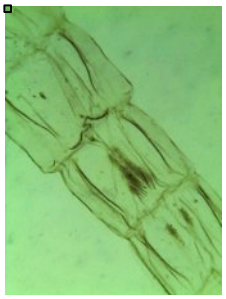

Figure 319. Tergites II-IV of *Tanytarsus* sp. 9

4(2'). Frontal setae robust, thorn-like (Fig. 320); tergites III-V with dark posterior patches of spines and with dark brown median pigmentation (Fig. 322)
……..... **Unknown Tanytarsini #1**

4'. Frontal setae long, slender (Fig. 321); tergites III-V with light posterior patches of spines and without dark brown median pigmentation (Fig. 323)
……..…….. **Unknown Tanytarsini #2**

Figure 320. Frontal apotome of Unknown Tanytarsini #1

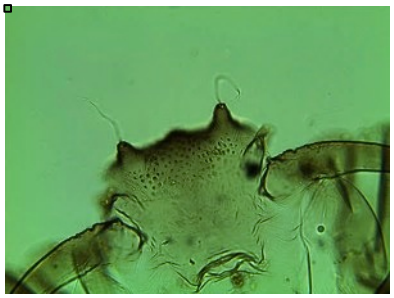

Figure 321. Frontal apotome of Unknown Tanytarsini #2

Figure 322. Tergites II-V of Unknown Tanytarsini #1

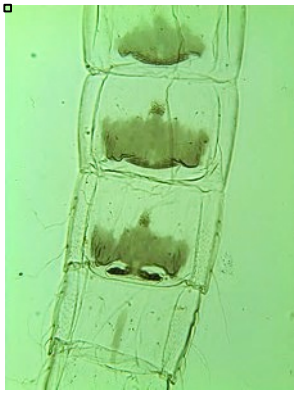

Figure 323. Tergites II-V of Unknown Tanytarsini #2

NOTES ON CLADOTANYTARSUS SPECIES

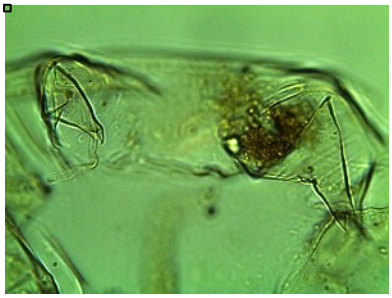

Figure 324. Cephalic tubercles of *Cladotanytarsus* sp. 1

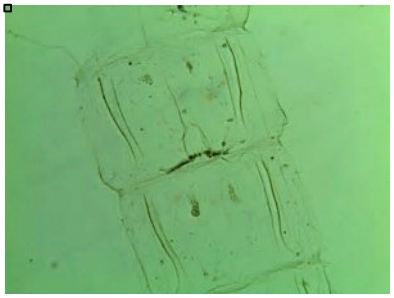

Figure 325. Tergites II-III of *Cladotanytarsus* sp. 1

Figure 326. Anal claw of *Cladotanytarsus* sp. 1

Cladotanytarsus sp. 1

Locality: Laguna del Tortuguero 2

Head: Cephalic tubercles long with frontal setae (Fig. 324)

Thorax: Thoracic horn with long chaetae (Fig. 311)

Abdomen: Tergites II-VI with paired anterior point patches; tergite VII bare; tergite VIII with anterolateral patches of shagreen (Fig. 325); multi-point anal claw (Fig. 326)

Comments: Very transparent exuviae

ADDITIONAL REFERENCES

Bilyj, B. and I.J. Davies. 1989. Descriptions and ecological notes on seven new species of *Cladotanytarsus* (Chironomidae: Diptera) collected from an experimentally acidified lake. Canadian Journal of Zoology 67: 948-962.

Wiedenbrug, S and R. Ospina-Torres. 2005. A key of pupal exuviae of Neotropical Tanytarsini (Diptera: Chironomidae). Amazoniana 18: 317-371.

NOTES ON *RHEOTANYTARSUS* SPECIES

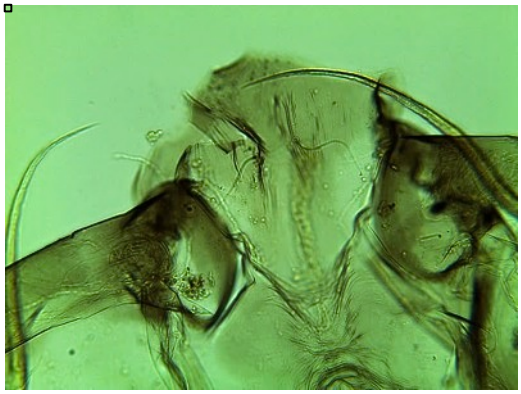

Figure 327. Frontal apotome of *Rheotanytarsus* sp. 1

Rheotanytarsus sp. 1

Locality: Laguna del Tortuguero 1, 2, 3 & Quebrada

Head: Cephalic tubercles short; long frontal setae (Fig. 327)

Thorax: Thoracic horn long, slender with short apical hairs; frontal apotome granulose; wing sheaths with prominent nose

Abdomen: Tergite I bare; tergite II-V with anterior dark pair of patches (Fig. 317); tergite II with small patches of posterior shagreen and hook row (1/3 width); tergite VI with very light anterior and posterolateral shagreen; tergite VIII with very light anterior patches of shagreen; dark curved single spur (Fig. 314); 3/4 complete anal fringe; tergite V with 3 LS setae; tergites VI-VII with 4 LS setae; tergite VIII with 4 LS setae

Comments: 3 mm long exuviae

ADDITIONAL REFERENCE

Wiedenbrug, S. and R. Ospina-Torres. 2005. A key of pupal exuviae of Neotropical Tanytarsini (Diptera: Chironomidae). Amazoniana 18: 317-371.

KEY TO *TANYTARSUS* SPECIES

1. Tergites III-VI with only anterior paired point patches (Figs. 328-329) ….....…. 2

1’. Tergites III-VI with some anterior paired point patches, bands of spines, or bare (Figs. 330-332) ……. 7

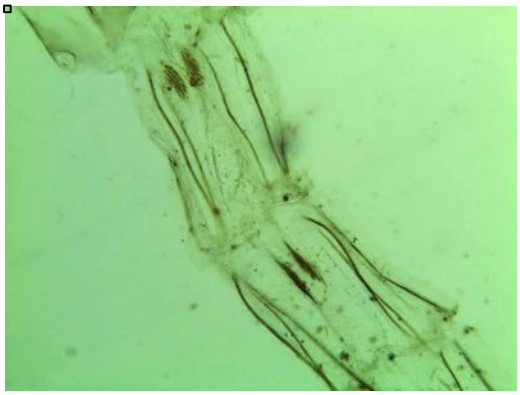

Figure 328. Tergites III-IV of *Tanytarsus* sp. 3

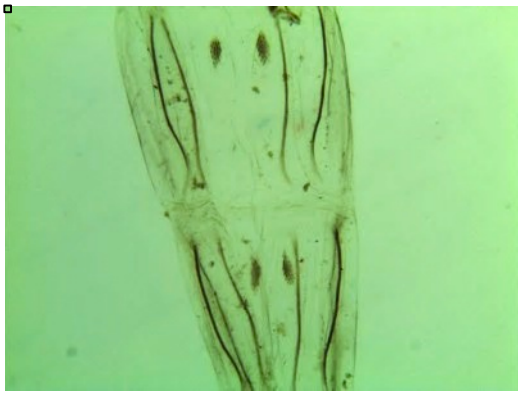

Figure 329. Tergites III-IV of *Tanytarsus* sp. 6

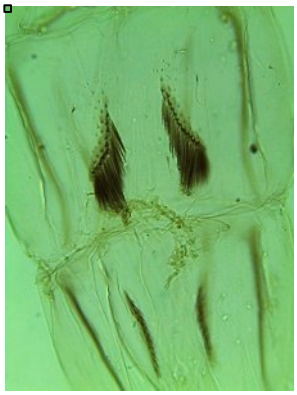

Figure 330. Tergites III-IV of *Tanytarsus* sp. 5

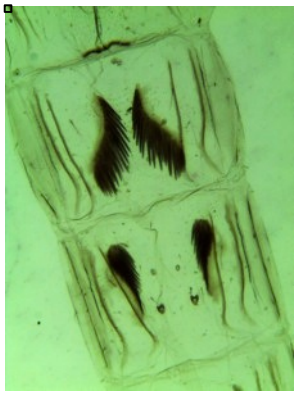

Figure 331. Tergites III-IV of *Tanytarsus* sp. 7

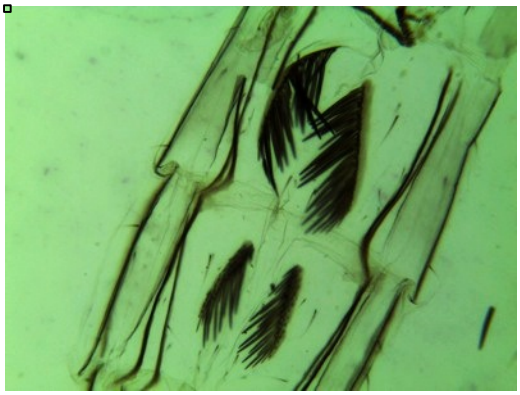

Figure 332. Tergites III-IV of *Tanytarsus* sp. 12

2(1). Tergite II with anterior paired point patch (Fig. 333-334) …… 3

2’. Tergite II without anterior paired point patch (Fig. 335-336) …….. 5

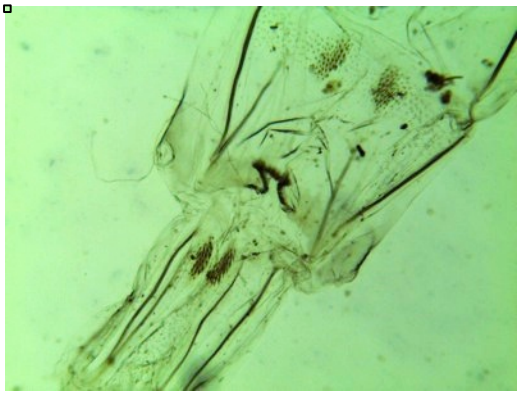

Figure 333. Tergites II-III of *Tanytarsus* sp. 3

Figure 334. Tergites II-III of *Tanytarsus* sp. 6

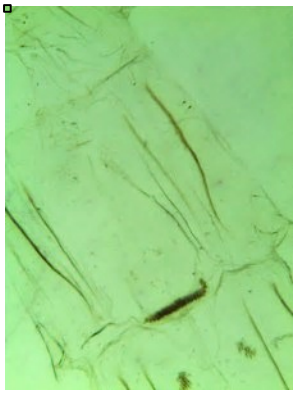

Figure 335. Tergite II of *Tanytarsus* sp. 8

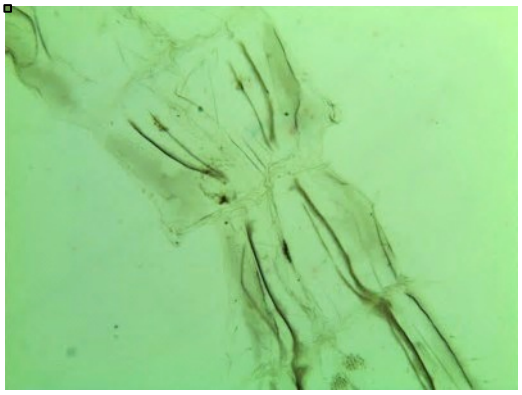

Figure 336. Tergites II-III of *Tanytarsus* sp. 13

3(2). Tergite II with anterior paired point patches without anterolateral or median shagreen (Fig. 337) ……..……. ***Tanytarsus* sp. 6**

3’. Tergite II with anterior paired point patches with anterolateral (Fig. 338) or median shagreen (Fig. 339) …… 4

Figure 337. Tergites II-III of *Tanytarsus* sp. 6

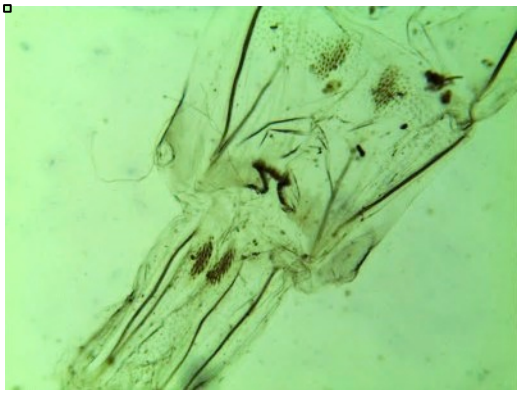

Figure 338. Tergites II-III of *Tanytarsus* sp. 3

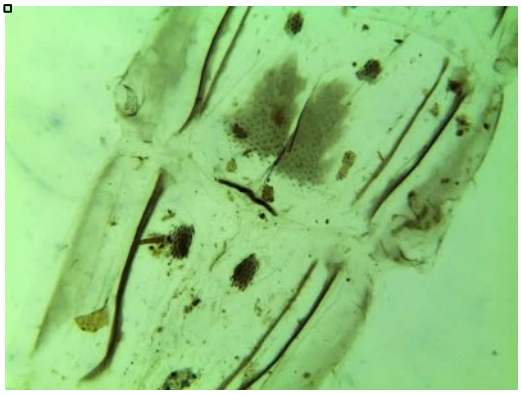

Figure 339. Tergites II-III of *Tanytarsus* sp. 10

4(3'). Tergite II with anterior paired point patches surrounded by anterolateral patches of shagreen (Fig. 338) ……... ***Tanytarsus* sp. 3**

4'. Tergite II with dark brown pigmentation and median shagreen below anterior paired point patches (Fig. 339) …….. ***Tanytarsus* sp. 10**

5(2'). Tergite II without a hook row (Figs. 336, 340) ……..…….. ***Tanytarsus* sp. 13**

5'. Tergite II with a hook row (Figs. 335, 341) ……..…… 6

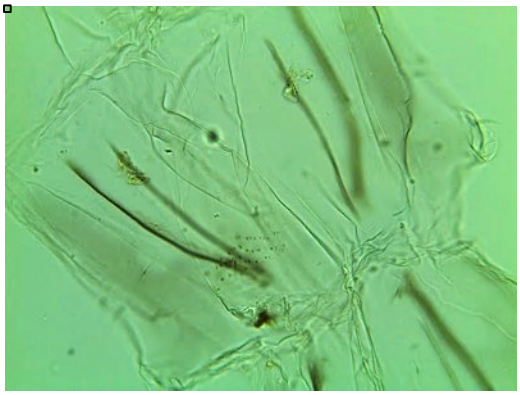

Figure 340. Tergite II of *Tanytarsus* sp. 13

Figure 341. Tergite II of *Tanytarsus* sp. 14

6(5'). Tergite II with light posterior patch of shagreen (Fig. 335); cephalic tubercles large and pointed (Fig. 342); anal claw large, yellow with multi-points (Fig. 344) …….. ***Tanytarsus* sp. 8**

6'. Tergite II with dark posterior patch of shagreen and dark brown pigmentation (Fig. 341); cephalic tubercles absent (Fig. 343); anal claw small, brown with few points (Fig. 345) ……..… ***Tanytarsus* sp. 14**

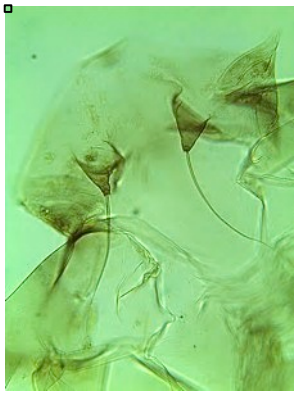

Figure 342. Frontal apotome of *Tanytarsus* sp. 8

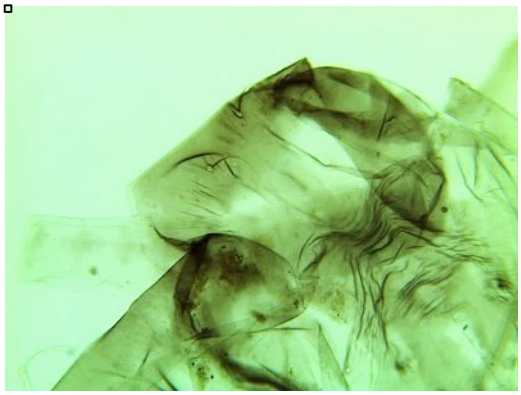

Figure 343. Frontal apotome of *Tanytarsus* sp. 14

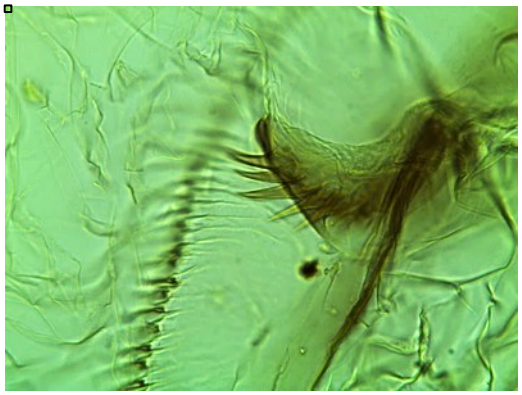

Figure 344. Anal claw of *Tanytarsus* sp. 8

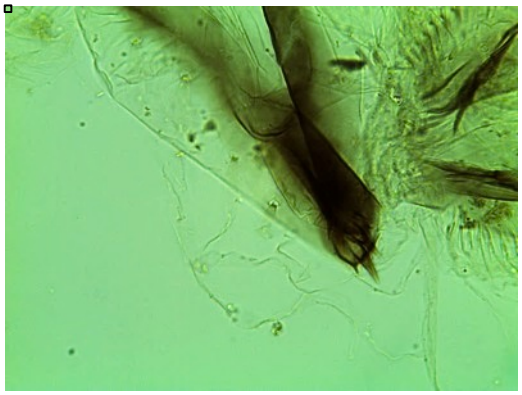

Figure 345. Anal claw of *Tanytarsus* sp. 14

7(1'). Tergite II with anterior paired point patches (Figs. 346-347) …….. 8

7'. Tergite II without anterior paired point patches (Figs. 348-349) ……..… 9

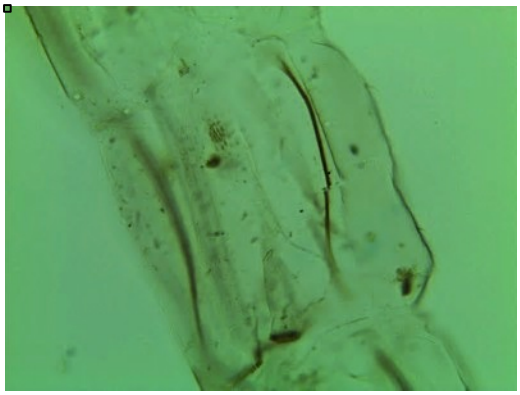

Figure 346. Tergite II of *Tanytarsus* sp. 4

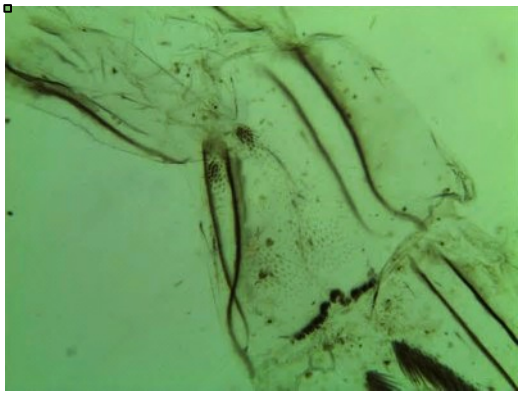

Figure 347. Tergite II of *Tanytarsus* sp. 11

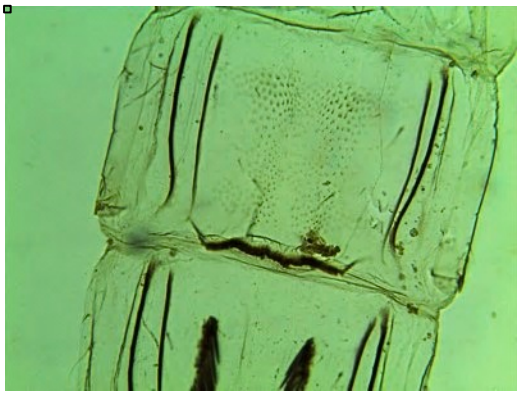

Figure 348. Tergite II of *Tanytarsus* sp. 1

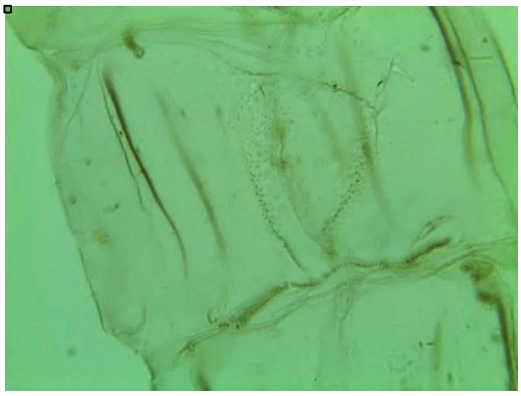

Figure 349. Tergite II of *Tanytarsus* sp. 5

8(7). Tergites II-III and VI with anterior paired point patches (Fig. 346); tergites IV-V with long bands of spines (Fig. 350) …… ***Tanytarsus* sp. 4**

8’. Tergite II with anterior paired point patches (Fig. 347); tergite III with long bands of spines; tergites IV-V with short bands of spines (Fig. 351) ……... ***Tanytarsus* sp. 11**

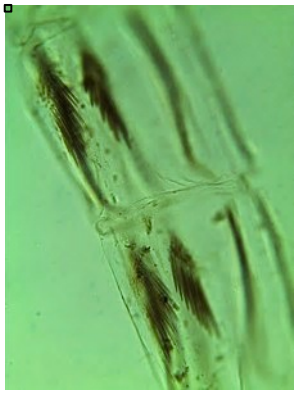

Figure 350. Tergites IV-V of *Tanytarsus* sp. 4

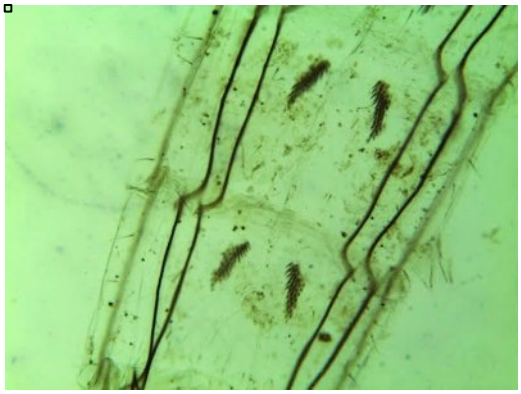

Figure 351. Tergites IV-V of *Tanytarsus* sp. 11

9(7’) Tergites III-IV with paired long bands of spines (Figs. 352-353) ……..…..… 10

9’. Tergites III with paired long bands (Fig. 356-357) or short bands of spines (Fig. 355); tergite IV with short bands of spines ……...……..... 12

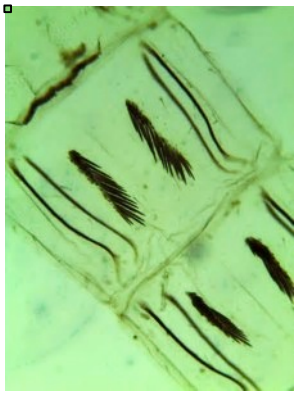

Figure 352. Tergites III-IV of *Tanytarsus* sp. 1

Figure 353. Tergites III-IV of *Tanytarsus* sp. 7

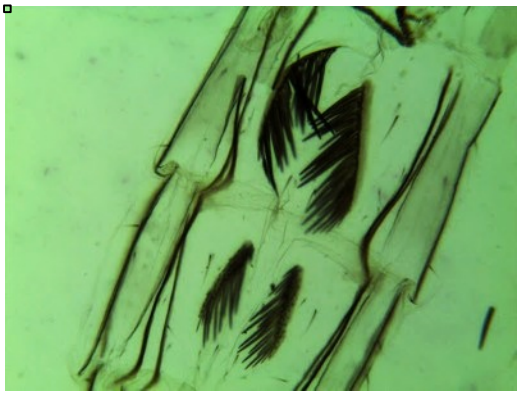

Figure 354. Tergites III-IV of *Tanytarsus* sp. 12

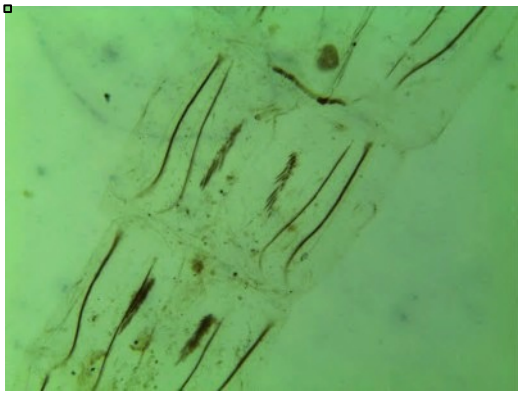

Figure 355. Tergites III-IV of *Tanytarsus* sp. 2

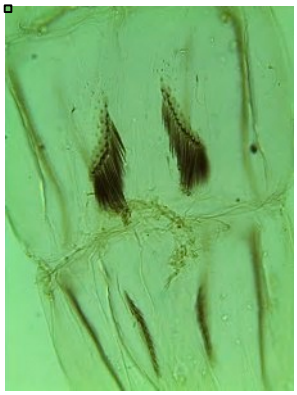

Figure 356. Tergites III-IV of *Tanytarsus* sp. 5

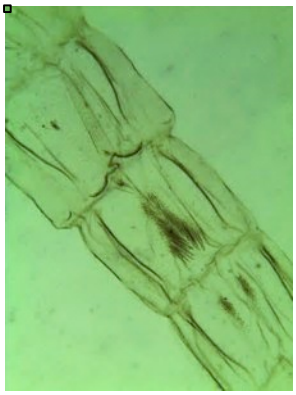

Figure 357. Tergites II-IV of *Tanytarsus* sp. 9

10(9). Tergite IV with paired, bifurcated sclerotized structure (Fig. 358) ……... ***Tanytarsus* sp. 7**

10'. Tergite IV without sclerotized structure ……...…… 11

Figure 358. Tergite IV of *Tanytarsus* sp. 7

11(10'). Tergite III with paired long, medially pointing parallel bands of spines (Fig. 352) ……..…….. ***Tanytarsus* sp. 1**

11'. Tergite III with paired very long, medially pointing C-shaped bands of spines (Fig. 354) ……...…….. ***Tanytarsus* sp. 12**

12(9’). Tergite III with paired parallel bands of spines (Fig. 355) ...…… ***Tanytarsus* sp. 2**

12’. Tergite III with paired posteriorly divergent band of spines (Figs. 356-357) ….…. 13

13(12’). Tergite III with paired thick, dark brown spines; tergite IV with paired line of short spines (Fig. 356) …….. ***Tanytarsus* sp. 5**

13’. Tergite III with paired thin, light brown spines; tergite IV with anterior paired point patches (Fig. 357) ……. ***Tanytarsus* sp. 9**

NOTES ON *TANYTARSUS* SPECIES

Tanytarsus sp. 1

Locality: Laguna del Tortuguero 1, 2 & 3

Thorax: Thoracic horn long, slender, and spinose (Fig. 312); wing sheaths with prominent nose

Abdomen: Tergite II with median bands of light shagreen, pedes spurii B, and continuous hook on projecting flap (1/2 width) (Fig. 348); tergite III with parallel dark spines pointing inward (1/2 length of segment); tergite IV with parallel dark spines slightly curved posteriorally (1/3 length) (Fig. 352); tergite V with anterior dark patch of spines; tergite VI with anterior smaller dark patch of spines; tergite VII bare; tergite VIII with small anterior patches of shagreen and dark anal claw (Fig. 315); 5 LS setae on tergite VIII; 4 LS setae on tergite VII; no LS setae on tergite V; D setae on tergite I longer than half of the segment; anal lobe with two anal macrosetae

Comments: Closest to *Tanytarsus* sp. 12; around 4mm long exuviae; keys to *Caladomyia* sp. 4 (Fig. 20 A-F, Wiedenbrug et al. 2005), close to *Tanytarsus hamatus* Reiss, but tergite II and III varies (Fig. 20, Sanseverino & Fittkau 2006)

Tanytarsus sp. 2

Locality: Laguna del Tortuguero 1, 2 & 3

Thorax: Thoracic horn long, slender, and spinose; wing sheaths with prominent nose

Abdomen: Tergite II with anterior and posterior light patches of shagreen (Fig. 335); tergites III-IV with paired light bands of spines (Fig. 355)

Comments: Closest to *Tanytarsus* sp. 5 and sp. 9; around 2 mm long exuviae; keys to *Caladomyia* sp. 4 (Fig. 20 A-F, Wiedenbrug *et al.* 2005)

***Tanytarsus* sp. 3**

Locality: Laguna del Tortuguero 3 & Quebrada

Thorax: Thoracic horn long and slender; granulose median suture; wing sheaths with prominent nose

Abdomen: Tergite I bare; tergite II-VI with light anterior patches surrounded by shagreen and very light anterolateral shagreen; tergite II only with continuous hook row (~1/2 width); tergite II and III with shagreen between point patches (Figs. 328, 333, 338); tergite VII bare; tergite VIII with dark, bulbous anal claw (Fig. 316); anal lobe with anterolateral patches of shagreen; 4-5 LS setae on tergite VIII

Comments: Closest to *Tanytarsus* sp. 10; 3 mm long exuviae; keys to *Tanytarsus* sp. 19 (Fig. 14 J-L, Wiedenbrug *et al.* 2005)

***Tanytarsus* sp. 4**

Locality: Laguna del Tortuguero 2

Thorax: Thoracic horn long and slender; rugulose frontal apotome

Abdomen: Tergite II with anterior patches of shagreen (Fig. 346); tergite III with anterior paired patch points; long spines present tergite IV-V (Fig. 350); tergite VI with anterior patches of spines; 3 LS setae on tergite VI-VII; 4 LS setae on tergite VIII

Comments: Closest to *Tanytarsus* sp. 11

***Tanytarsus* sp. 5**

Locality: Laguna del Tortuguero 1, 2 & 3

Thorax: Wing sheaths with prominent nose

Abdomen: Tergite I bare; tergite II with strong median shagreen and thin, light, continuous hook row (3/4 width) (Fig. 349); tergite III with long spines (curved outward posteriorally); tergite IV with linear, short dark spines (Figs. 330, 356); tergites V-VI with anterior patches of spines; tergite VIII with bulbous anal claw

Comments: Closest to *Tanytarsus* sp. 9; around 4mm long exuviae; keys to *Caladomyia* sp. 5 (Fig. 25 F-J, Wiedenbrug *et al.* 2005)

***Tanytarsus* sp. 6**

Locality: Laguna del Tortuguero 2 & 3

Thorax: Thoracic horn short and slender

Abdomen: Tergite II with anterior patches of dark spines and continuous dark hook row (1/2 width) (Figs. 318, 334, 337); tergites III-VI with anterior patches of dark spines (circular shagreen patches like *Cladotanytarsus*) (Fig. 329); segment VIII with dark anal claw; anal lobe with two anal macrosetae; anal lobes with around 16 fringe setae

Comments: Closest to *Tanytarsus* sp. 3 and sp. 10; keys to *Tanytarsus* sp. 21 (Fig. 15 A-I, Wiedenbrug *et al.* 2005)

***Tanytarsus* sp. 7**

Locality: Laguna del Tortuguero 1, 2, 3 & Quebrada

Thorax: Thoracic horn long and slender

Abdomen: Tergite III with convex origin for spines; tergite IV with anterior long spines originating from several points rather than in a line and unusual sclerotized paired structures each with two points along posterior half of tergite (Figs. 331, 353, 358); pair of point patches on anterior of tergites V-VI; tergite VII bare; tergite VIII with anterolateral pair of shagreen; 5 LS setae on tergite VIII

Comments: Closest to *Tanytarsus* sp. 1 and sp. 12

***Tanytarsus* sp. 8**

Figure 359. Thoracic horn of *Tanytarsus* sp. 8

Locality: Laguna del Tortuguero 1 & 3

Head: Cephalic tubercles large and point with frontal setae (Fig. 342)

Thorax: Thoracic horn long and thick (thicker than other *Tanytarsus* species) (Fig. 359); wing sheaths with prominent nose

Abdomen: Tergite II with continuous dark hook row on projecting flap (1/3 width) and small anterior and posterior patches of shagreen (Fig. 335); tergites III-VI with paired anterior circular patches; tergite VIII with large, light colored anal claw with around 8 points (Fig. 344)

Comments: Closest to *Tanytarsus* sp. 14

***Tanytarsus* sp. 9**

Figure 360. Thoracic horn of *Tanytarsus* sp. 9

Locality: Laguna del Tortuguero 1, 2 & 3

Thorax: Thoracic horn serrated on one side (Fig. 360); wing sheaths with prominent nose

Abdomen: Tergite II light median shagreen and continuous hook row (3/4 width); tergite III with two medially pointing bands of spines with lateral shagreen; tergite IV with two point patches of spines (Figs. 319, 357); tergite V-VI with smaller point patches of spines; tergite VII-VII bare; anal claw light brown, 4-5 point

Comments: Closest to *Tanytarsus* sp. 5; keys to *Caladomyia* sp. 4, but more lighter spines on tergite III, shorter spines of tergite IV, and serrated thoracic horn (Fig. 20 A-F, Wiedenbrug *et al.* 2005)

***Tanytarsus* sp. 10**

Locality: Laguna del Tortuguero 1 & Quebrada

Thorax: Thoracic horn long and slender

Abdomen: Tergite II with anterior dark patches of spines, posterior median patch of shagreen on dark segment coloration, continuous hook row on projecting flap (~1/4 width), and pedes spurii B (Fig. 339); tergites III-VI with dark anterior patches of spines; tergite VIII with small dark anal claw; 3 LS setae on tergite VI, 4 LS setae on tergites VII-VIII

Comments: Closest to *Tanytarsus* sp. 3; keys to *Tanytarsus amazonicus*, but there is variation from tergite II (Fig. 46, Sanseverino & Fittkau 2006)

***Tanytarsus* sp. 11**

Locality: Quebrada

Thorax: Thoracic horn long and slender; wing sheath with prominent nose

Abdomen: Tergite II with dark anterior patches of spines, median shagreen, and continuous hook row (1/2 width) (Fig. 347); tergite III with long band of spines; tergites IV-V with dark bands of spines (Fig. 351); tergites VI-VIII bare; tergite VIII with dark, bulbous anal claw; 5 LS setae on tergite VIII

Comments: Closest to *Tanytarsus* sp. 4; keys to *Tanytarsus hamatus* Reiss, but varies in tergites II-IV (Fig. 20, Sanseverino & Fittkau 2006)

***Tanytarsus* sp. 12**

Locality: Laguna del Tortuguero 2

Thorax: Thoracic horn long and slender; wing sheath with prominent nose

Abdomen: Tergite II with dense shagreen; tergite III with a pair long bands of spines pointing medially (C-shaped); tergite IV with long spines pointing medially (Figs. 332, 354); segment VIII with large, wide light brown anal claw

Comments: Closest to *Tanytarsus* sp. 1

***Tanytarsus* sp. 13**

Locality: Laguna del Tortuguero 2

Thorax: Thoracic horn long and slender

Abdomen: No hook row on tergite II; pairs of spine patches on tergite III-VI; tergite II with pedes spurii B and posterior patch of shagreen (Figs. 336, 340); tergite VIII with anterolateral patches of shagreen; anal lobe with patches of shagreen; segment VIII with dark anal comb with many minor spines; anal lobe with 2 anal macroseate; 4 LS setae on tergite VIII

Comments: Closest to *Tanytarsus* sp. 8; keys close to *Tanytarsus* sp. 62 (Wiedenbrug *et al.* 2005)

***Tanytarsus* sp. 14**

Locality: Laguna del Tortuguero 2

Head: Cephalic tubercles absent (Fig. 343)

Thorax: Thoracic horn long and slender; wing sheath with prominent nose

Abdomen: Tergite II with continuous, 1/4 width hook row and median to posterior patches of shagreen (Fig. 341); tergite III-VI with anterior patches of shagreen; segment VIII wit 2-3 point anal claw (Fig. 345)

Comments: Closest to *Tanytarsus* sp. 8; 3 mm long exuviae

ADDITIONAL REFERENCES

Ekrem, T., M.F. Sublette and J.E. Sublette. 2003. North American *Tanytarsus* I. Descriptions and keys to species in the eminulus, gregarious, lugens and mendax species groups (Diptera: Chironomidae). Annals of the Entomological Society of America 96: 265-328.

Sanseverino, A. M. and E.J. Fittkau. 2006. Four new species of *Tanytarsus* van der Wulp, 1874 (Diptera: Chironomidae) from South America. Zootaxa 1162: 1-18.

Sublette, J.E. and M. Sasa. 1994. Chironomidae collected in Onchocerciasis endemic areas of Guatemala (Insecta, Diptera). Spixiana Supplement 20: 1-60.

Wiedenbrug, S. and R. Ospina-Torres. 2005. A key of pupal exuviae of Neotropical Tanytarsini (Diptera: Chironomidae). Amazoniana 18: 317-371.

NOTES ON UNKNOWN TANYTARSINI GENERA

Unknown Tanytarsini #1

Locality: Laguna del Tortuguero 1 & 2

Head: Frontal apotome with granulose mound; frontal setae robust, thorn-like (Fig. 320)

Thorax: Thoracic horn slender with small spines (Fig. 313); median suture of thorax with small spines; prominent nose

Abdomen: Tergite I and II bare; hook row of tergite II complete (1/3 width); tergites III-V with dark posterior patches of spines and with dark brown median pigmentation (Fig. 322); tergite III with two posterior patches of shagreen; tergite IV with one median band of shagreen and two posterior patches of shagreen; tergite V with one median band of shagreen and two posterior patches of dark spines (extending laterally) and light shagreen in pleural area; tergite VI with median band of light shagreen and light shagreen in pleural area; two small anterior patches of shagreen on tergites VII-VIII; anal spur with one main point and around 4 minor points; 3/4 complete anal fringe with 18 fringe setae per lobe (like *Stempellina*); pedes spurii A present and B absent; 3 LS setae on tergite V; 4 LS setae on tergites VI-VII; 2 LS setae on tergite VIII (setation like *Constempellina*)

Comments: Genera between *Constempellina* and *Stempellina*

Unknown Tanytarsini #2

Locality: Laguna del Tortuguero 1, 2 & 3

Head: Frontal apotome with granulose mound; frontal setae long, slender (Fig. 321)

Thorax: Thoracic horn slender with small spines; median suture of thorax with small spines; prominent nose

Abdomen: Tergite I bare; tergite II with continuous hook row (1/3-1/2 width) and minimal shagreen; tergites III-V with light posterior patches of spines and without dark brown median pigmentation (Fig. 323); tergites III with triangular dark patch and posterior row of small spines; tergite IV with triangular dark patch, median circle of shagreen and posterior row of small spines; tergite V with triangular dark patch, median circle of shagreen, and posterior row of dark, larger spines; tergite VI with shagreen in pleural area; tergite VII with two anterior lateral patches of shagreen; tergite VIII with lateral bands of shagreen; pedes spurii A present and B absent; 3 LS setae on tergite V; 4 LS setae on tergites VI-VII; 2 LS setae on tergite VIII; 3-point yellow to brown anal claw; complete anal fringe with 11 fringe setae per lobe (like *Constempellina*)

Comments: Genera between *Constempellina* and *Stempellina*

REFERENCES CITED

Adam, J.I. and O.A. Sæther. 1999. Revision of the genus *Nilothauma* Kieffer, 1921 (Diptera: Chironomidae). Entomologica Scandinavica Supplement 56: 1-107.

Armitage, P.D. and J.H. Blackburn. 1985. Chironomidae in a Pennine stream system receiving mine drainage and organic enrichment. Hydrobiologia. 121: 165-172.

Armitage, P.D, P.S. Cranston and L.C.V. Pinder. 1995. The Chironomidae: The Biology and Ecology of Non-biting Midges. Chapman and Hall, London.

Barbour, M.T., J. Gerritsen, B.D. Snyder and J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: Periphyton, benthic macroinvertebrates, and Fish. 2nd edition. Report number EPA 841-B-99-002. US EPA, Washington, U.S.A.

Bilyj, B. and I.J. Davies. 1989. Descriptions and ecological notes on seven new species of *Cladotanytarsus* (Chironomidae: Diptera) collected from an experimentally acidified lake. Canadian Journal of Zoology 67: 948-962.

Borkent, A. 1984. The systematics and phylogeny of the *Stenochironomus* complex (*Xestochironomus, Harrisius, and Stenochironomus*) (Diptera: Chironomidae). Memoirs of the Entomological Society of Canada. No. 128.

Coffman, W.P. and L.C. Ferrington Jr. 1996. Chironomidae. In Meritt, R. W. & K. W. Cummins (eds), An introduction to the aquatic insects of North America, Third Edition. Kendall/Hunt Publishing Company, Dubuque, IW: 635-643.

Curry, L.L. 1958. Larvae and pupae of the species *Cryptochironomus* (Diptera) in Michigan. Limnology and Oceanography 3: 427-442.

De la Rosa, C.L. 1997. Chironomidae. In Solís, A. (ed.) Las familias de insectos de Costa Rica. INBio. http://www.inbio.ac.cr/papers/insectoscr/Texto197.htm

Ekrem, T., M.F. Sublette and J.E. Sublette. 2003. North American *Tanytarsus* I. Descriptions and keys to species in the eminulus, gregarious, lugens and mendax species groups (Diptera: Chironomidae). Annals of the Entomological Society of America 96: 265-328.

Ferrington, L.C. Jr., M.A. Blackwood, C.A. Wright, N.H. Crisp, J.L. Kavanaugh and F.J. Schmidt. 1991. A protocol for using surface-floating pupal exuviae of Chironomidae for rapid bioassessment of changing water quality. Pp.181-190. In sediment and stream water quality in a changing environment: trends and explanations. IAHS Publication Number 203. 374 pp.

Ferrington, L.C. Jr., M.B. Berg and W.P. Coffman. 2008. Chironomidae. Chapter 26 In R.W. Merritt, K.W. Cummins, and M.B. Berg, eds. An introduction to the aquatic insects of North America. 4th Ed., Kendall/Hunt Publishing Co., Dubuque, Iowa.

Fittkau, E.J. 1968. *Chironomus streinzkei* n. sp. (Chironomidae, Dipt.), ein neues Laboratoriumstier. Zeitschtift für Morphologie der Tiere 63: 239–250.

Grodhaus, G. 1976. Two species of *Phaenopsectra* with drought-resistant larvae (Diptera: Chironomidae). Journal of the Kansas Entomological Society. 49: 405-418.

Grodhaus, G. 1987. *Endochironomus* Kieffer, *Tribelos* Townes, *Synendotendipes*, n. gen., and *Endotribelos*, n. gen. (Diptera: Chironomidae) of the Nearctic Region. Journal of the Kansas Entomological Society 60: 167-247.

Hayford, B.L. 1998. A systematic revision of *Paratendipes* (Diptera: Chironomidae) with special emphasis on the evolution of thermophily. Unpublished PhD thesis.

Hayford, B. and L.C. Ferrington Jr. 2006. Distribution of Chironomidae (Diptera) in Lake Hövsgöl, Mongolia. In Goulden, C. E., T. Sitnikova, J. Gelhaus, B. Boldgiv (eds), The geology, biodiversity, ecology of Lake Hövsgöl (Mongolia). Backhuys Publishers, Leiden, The Netherlands, 433–452, Chapter 26.

Hestenes, T.C. and O.A. Saether. 2000. Three new Nearctic *Thiennemanniella* Kieffer species with a review of the Nearctic species. In late 20th century research on Chirononomidae: an anthology from the 13th International Symposium on Chironomidae. O. Hoffrichter (ed.). Shaker Verlag, Aachen.

Heyn, M.W. 1992. A review of the systematic position of the North American species of the genus *Glyptotendipes*. Netherlands Journal of Aquatic Ecology 26: 129-137.

Jackson, G.A. 1977. Nearctic and Palaearctic *Paracladopelma*, *Harnischa*, and *Sætheria* n. gen. (Diptera: Chironomidae). Journal of the Fisheries Research Board of Canada 34: 1321-1359.

Jacobsen, R.E. and S.A. Perry. 2000. A review of *Beardius* Reiss & Sublette, with description of a new species from Everglades National Park (Insecta, Diptera, Chironomidae). Spixiana 23: 129-144.

Lehmann, J. 1970a. Revision der europäischen Arten (Imagines) der Gattung *Parachironomus* Lenz (Diptera, Chironomidae). Hydrobiologia 33: 129-158.

Lehmann, J. 1970b. Revision der europäischen Arten (Imagines und Puppen) der Gattung *Rheotanytarsus* Bause (Diptera, Chironomidae). Zoologische Anzeiger 185: 344-378.

Maschwitz, D.E. and E.F. Cook. 2000. Revision of the Nearctic species of the genus *Polypedilum* Kieffer (Diptera: Chironomidae) in the subgenera *P.* (Polypedilum) Kieffer and *P.* (Uresipedilum) Oyewo and Sæther. Ohio Biological Survey, Ohio State University.

Mason, P.G. 1986. Four new species of the *Cryptochironomus fulvus* (Johannsen) species complex (Diptera: Chironomidae). Entomologica Scandanavica 16: 399-413.

Mendes, H.F. and T. Andersen. 2009. Neotropical *Nilothauma* Kieffer, 1921, with the description of thirteen new species (Diptera: Chironomidae). Zootaxa 2063: 1-45.

Murphy, P.M. and R.W. Edwards. 1982. The spatial distribution of the freshwater macroinvertebrate fauna of the River Ely, South Wales, in relation to pollutional discharges. Environmental Pollution (Series A). 29: 111-124.

Oliveira, C.S.N. and F.L. Da Silva. 2011. Two new species of *Larsia* Fittkau, 1962 (Diptera Chironomonidae: Tanypodinae) from Neotropical region, with a checklist of *Larsia* species of the world. Zootaxa 2786: 27-41.

Oliver, D.R., M.E. Dillon and P.S. Cranston. 1990. A catalog of Nearctic Chironomidae. Research Branch Agriculture Canada, Publication 1857/B.

Oliver, D. R. and M.E. Dillon. 1994. Corrections and additions to "A catalog of Nearctic Chironomidae". Proceedings of the Entomological Society of Washington 96: 8-10.

Oyewo, E.A. and O.A. Sæther. 2008. Revision of *Polypedilum* (Pentapedilum) Kieffer and Ainuyusurika Sasa et Shirasaki (Diptera: Chironomidae). Zootaxa 1953: 1-145.

Rae, J.G. 1989. Chironomid midges as indicators of organic pollution in the Sciotio River Basin, Ohio. The Ohio Journal of Science 89: 5-9.

Rawson, D. S. and J.E. Moore. 1944. The saline lakes of Saskatchewan. Canadian Journal of Research 22: 141-201.

Reiss, F. 1974a. Vier neue *Chironomus*-Arten (Chironomidae, Diptera) und ihre ökologische Bedeutung für die Benthosfauna zentralamazonischer Seen und Überschwemmungswälder. Amazoniana 5: 3-23.

Reiss, F. 1974b. Die in stehenden Gewässern der Neotropis verbreitete Chironomidengattung *Goeldichironomus* Fittkau (Diptera, Insecta). Studies on Neotropical Fauna 9: 85-122.

Reiss, F. and L. Säwedal. 1981. Keys to males and pupae of the Palaearctic (excl. Japan) *Paratanytarsus* Thienemann & Bause, 1913, n. comb., with descriptions of three new species (Diptera: Chironomidae). Entomologica Scandinavica Supplement 15:

Reiss, F. 1990. Revision der Gattung *Zavreliella* Kieffer, 1920 (Diptera: Chironomidae). Spixiana 13: 73-104.

Reiss, F. and J.E. Sublette. 1985. *Beardius* new genus with notes on additional Pan-American taxa (Diptera, Chironomidae). Spixiana Supplement 11: 179-193.

Roback, S.S. 1974. The immature stages of the genus *Coelotanypus* (Chironomidae; Tanypodinae: Coelotanypodini) in North America. Proceedings of the Academy of Natural Sciences of Philadelphia 126: 9-19.

Roback, S.S. and K.J. Tennessen. 1978. The immature stages of *Djalmabatista pulcher* [=P*rocladius* (*Calotanypus*) *pulcher* (Joh.)]. Proceedings of the Academy of Natural Sciences of Philadelphia 130: 11-20.

Roback, S.S. 1980. The immature chironomids of the eastern United States IV. Tanypodinae – Procladiinae. Proceedings of the Academy of Natural Sciences of Philadelphia 132: 1-63.

Roback, S.S. 1981. The immature chironomids of the eastern United States V. Pentaneurini – Thienemannimyia Group. Proceedings of the Academy of Natural Sciences of Philadelphia 133: 73-128.

Roback, S.S. and W.P. Coffman. 1983. Results of the Catherwood Bolivian-Peruvian Altiplano expedition Part II. Aquatic Diptera including montane Diamesinae and Orthocladiinae (Chironomidae) from Venezuela. Proceedings of the Academy of Natural Sciences of Philadelphia 135: 9-79.

Roback, S.S. 1985. The immature chironomids of the eastern United States VI. Pentaneurini – Genus *Ablabesmyia*. Proceedings of the Academy of Natural Sciences of Philadelphia 137: 153-212.

Roback, S.S. 1987. The immature chironomids of the eastern United States IX. Pentaneurini – genus Labrundinia with the Description of some Neotropical material. Proceedings of the Academy of Natural Sciences of Philadelphia 139: 159-209.

Roque, F.O. and S. Trivinho-Strixino. 2008. Four new species of *Endotribelos* Grodhaus, a common fallen fruit-dwelling chironomid genus in Brazilian streams (Diptera: Chironomidae: Chironominae). Studies on Neotropical Fauna and Environment 43: 191-207.

Sæther, O.A. 1977. Taxonomic studies on Chironomidae: *Nanocladius*, P*seudochironomus*, and the *Harnischia* complex. Bulletin of the Fisheries Research Board of Canada. Bulletin 196.

Sæther, O.A. 1980. Glossary of chironomid morphology terminology (Chironomidae: Diptera). Entomologica Scandinavica Supplement 14: 1-51.

Sæther, O.A. 1981. Orthocladiinae (Chironomidae: Diptera) from the British West Indies with descriptions of *Antillocladius* n. gen., *Lipurometriocmemus* n. gen. , *Compterosmittia* n. gen. and *Diplosmittia* n. gen. – Entomogica Scandinavica Supplement 16: 1-46.

Sæther, O.A. and A. Sundal. 1999. *Cerobregma*, a new subgenus of *Polypedilum* Kieffer, with a tentative phylogeny of subgenera and species groups within *Polypedilum* (Diptera: Chironomidae). Journal of the Kansas Entomological Society 71: 315-382.

Saether, O.A., T. Andersen, L.C. Pinho, and H.F. Mendes. 2010: The problems with *Polypedilum* Kieffer (Diptera: Chironomidae), with the description of *Probolum* subgen. n.. Zootaxa 2497: 1-36.

Serrano, M.A.S. and U. Nolte. 1996. A sit-and-wait predatory chironomid from tropical Brazil - *Fittkauimyia crypta* sp. n. (Diptera: Chironomidae). Entomologica Scandinavica 27: 251-258.

Simpson, K.W., R.W. Bode and P. Albu. 1983. Keys for the genus *Cricotopus* adapted from Revison der Gattung *Cricotopus* van der Wulp und ihrer Verwandten (Diptera, Chironomidae) by M. Hirvenoja. New York State Museum, The University of the State of New York, Albany, NY. Bulletin 450.

Soponis, A.R. and K.W. Simpson. 1992. *Polypedilum digitifer* Townes and *Polypedilum griseopunctatum* (Malloch) (Diptera, Chironomidae): Redescription of adult males with a description and separation of the immature stages. Netherlands Journal of Aquatic Ecology 26: 203–213.

Spies, M. and F. Reiss. 1996. Catalog and bibliography of Neotropical and Mexican Chironomidae (Insecta, Diptera). Spixiana Supplement 22: 61-119.

Spies, M., T. Andersen, J.H. Epler and C.N. Watson Jr. 2009. Chironomidae (non-biting midges). Pp. 437-480 in: Brown, B.V. et al. (eds.) Manual of Central American Diptera, vol. 1. NRC Research Press, Ottawa.

Sublette, J.E. and M. Sasa. 1994. Chironomidae collected in Onchocerciasis endemic areas of Guatemala (Insecta, Diptera). Spixiana Supplement 20: 1-60.

Trivinho-Strixino, S. and T. Siqueira. 2007. New species of *Beardius* Reiss et Sublette, 1985 (Diptera: Chironomidae) from southeastern Brazil. In: T. Andersen (ed.). Contributions to the Systematics and Ecology of Aquatic Diptera- A tribute to Ole A. Saether. The Caddis Press. p 281-286.

Vårdal, H., A. Bjørlo and O.A. Sæther. 2002. Afrotropical *Polypedilum* subgenus *Tripodura*, with a review of the subgenus (Diptera: Chironomidae). Zoologica Scripta 31: 331-402.

Vallenduuk H.J. and E.E. Morozova. 2005. *Cryptochironomus*: An identification key to the larvae and pupal exuviae in Europe. Lautrebornia 55: 1-22.

Wiedenbrug, S. and R. Ospina-Torres. 2005. A key of pupal exuviae of Neotropical Tanytarsini (Diptera: Chironomidae). Amazoniana 18: 317-371.

Wiedenbrug, S. and S. Trivinho-Strixino. 2011. New species of the genus *Corynoneura* Winnertz (Diptera, Chironomidae) from Brazil. Zootaxa 2822: 1-40.

Wiederholm, T. 1989. Chironomidae of the Holarctic Region: Keys and diagnoses. Part 2. Pupae. Entomologica scandanavica Supplement 28: 1-482.

Wilson, R.S. 1987. Chironomid communities in the River Trent in relation to water chemistry. Entomologica Scandinavica Supplement. 29: 387-193.

Table 1. Chironomid taxa collected in Tortuguero National Park, Costa Rica in June 2010 and January 2011 (taxonomic order follows Ferrington *et al*. 2008)

Subfamily	Tribe	Genus	Species
Tanypodinae	Coelotanypodini		*Coelotanypus* sp. 1
			Coelotanypus sp. 2
	Macropelopiini		*Fittkauimyia crypta* Serrano & Nolte, 1996
	Procladiini		*Djalmabatista* sp. 1
			Procladius (*Psilotanypus*) *bellus* Loew, 1866
	Pentaneurini		*Ablabesmyia* sp. 1
			Ablabesmyia sp. 2
			Labrundinia sp. 1
			Labrundinia sp. 2
			Labrundinia sp. 3
			Larsia sp. 1
			Paramerina sp. 1
		Unknown Pentaneurini #1	
		Unknown Pentaneurini #2	
		Unknown Pentaneurini #3	
Orthocladiinae	Corynoneurini		*Corynoneura* sp. 1
			Corynoneura sp. 2
			Corynoneura sp. 3
			Thienemanniella sp. 1
			Thienemanniella sp. 2
	Orthocladiini		*Cricotopus* sp. 1
			Cricotopus sp. 2
			Cricotopus sp. 3
			Nanocladius (*Nanocladius*) *minimus* Saether, 1977
			Nanocladius sp. 1
		Unknown Orthocladiinae #1	
		Unknown Orthocladiinae #2	
Chironominiae	Chironomini		*Beardius* sp. 1
			Chironomus sp. 1
			Chironomus sp. 2
			Cladopelma sp. 1
			Cryptochironomus sp. 1
			Cryptochironomus sp. 2
			Cryptochironomus sp. 3
			Cryptochironomus sp. 4
			Cryptotendipes sp. 1
			Cryptotendipes sp. 2
			Endotribelos sp. 1
			Goeldichironomus sp. 1
			Goeldichironomus sp. 2
			Goeldichironomus sp. 3
			Goeldichironomus sp. 4

(Table 1. Continued)

Subfamily	Tribe	Genus	Species
			Harnischia sp. 1
			Nilothauma nr. *reissi* 1 Mendes & Anderson, 2009
			Nilothauma nr. *reissi* 2 Mendes & Anderson, 2009
			Nilothauma nr. *reissi* 3 Mendes & Anderson, 2009
			Nilothauma sp. 1
			Nilothauma sp. 2
			Nilothauma sp. 3
			Nilothauma sp. 4
			Parachironomus nr. *cayapo* Spies *et al.* 1994
			Parachironomus sp. 1
			Parachironomus sp. 2
			Parachironomus sp. 3
			Parachironomus sp. 4
			Paralauterborniella nigrohalteralis Malloch, 1915
			Paratendipes sp. 1
			Paratendipes sp. 2
			Paratendipes sp. 3
			Paratendipes sp. 4
			Paratendipes sp. 5
			Paratendipes sp. 6
			Paratendipes sp. 7
			Polypedilum sp. 1
			Polypedilum sp. 2
			Polypedilum sp. 3
			Polypedilum sp. 4
			Polypedilum sp. 5
			Polypedilum sp. 6
			Polypedilum sp. 7
			Polypedilum sp. 8
			Polypedilum sp. 9
			Polypedilum sp. 10
			Polypedilum sp. 11
			Polypedilum sp. 12
			Polypedilum sp. 13
			Saetheria nr. *tylus* Townes, 1945
			Stenochironomus quadrinotatus Borkent, 1984
			Stenochironomus sp. 1
			Stenochironomus sp. 2
			Stenochironomus sp. 3
			Stenochironomus sp. 4

(Table 1. Continued)

Subfamily	Tribe	Genus	Species
			Stenochironomus sp. 5
			Xestochironomus subletti Borkent, 1984
			Xestochironomus sp. 1
			Zavreliella nr. *marmorata* van der Wulp, 1859
			Zavreliella sp. 1
		Unknown Chironomini #1	
		Unknown Chironomini #2	
		Unknown Chironomini #3	
		Unknown Chironomini #4	
	Pseudochironomini		*Pseudochironomus richardsoni* Malloch, 1915
			Pseudochironomus sp. 1
			Pseudochironomus sp. 2
	Tanytarsini		*Cladotanytarsus* sp. 1
			Rheotanytarsus sp. 1
			Tanytarsus sp. 1
			Tanytarsus sp. 2
			Tanytarsus sp. 3
			Tanytarsus sp. 4
			Tanytarsus sp. 5
			Tanytarsus sp. 6
			Tanytarsus sp. 7
			Tanytarsus sp. 8
			Tanytarsus sp. 9
			Tanytarsus sp. 10
			Tanytarsus sp. 11
			Tanytarsus sp. 12
			Tanytarsus sp. 13
			Tanytarsus sp. 14
		Unknown Tanytarsini #1	
		Unknown Tanytarsini #2	

BIBLIOGRAPHY

Adam, J.I. and O.A. Sæther. 1999. Revision of the genus *Nilothauma* Kieffer, 1921 (Diptera: Chironomidae). Entomologica Scandinavica Supplement 56: 1-107.

Anderson, A.M. and Ferrington, L.C. in press. Time-efficiency of sorting Chironomidae surface floating pupal exuviae samples from urban trout streams in northeastern Minnesota. Proceedings of the 18th International Symposium on Chironomidae.

Armitage, P.D. and Blackburn, J.H. 1985. Chironomidae in a Pennine stream system receiving mine drainage and organic enrichment. Hydrobiologia 121: 165-172.

Armitage, P.D, P.S. Cranston and L.C.V. Pinder. 1995. The Chironomidae: The Biology and Ecology of Non-biting Midges. Chapman and Hall, London.

Barbour, M.T., J. Gerritsen, B.D. Snyder and J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates, and Fish. 2nd edition. Report number EPA 841-B-99-002. US EPA, Washington, U.S.A.

Blanckenhorn, W.U., and M. Demont. 2004. Bergmann and converse Bergmann latitudinal clines in arthropods: Two ends of a continuum? Integrative and Comparative Biology 44: 413-424.

Bilyj, B., and I.J. Davies. 1989. Descriptions and ecological notes on seven new species of *Cladotanytarsus* (Chironomidae: Diptera) collected from an experimentally acidified lake. Canadian Journal of Zoology 67: 948-962.

Borkent, A., 1984. The systematics and phylogeny of the *Stenochironomus* complex (*Xestochironomus*, *Harrisius*, and *Stenochironomus*) (Diptera: Chironomidae). Memoirs of the Entomological Society of Canada. No. 128.

Bouchard, R.W., Jr. 2007. Comparison of phenology and taxonomic composition of lotic Chironomidae (Diptera) communities in contrasting thermal regimes. Unpublished Ph.D. thesis, University of Minnesota, 411 pp.

Bouchard, R.W., Jr. and L.C. Ferrington. 2010. The effects of subsampling and sampling frequency on the use of surface-floating pupal exuviae to measure Chironomidae (Diptera) communities in wadeable temperate streams. Environmental Monitoring and Assessment 181: 205-23.

Carr, A. 1982. Tropical forest conservation and estuarine ecology. Biological Conservation. 23.4: 247-259.

Casas, J., and A. Vilchez-Quero. 1996. Chironomid assemblages of three endoreic karstic lagoons (Southern Spain) determined by collection of pupal exuviae: Importance of the water mineralization and sediment characteristics. Internationale Revue der gesamten Hydrobiologie 81: 555-564.

Chao, A., R.L. Chazdon, R.K. Colwell and T.J. Shen. 2005. A new statistical approach for assessing compositional similarity based on incidence and abundance data. Ecology Letters 8: 148-159.

Chao, A., R.L. Chazdon, R.K. Colwell and T.J. Shen. 2006. Abundance-based similarity indices and their estimation when there are unseen species in samples. Biometrics 62: 361-371.

Chazdon, R.L., R.K. Colwell, J.S. Denslow and M.R. Guariguata. 1998. Statistical methods for estimating species richness of woody regeneration in primary and secondary rain forests of NE Costa Rica. In F. Dallmeier and J. A. Comiskey, eds. Forest biodiversity research, monitoring and modeling: Conceptual background and Old World case studies. Parthenon Publishing, Paris.

Coffman, W.P., C.L. de la Rosa, K.W. Cummins and M.A. Wilzbach. 1992. Species richness in some neotropical (Costa Rica) and afrotropical (west Africa) lotic communities of Chironomidae (Diptera). Netherlands Journal of Aquatic Ecology 26: 229-237.

Coffman, W.P., and L.C. Ferrington Jr. 1996. Chironomidae. In Meritt, R. W. & K. W. Cummins (eds), An introduction to the aquatic insects of North America, Third Edition. Kendall/Hunt Publishing Company, Dubuque, IW: 635-643.

Coffman, W.P., and C.L. De La Rosa. 1998. Taxonomic composition and temporal organization of tropical and temperate species assemblages of lotic Chironomidae. Journal of the Kansas Entomological Society 71: 388-406.

Colwell, R. K., and J.A. Coddington. 1994. Estimating terrestrial biodiversity through extrapolation. Philosophical Transactions of the Royal Society (Series B) 345: 101-118.

Colwell, R.K. 2009. EstimateS: Statistical estimation of species richness and shared species from samples. Version 8.2. User's Guide and application published at: http://purl.oclc.org/estimates.

Curry, L.L. 1958. Larvae and pupae of the species *Cryptochironomus* (Diptera) in Michigan. Limnology and Oceanography 3: 427-442.

De la Rosa, C.L. 1997. Chironomidae. In Solís, A. (ed.) Las familias de insectos de Costa Rica. INBio. http://www.inbio.ac.cr/papers/insectoscr/Texto197.htm

Dimitriadis, S. and P.S. Cranston. 2007. From the mountains to the sea: assemblage structure and dynamics in Chironomidae (Insecta: Diptera) in the Clyde River estuary gradient, New South Wales, southeastern Australia. Australian Journal of Entomology 46: 188-197.

Ekrem, T., M.F. Sublette and J.E. Sublette. 2003. North American *Tanytarsus* I. Descriptions and keys to species in the eminulus, gregarious, lugens and mendax species groups (Diptera: Chironomidae). Annals of the Entomological Society of America 96: 265-328.

Epler, J.H. 2001. Identification Manual for the larval Chironomidae (Diptera) of North and South Carolina. A guide to the taxonomy of the midges of the southeastern United States, including Florida. Special Publication SJ2001-SP13. North Carolina Department of Environment and Natural Resources, Raleigh, NC, and St. Johns River Water Management District, Palatka, FL. 526 pp.

Ferrington, L.C., Jr. and N.H. Crisp. 1989. Water chemistry characteristics of receiving streams and the occurrence of *Chironomus riparius* and Other Chironomidae in Kansas. Acta Biologia Debrecina, Oecologica Hungarica 3: 115-126.

Ferrington, L.C., Jr., M.A. Blackwood, C.A. Wright, N.H. Crisp, J.L. Kavanaugh and F.J. Schmidt. 1991. A protocol for using Ssurface-floating pupal exuviae of Chironomidae for rapid bioassessment of changing water quality. In Sediment and stream water quality in a changing environment: trends and explanations. IAHS Publication Number 203. 374 pp.

Ferrington, L.C. Jr., K.M. Buzby and E.C. Masteller. 1993. Composition and temporal abundance of Chironomidae emergence from a tropical rainforest stream at El Verde, Puerto Rico. Journal of the Kansas Entomological Society 66: 167-180.

Ferrington, L.C. Jr., M.B. Berg and W.P. Coffman. 2008. Chironomidae. Chapter 26 In: R.W. Merritt, K.W. Cummins, and M.B. Berg, eds. An introduction to the aquatic insects of North America. 4th Ed., Kendall/Hunt Publishing Co., Dubuque, Iowa.

Ferrington, L.C. Jr., E.C. Masteller and J.A. Santiago-Blay. 2009. Comparison and significance of Chironomidae emergence from Lake Erie and Presque Isle Bay, Erie, Pennsylvania, U. S. A. In Hughes, S. J., Khadem, M. and Carvalho, M. A. (eds.): Proceedings of the 16th International Chironomid Symposium, Boletim do Museu Municipal do Funchal Supplement 13: 21-28.

Flecker, A. S. 1992. Fish trophic guilds and the structure of a tropical stream: weak direct vs. strong indirect effects. Ecology 73: 927-940.

Flecker, A.S. 1996. Ecosystem engineering by a dominant detritivore in a diverse tropical stream. Ecology 77: 1845-1854.

Fittkau, E. J. 1968. *Chironomus streinzkei* n. sp. (Chironomidae, Dipt.), ein neues Laboratoriumstier. Zeitschtift für Morphologie der Tiere 63: 239-250.

Grodhaus, G. 1976. Two species of *Phaenopsectra* with drought-resistant larvae (Diptera: Chironomidae). Journal of the Kansas Entomological Society 49: 405-418.

Grodhaus, G. 1987. *Endochironomus* Kieffer, *Tribelos* Townes, *Synendotendipes*, n. gen., and *Endotribelos*, n. gen. (Diptera: Chironomidae) of the Nearctic Region. Journal of the Kansas Entomological Society 60: 167-247.

Hayford, B.L. 1998. A systematic revision of *Paratendipes* (Diptera: Chironomidae) with special emphasis on the evolution of thermophily. Unpublished Ph.D. thesis, University of Kansas.

Hayford, B., and L.C. Ferrington Jr. 2006. Distribution of Chironomidae (Diptera) in Lake Hövsgöl, Mongolia. In Goulden, C. E., T. Sitnikova, J. Gelhaus, B. Boldgiv (eds), The Geology, Biodiversity, Ecology of Lake Hövsgöl (Mongolia). Backhuys Publishers, Leiden, The Netherlands, 433–452, Chapter 26.

Hestenes, T.C., and O.A. Sæther. 2000. Three new Nearctic *Thienemanniella* Kieffer species with a review of the Nearctic species. In: Late 20th century research on Chironomidae: An Anthology from the 13th International Symposium on Chironomidae. O. Hoffrichter (ed.) Shaker Verlag. Aachen.

Heyn, M.W. 1992. A review of the systematic position of the North American species of the genus *Glyptotendipes*. Netherlands Journal of Aquatic Ecology 26: 129-137.

Hirth, H.F. 1963. The ecology of two lizards on a tropical beach. Ecological Monographs 33: 83-112.

Jackson, G.A. 1977. Nearctic and Palaearctic *Paracladopelma*, *Harnischa*, and *Sætheria* n. gen. (Diptera: Chironomidae). Journal of the Fisheries Research Board of Canada. 34: 1321-1359.

Jackson, J.K. and B.W. Sweeney. 1995. Egg and larval development times for 35 species of tropical stream insects from Costa Rica. Journal of the North American Benthological Society 14: 115-130.

Kavanaugh, J.L., R.W. Bouchard, Jr., L.C. Ferrington, Jr. 2003. Efficacy of surface-floating pupal exuviae collections for estimating emergence frequencies of abundant species. Poster at XV International Chironomidae Symposium.

Kawai, K., S. Morihiro and H. Imabayashi. 2000. Transectional distribution patterns of chironomid larvae in estuaries. Medical Entomology and Zoology 51: 215-220.

Langton, P.H. 1991 A key to pupal exuviae of West Palaearctic Chironomidae. 386pp. Privately published at 3 St Felix Road, Huntingdon, Cambridgeshire, PE17 1YH, UK.

Lehmann, J. 1970a. Revision der europäischen Arten (Imagines) der Gattung *Parachironomus* Lenz (Diptera, Chironomidae). Hydrobiologia 33: 129-158.

Lehmann, J. 1970b. Revision der europäischen Arten (Imagines und Puppen) der Gattung *Rheotanytarsus* Bause (Diptera, Chironomidae). Zoologische Anzeiger 185: 344-378.

Levinton, J.S. 1995. Marine biology: function, biodiversity, ecology. New York: Oxford University Press.

Magurran, A.E. 1998. Ecological diversity and its measurement. Princeton University Press, Princeton, New Jersey, U.S.A.

Magurran, A.E. 2004. Measuring biological diversity. Blackwell.

Maschwitz, D.E. and E.F. Cook. 2000. Revision of the Nearctic species of the genus *Polypedilum* Kieffer (Diptera: Chironomidae) in the subgenera *P.* (Polypedilum) Kieffer and *P.* (Uresipedilum) Oyewo and Sæther. Ohio Biological Survey, Ohio State University.

Mason, P.G. 1986. Four new species of the *Cryptochironomus fulvus* (Johannsen) species complex (Diptera: Chironomidae). Entomologica scandanavica 16: 399-413.

Mendes, H. F. and T. Andersen. 2009. Neotropical *Nilothauma* Kieffer, 1921, with the description of thirteen new species (Diptera: Chironomidae). Zootaxa 2063: 1-45.

Menzie, C.A. 1980. The chironomid (Insecta: Diptera) and other fauna of a *Myriophyllum spicatum L.* plant bed in the lower Hudson River. Estuaries 3: 38-54.

Merritt, R.W., K.W. Cummins and M.B. Berg. 2008. An introduction to the aquatic insects of North America. 4th Ed., Kendall/Hunt Publishing Co., Dubuque, Iowa.

Mora, B., R. Rodriguez and U. Lopez. 2003. Sondeo ecológico rápido y monitoreo de especies indicadoras en el Parque Nacional Tortuguero. Editorial Guápiles. 150.

Murphy, P.M. and R.W. Edwards. 1982. The spatial distribution of the freshwater macroinvertebrate fauna of the River Ely, South Wales, in relation to pollutional discharges. Environmental Pollution (Series A). 29: 111-124.

Nordlie, F.G. and D.P. Kelso. 1975. Trophic relationships in a tropical estuary. Revista de Biologia Tropical 23: 77–99.

Nuhn, H. and S. Pérez. 1967. Estudio geográfico regional: zona atlántico norte de Costa Rica. Programa de Asistencia Técnica del Gobierno de la Republica Federal de Alemania, Instituto de Tierras y Colonización, San José, Costa Rica.

Oliveira, C.S.N. and F.L. Da Silva. 2011. Two new species of *Larsia* Fittkau, 1962 (Diptera Chironomonidae: Tanypodinae) from Neotropical region, with a checklist of *Larsia* species of the world. Zootaxa 2786: 27-41.

Oliver, D. R., M.E. Dillon and P.S. Cranston. 1990. A catalog of Nearctic Chironomidae. Research Branch Agriculture Canada, Publication 1857/B.

Oliver, D.R. & M.E. Dillon. 1994. Corrections and additions to "A catalog of Nearctic Chironomidae". Proceedings of the Entomological Society of Washington 96: 8-10.

Oyewo, E.A. and O.A. Sæther. 2008. Revision of *Polypedilum* (Pentapedilum) Kieffer and Ainuyusurika Sasa et Shirasaki (Diptera: Chironomidae). Zootaxa 1953: 1-145.

Pringle, C.M. and G.A. Blake. 1994. Quantitative effects of atyid shrimp (Decapoda: Atyidae) on the depositional environment in a tropical stream: use of electricity for experimental exclusion. Canadian Journal of Fisheries and Aquatic Sciences 51: 1443-1450.

Pringle C.M. and T. Hamasaki. 1998. The role of omnivory in a Neotropical stream: Separating diurnal and nocturnal effects. Ecology 79: 269-80.

R Development Core Team. 2009. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

Rae, J.G. 1989. Chironomid midges as indicators of organic pollution in the Sciotio River Basin, Ohio. The Ohio Journal of Science 89: 5-9.

Ramirez, A. and C.M. Pringle. 2006. Fast growth and turnover of chironomid assemblages in response to stream phosphorus levels in a tropical lowland landscape. Limnology and Oceanography 51: 189-196.

Ramirez, M.F. 2008. Emergent aquatic insects: assemblage structure and patterns of availability in freshwater wetlands of the lower Columbia River Estuary. Unpublished Master's thesis, University of Washington.

Raunio J., T. Ihaksi, A. Haapala and T. Muotka. 2007. Within- and among-lake variation in benthic macroinvertebrate communities—comparison of profundal grab sampling and the chironomid pupal exuvial technique. Journal of the North American Benthological Society 26: 708-718.

Rawson, D.S. and J.E. Moore. 1944. The saline lakes of Saskatchewan. Canadian Journal of Forest Research 22: 141-201.

Reiss, F. 1974a. Vier neue *Chironomus*-Arten (Chironomidae, Diptera) und ihre ökologische Bedeutung für die Benthosfauna zentralamazonischer Seen und Überschwemmungswälder. Amazoniana 5: 3-23.

Reiss, F. 1974b. Die in stehenden Gewässern der Neotropis verbreitete Chironomidengattung *Goeldichironomus* Fittkau (Diptera, Insecta). Studies on Neotropical Fauna 9: 85-122.

Reiss, F. and L. Säwedal. 1981. Keys to males and pupae of the Palaearctic (excl. Japan) *Paratanytarsus* Thienemann & Bause, 1913, n. comb., with descriptions of three new species (Diptera: Chironomidae). Entomogica Scandinavica Supplement 15: 73-104.

Reiss, F. 1990. Revision der Gattung *Zavreliella* Kieffer, 1920 (Diptera, Chironomidae). Spixiana 13: 83-115.

Roback, S.S. 1974. The immature stages of the genus *Coelotanypus* (Chironomidae; Tanypodinae: Coelotanypodini) in North America. Proceedings of the Academy of Natural Sciences of Philadelphia 126: 9-19.

Roback, S. S. and K. J. Tennessen. 1978. The immature stages of *Djalmabatista pulcher* [=*Procladius* (*Calotanypus*) *pulcher* (Joh.)]. Proceedings of the Academy of Natural Sciences of Philadelphia 130: 11-20.

Roback, S.S. 1980. The immature chironomids of the eastern United States IV. Tanypodinae – Procladiinae. Proceedings of the Academy of Natural Sciences of Philadelphia 132: 1-63.

Roback, S.S. 1981. The immature chironomids of the eastern United States V. Pentaneurini – Thienemannimyia Group. Proceedings of the Academy of Natural Sciences of Philadelphia 133: 73-128.

Roback, S.S. and W.P. Coffman. 1983. Results of the Catherwood Bolivian-Peruvian Altiplano expedition Part II. Aquatic Diptera including montane Diamesinae and Orthocladiinae (Chironomidae) from Venezuela. Proceedings of the Academy of Natural Sciences of Philadelphia 135: 9-79.

Roback, S.S. 1985. The immature chironomids of the eastern United States VI. Pentaneurini – Genus *Ablabesmyia*. Proceedings of the Academy of Natural Sciences of Philadelphia 137: 153-212.

Roback, S.S. 1987. The immature chironomids of the eastern United States IX. Pentaneurini – genus *Labrundinia* with the Description of some Neotropical material. Proceedings of the Academy of Natural Sciences of Philadelphia 139: 159-209.

Rufer, M.M. and L.C. Ferrington, Jr. 2007. Key to the Chironomidae pupal exuviae in the Twin Cities metro area lentic waters. Unpublished master's thesis, University of Minnesota, St. Paul, USA.

Ruse, L. 2002. Chironomid pupal exuviae as indicators of lake status. Archiv für Hydrobiologie 153: 367-390.

Sæther, O.A. 1977. Taxonomic studies on Chironomidae: *Nanocladius*, *Pseudochironomus*, and the *Harnischia* complex. Bulletin of the Fisheries Research Board of Canada. Bulletin 196.

Sæther, O.A. 1980. Glossary of chironomid morphology terminology (Chironomidae: Diptera). Entomologica Scandinavica Supplement 14: 1-51.

Sæther, O.A. 1981. Orthocladiinae (Chironomidae: Diptera) from the British West Indies with descriptions of *Antillocladius* n. gen., *Lipurometriocmemus* n. gen., *Compterosmittia* n. gen. and *Diplosmittia* n. gen. Entomogica Scandinavica Supplement 16: 1-46.

Sæther, O.A. and A. Sundal. 1999. *Cerobregma*, a new subgenus of *Polypedilum* Kieffer, with a tentative phylogeny of subgenera and species groups within *Polypedilum* (Diptera: Chironomidae). Journal of the Kansas Entomological Society 71: 315-382.

Saether, O. A., T. Andersen, L.C. Pinho and H.F. Mendes. 2010: The problems with *Polypedilum* Kieffer (Diptera: Chironomidae), with the description of *Probolum* subgen. n. Zootaxa 2497: 1-36.

Serrano, M.A.S. and U. Nolte. 1996. A sit-and-wait predatory chironomid from tropical Brazil - *Fittkauimyia crypta* sp. n. (Diptera: Chironomidae). Entomologica Scandinavica 27: 251-258.

Siqueira, T, F.O. Roque and S. Trivinho-Strixino. 2008. Species richness, abundance, and body size relationships from a neotropical chironomid assemblage: Looking for patterns. Basic and Applied Ecology 9: 606-612.

Simpson, K.W., R.W. Bode, and P. Albu. 1983. Keys for the genus *Cricotopus* adapted from Revison der Gattung *Cricotopus* van der Wulp und ihrer Verwandten (Diptera, Chironomidae) by M. Hirvenoja. New York State Museum, The University of the State of New York, Albany, NY. Bulletin 450.

Soponis, A.R. and K.W. Simpson. 1992. *Polypedilum digitifer* Townes and *Polypedilum griseopunctatum* (Malloch) (Diptera, Chironomidae): Redescription of adult males with a description and separation of the immature stages. Netherlands Journal of Aquatic Ecology 26: 203-213.

Souza, M.L., T.P. Moulton, R.M.L. Silveira, F.A.M. Krsulović and E.F. Brito. 2007. Responses of Chironomidae (Diptera: Insecta) to exclusion of shrimps and Ephemeroptera in a coastal forest stream, Rio de Janeiro, Brazil. Brazilian Journal of Biology 67: 631-637.

Spies, M. and F. Reiss. 1996. Catalog and bibliography of Neotropical and Mexican Chironomidae (Insecta, Diptera). Spixiana Supplement 22: 61-119.

Spies, M., T. Andersen, J.H. Epler, C.N. Watson, Jr. 2009. Chironomidae (non-biting midges). In Brown, B.V. et al. (eds.) Manual of Central American Diptera, vol. 1. - NRC Research Press, Ottawa.

Springer, M. 2009. Marine insects. Pp. 313-322. In I.S. Wehrtmann & J. Cortés (eds). Marine Biodiversity of Costa Rica, Central America. Monographiae Biologicae 86. SpringerScience + Business Media B.V., Germany.

Sublette, J.E. and M. Sasa. 1994. Chironomidae collected in Onchocerciasis endemic areas of Guatemala (Insecta, Diptera). Spixiana Supplement 20: 1-60.

Vårdal, H., A. Bjørlo and O.A. Sæther. 2002. Afrotropical *Polypedilum* subgenus *Tripodura*, with a review of the subgenus (Diptera: Chironomidae). Zoologica Scripta 31: 331-402.

Vallenduuk H.J. and E.E. Morozova. 2005. *Cryptochironomus*: An identification key to the larvae and pupal exuviae in Europe. Lautrebornia 55: 1-22.

Watson, C. N. Jr. and M.W. Heyn. 1992. A preliminary survey of Chironomidae (Diptera) of Costa Rica, with emphasis on the lotic fauna. Netherlands Journal of Aquatic Ecology 26: 257-262.

Wiedenbrug, S. and R. Ospina-Torres. 2005. A key of pupal exuviae of Neotropical Tanytarsini (Diptera: Chironomidae). Amazoniana 18: 317-371.

Wiedenbrug, S. and S. Trivinho-Strixino. 2011. New species of the genus *Corynoneura* Winnertz (Diptera, Chironomidae) from Brazil. Zootaxa 2822: 1-40.

Wiederholm, T. 1989. Chironomidae of the Holarctic Region: Keys and diagnoses. Part 2. Pupae. Entomologica Scandanavica Supplement 28: 1-482.

Wilson, R.S. and J.D. McGill. 1977. A new method of monitoring water quality in a stream receiving sewage effluent, using chironomid pupal exuviae. Water Research 11: 959-962.

Wilson, R.S. and J.D. McGill. 1982. A practical key to the genera of pupal exuviae of the British Chironomidae (Diptera, Insecta). University of Bristol Press. UK.

Wilson, R.S. 1987. Chironomid communities in the River Trent in relation to water chemistry. Entomologica Scandinavica Supplement 29: 387-193.

Wilson R.S. and L.P. Ruse. 2005. A guide to the identification of genera of chironomid pupal exuviae occurring in Britain and Ireland (including common genera from northern Europe) and their use in monitoring lotic and lentic fresh waters. Special Publication No 13. Freshwater Biological Association, Ambleside, Cumbria, UK.

Winemiller, K.O. and M.A. Leslie. 1992. Fish assemblages across a complex freshwater-marine ecotone. Environmental Biology of Fishes 34: 29-50.

Winemiller, K.O. and B.J. Ponwith. 1998. Comparative ecology of eleotrid fishes in Central American coastal streams. Environmental Biology of Fishes 53: 373-384.

APPENDIX

Table 1. Chironomidae generic richness from samples collected in Laguna del Tortuguero 1.

Laguna del Tortuguero 1	Total	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun	4-Jan	5-Jan	6-Jan	7-Jan	8-Jan	9-Jan	10-Jan
Ablabesmyia	5						3		1	1					
Beardius	2				2										
Chironomus	2					1					1				
Cladopelma	6						6								
Coelotanypus	45	11			3					14	11	2	1	2	1
Cricotopus	12		2		2	1		6				1			
Cryptochironomus	4			1	1			1			1				
Cryptotendipes	102	5	6	15	31	15	30								
Djalmabatista	1				1										
Endotribelos	3				3										
Goeldichironomus	1				1										
Harnischia	1				1										
Labrundinia	6		5			1									
Nanocladius	51	2		1		7	23	2	1		5	2	2	6	
Nilothauma	4					1	3								
Parachironomus	4				1		2				1				
Paratendipes	8				5						3				
Polypedilum	105	1	2	16	61	3	7			1	7	2		5	
Procladius	14		5	4	3		1							1	
Pseudochironomus	7	1	1		4	1									
Rheotanytarsus	7			1	1	3	2								
Stenochironomus	6				4	1	1								
Tanytarsus	452		25	33	172	61	154	5		1				1	
Unknown Chironomini #2	1				1										
Unknown Chironomini #3	1				1										
Unknown Orthocladiinae #1	1							1							
Unknown Tanytarsini #1	1						1								
Xestochironomus	1				1										
Total	**853**	**20**	**46**	**71**	**299**	**95**	**233**	**15**	**2**	**17**	**29**	**7**	**3**	**15**	**1**
Generic Richness	**28**	**5**	**7**	**7**	**20**	**11**	**12**	**5**	**2**	**4**	**7**	**4**	**2**	**5**	**1**
Percent Richness	**100**	**17.9**	**25.0**	**25.0**	**71.4**	**39.3**	**42.9**	**17.9**	**7.1**	**14.3**	**25.0**	**14.3**	**7.1**	**17.9**	**3.6**

Table 2. Chironomidae species richness from samples collected in Laguna del Tortuguero 1.

Laguna del Tortuguero 1	Total	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun	4-Jan	5-Jan	6-Jan	7-Jan	8-Jan	9-Jan	10-Jan
Ablabesmyia sp. 1	4						3		1						
Beardius sp. 1	2				2										
Chironomus sp. 1	1					1									
Chironomus sp. 2	1										1				
Cladotanytarsus sp. 1	3				3										
Coelotanypus sp. 1	42	11								14	11	2	1	2	1
Cricotopus sp. 1	17		2		1	1	6	6				1			
Cricotopus sp. 3	2				1			1							
Cryptochironomus sp. 1	2				1						1				
Cryptotendipes sp. 1	92		6	15	29	13	29								
Cryptotendipes sp. 2	2				1		1								
Djalmabatista sp. 1	1				1										
Endotribelos sp. 1	3				3										
Goeldichironomus sp. 1	1				1										
Harnischia sp. 1	1				1										
Labrundinia sp. 1	6		5			1									
Nanocladius minimus	51	2		1		7	23	2	1		5	2	2	6	
Nilothauma near *reissi* var. 2	1						1								
Nilothauma near *reissi* var. 3	1						1								
Nilothauma sp. 1	1					1									
Nilothauma sp. 2	1						1								
Parachironomus sp. 1	2				1		1								
Parachironomus sp. 2	1						1								
Parachironomus sp. 4	1										1				
Paratendipes sp. 3	7				4						3				
Paratendipes sp. 5	1				1										
Polypedilum sp. 1	61			11	38	1	4				6	1			
Polypedilum sp. 2	12				9	2	1								
Polypedilum sp. 3	3				3										
Polypedilum sp. 4	1			1											
Polypedilum sp. 5	7				1		2			1				3	
Polypedilum sp. 8	4				3									1	
Polypedilum sp. 9	3				3										
Procladius bellus	14		5	4	3		1						1		
Pseudochironomus richardsoni	5		1		3	1									
Pseudochironomus sp. 1	1				1										
Rheotanytarsus sp. 1	7			1	1	3	2								
Stenochironomus sp. 1	3				2		1								
Stenochironomus sp. 3	1					1									
Stenochironomus sp. 5	3				2						1				
Tanytarsus sp. 1	230		19	20	137	3	51								
Tanytarsus sp. 2	179		4	13	22	49	91								
Tanytarsus sp. 4	4							4							
Tanytarsus sp. 7	12				10			1			1				
Tanytarsus sp. 8	10			1		7	2								
Tanytarsus sp. 9	4				1		2			1					
Tanytarsus sp. 10	1													1	
Xestochironomus subletti	1				1										
Total	**813**	**13**	**42**	**67**	**290**	**91**	**224**	**14**	**2**	**16**	**30**	**6**	**4**	**13**	**1**
Species Richness	**48**	**2**	**7**	**9**	**31**	**14**	**20**	**5**	**2**	**3**	**9**	**4**	**3**	**5**	**1**
Percent Richness	**100.0**	**4.2**	**14.6**	**18.8**	**64.6**	**29.2**	**41.7**	**10.4**	**4.2**	**6.3**	**18.8**	**8.3**	**6.3**	**10.4**	**2.1**

Table 3. Chironomidae generic richness from samples collected in Laguna del Tortuguero 2.

Laguna del Tortuguero 2	Total	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun	4-Jan	5-Jan	6-Jan	7-Jan	8-Jan	9-Jan	10-Jan
Ablabesmyia	26	2	4	5	4		1	1	4		5				
Beardius	7			1	1		1				3			1	
Chironomus	25	23			1						1				
Cladopelma	5		2	1	1						1				
Cladotanytarsus	4			2	1		1								
Coelotanypus	82		18						7	22	30	1	2	1	1
Corynoneura	2					1			1						
Cricotopus	33	4	1	2	4	2	16	4							
Cryptochironomus	17		1	4	1	1			4		1		1	3	1
Cryptotendipes	138	13	29	25	46	2	2	18		1	1				1
Djalmabatista	2		1	1											
Endotribelos	7				1				2		1	1		2	
Goeldichironomus	8		2		3		2							1	
Harnischia	1				1										
Labrundinia	31		3	8	6	2	1	3	5		1			2	
Nanocladius	74		7	3		3	2	5	21		9	7	5	10	2
Nilothauma	5		2			1					2				
Parachironomus	6				1					1	1			3	
Paratendipes	13			4	2		3		1		1	1	1		
Polypedilum	322	3	48	57	57	2	6	5	6	1	61	4	11	61	
Procladius	75	4	33	24	8	1	1		1	3					
Pseudochironomus	15	6	1	4	2			1	1						
Rheotanytarsus	12		2	2		1				1	1		1	4	
Saetheria	1			1											
Stenochironomus	20		4	5	2				1	2	3	2	1		
Tanytarsus	417	2	75	81	151	11	38	21	1	1	30	1	2	3	
Thienemanniella	1													1	
Unknown Chironomini #1	4		1	1							1				1
Unknown Chironomini #2	2		1		1										
Unknown Orthocladiinae #1	2			1					1						
Unknown Orthocladiinae #2	1		1												
Unknown Pentaneurini #1	3				2						1				
Unknown Tanytarsini #1	5				3				1		1				
Unknown Tanytarsini #2	3										3				
Zavreliella	1			1											
Total	**1370**	**57**	**236**	**233**	**299**	**27**	**74**	**58**	**57**	**32**	**158**	**17**	**24**	**92**	**6**
Generic Richness	**35**	**8**	**20**	**21**	**22**	**11**	**12**	**8**	**15**	**8**	**21**	**7**	**8**	**12**	**5**
Percent Richness	**100**	**22.9**	**57.1**	**60.0**	**62.9**	**31.4**	**34.3**	**22.9**	**42.9**	**22.9**	**60.0**	**20.0**	**22.9**	**34.3**	**14.3**

Table 4. Chironomidae species richness from samples collected in Laguna del Tortuguero 2.

Laguna del Tortuguero 2	Total	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun	4-Jan	5-Jan	6-Jan	7-Jan	8-Jan	9-Jan	10-Jan
Ablabesmyia sp. 1	25	2	4	5	3		1	1	4		5				
Ablabesmyia sp. 2	1				1										
Beardius sp. 1	7			1	1		1				3			1	
Chironomus sp. 1	2				1						1				
Cladopelma sp. 1	5		2	1	1						1				
Cladotanytarsus sp. 1	2				1		1								
Coelotanypus sp. 1	102	22	16	2					7	21	30	1	1	1	1
Corynoneura sp. 1	1					1									
Corynoneura sp. 2	1								1						
Cricotopus sp. 1	25	4		1	3		13	4							
Cricotopus sp. 2	4					2	2								
Cricotopus sp. 3	2			1	1										
Cryptochironomus sp. 1	4			1	1				2						
Cryptochironomus sp. 2	8		1			1			2		1		1	2	
Cryptochironomus sp. 4	2													1	1
Cryptotendipes sp. 1	128	13	28	24	45		1	15		1					1
Cryptotendipes sp. 2	2							1			1				
Djalmabatista sp. 1	1		1												
Endotribelos sp. 1	6				1				2			1		2	
Goeldichironomus sp. 1	4		2		2										
Goeldichironomus sp. 2	3				1		2								
Goeldichironomus sp. 4	1													1	
Harnischia sp. 1	1				1										
Labrundinia sp. 1	13		2		6	1	1	2			1				
Labrundinia sp. 2	1							1							
Labrundinia sp. 3	2													2	
Nanocladius minimus	76		7	3		3	2	5	23		9	7	5	10	2
Nilothauma near *reissi* var. 1	2		2												
Nilothauma sp. 1	1					1									
Nilothauma sp. 3	1										1				
Nilothauma sp. 4	1										1				
Parachironomus near *cayapo*	4				1					1	1			1	
Parachironomus sp. 2	2													2	
Paratendipes sp. 1	1										1				
Paratendipes sp. 2	2				1				1						
Paratendipes sp. 3	9			4	1		3						1		
Polypedilum sp. 1	160	2	35	42	40	2	4	2	3	1	1	3	7	18	
Polypedilum sp. 2	53		3	1	5		2	2	1		36		1	2	
Polypedilum sp. 3	3										1		1	1	
Polypedilum sp. 4	15		3	4	6									2	
Polypedilum sp. 5	11		2	1							7		1		
Polypedilum sp. 6	2			1										1	
Polypedilum sp. 7	31			3	1						2			25	
Polypedilum sp. 8	12				1						11				
Polypedilum sp. 9	3				3										
Polypedilum sp. 10	1				1										
Procladius bellus	74	4	33	24	8	1	1			3					
Pseudochironomus richardsoni	14	6	1	4	1			1	1						
Pseudochironomus sp. 2	1				1										
Rheotanytarsus sp. 1	12		2	2		1				1	1		1	4	
Saetheria near *tylus*	1			1											
Stenochironomus quadrinotatus	5		1							1	1	1	1		
Stenochironomus sp. 1	6		1	2					1		1	1			
Stenochironomus sp. 2	3				2					1					
Stenochironomus sp. 3	1		1												
Stenochironomus sp. 4	2			1							1				
Stenochironomus sp. 5	3		1	2											
Tanytarsus sp. 1	208	2	66	61	68		6	3			1	1			
Tanytarsus sp. 2	138		1	8	70	10	30	12	1	1	4			1	

Laguna del Tortuguero 2	Total	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun	4-Jan	5-Jan	6-Jan	7-Jan	8-Jan	9-Jan	10-Jan
Tanytarsus sp. 5	4		2	1	1										
Tanytarsus sp. 6	3		1	1							1				
Tanytarsus sp. 7	30		1	4	11		1	3			8		1	1	
Tanytarsus sp. 8	1			1											
Tanytarsus sp. 9	19			4	1	1					12			1	
Tanytarsus sp. 12	2										1		1		
Tanytarsus sp. 13	1										1				
Tanytarsus sp. 14	1		1												
Zavreliella sp. 1	1			1											
Total	**1277**	**55**	**221**	**212**	**292**	**24**	**71**	**52**	**49**	**31**	**148**	**15**	**22**	**80**	**5**
Species Richness	**70**	**8**	**28**	**31**	**34**	**11**	**16**	**13**	**13**	**9**	**31**	**7**	**12**	**21**	**4**
Percent Richness	**100.0**	**11.4**	**40.0**	**44.3**	**48.6**	**15.7**	**22.9**	**18.6**	**18.6**	**12.9**	**44.3**	**10.0**	**17.1**	**30.0**	**5.7**

Table 5. Chironomidae generic richness from samples collected in Laguna del Tortuguero 3.

Laguna del Tortuguero 3	Total	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun	4-Jan	5-Jan	6-Jan	7-Jan	8-Jan	9-Jan	10-Jan
Ablabesmyia	2					1	1								
Beardius	4					1	1						2		
Coelotanypus	6										4	1	1		
Corynoneura	3									1	1				1
Cricotopus	344	6	9	12	141	68	44	2	8	6	15	18	9		6
Cryptochironomus	6					1			1				4		
Cryptotendipes	10					6	4								
Endotribelos	2										1		1		
Nanocladius	14					1	10		1		1		1		
Parachironomus	2					1	1								
Paralauterborniella	3						3								
Paratendipes	4				1		1		1			1			
Polypedilum	20	1			1	2	1		1			1	12		1
Procladius	1												1		
Pseudochironomus	8		1	1					2	1	1				2
Rheotanytarsus	26					4	22								
Stenochironomus	2				1								1		
Tanytarsus	70				4	14	42	2					5	3	
Thienemanniella	2										1		1		
Unknown Pentaneurini #2	1					1									
Unknown Tanytarsini #2	1						1								
Xestochironomus	2					1								1	
Zavreliella	2						1						1		
Total	**535**	**7**	**10**	**13**	**148**	**101**	**132**	**4**	**14**	**8**	**24**	**21**	**39**	**4**	**10**
Generic Richness	**23**	**2**	**2**	**2**	**5**	**12**	**13**	**2**	**6**	**3**	**7**	**4**	**12**	**2**	**4**
Percent Richness	**100.0**	**8.7**	**8.7**	**8.7**	**21.7**	**52.2**	**56.5**	**8.7**	**26.1**	**13.0**	**30.4**	**17.4**	**52.2**	**8.7**	**17.4**

Table 6. Chironomidae species richness from samples collected in Laguna del Tortuguero 3.

Laguna del Tortuguero 3	Total	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun	4-Jan	5-Jan	6-Jan	7-Jan	8-Jan	9-Jan	10-Jan
Ablabesmyia sp. 1	1						1								
Beardius sp. 1	4					1	1						2		
Coelotanypus sp. 1	1												1		
Coelotanypus sp. 2	3										2	1			
Corynoneura sp. 1	1														1
Corynoneura sp. 2	2									1	1				
Cricotopus sp. 1	244	5	8	12	107	33	34	2	5	4	8	16	9		1
Cricotopus sp. 2	89	1			32	35	8		3	1	7	2			
Cryptochironomus sp. 1	3					1			1				1		
Cryptochironomus sp. 2	3												3		
Cryptotendipes sp. 1	10					6	4								
Endotribelos sp. 1	2										1		1		
Nanocladius minimus	13						10		1		1		1		
Parachironomus near *cayapo*	1						1								
Paralauterborniella nigrohalteralis	3						3								
Paratendipes sp. 1	1						1								
Paratendipes sp. 3	3				1				1			1			
Polypedilum sp. 1	7				1		1						5		
Polypedilum sp. 5	1								1						
Polypedilum sp. 6	1														1
Polypedilum sp. 8	1												1		
Polypedilum sp. 11	1											1			
Procladius bellus	1												1		
Pseudochironomus richardsoni	7		1	1					2	1	1				1
Rheotanytarsus sp. 1	22						22								
Stenochironomus sp. 3	1				1										
Stenochironomus sp. 4	1												1		
Tanytarsus sp. 1	12				2		6	1					3		
Tanytarsus sp. 2	8				1		4	2						1	
Tanytarsus sp. 3	2				1									1	
Tanytarsus sp. 5	2						2								
Tanytarsus sp. 6	1						1								
Tanytarsus sp. 7	12						11						1		
Tanytarsus sp. 9	14						12						1	1	
Thienemanniella sp. 1	1										1				
Thienemanniella sp. 2	1												1		
Xestochironomus subletti	1													1	
Xestochironomus sp. 1	1					1									
Zavreliella near *marmorata*	1												1		
Zavreliella sp. 1	1						1								
Total	**484**	**6**	**9**	**13**	**146**	**77**	**123**	**5**	**14**	**7**	**22**	**21**	**33**	**4**	**4**
Species Richness	**40**	**2**	**2**	**2**	**8**	**6**	**18**	**3**	**7**	**4**	**8**	**5**	**16**	**4**	**4**
Percent Richness	**100.0**	**5.0**	**5.0**	**5.0**	**20.0**	**15.0**	**45.0**	**7.5**	**17.5**	**10.0**	**20.0**	**12.5**	**40.0**	**10.0**	**10.0**

Table 7. Chironomidae generic richness from samples collected in Quebrada.

Quebrada	Total	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun	4-Jan	5-Jan	6-Jan	7-Jan	8-Jan	9-Jan	10-Jan
Beardius	17				1				3	1	4	5	2	1	
Chironomus	26			1	1	3			5	2	8	5			1
Corynoneura	1											1			
Cricotopus	1						1								
Endotribelos	3									1		2			
Fittkauimyia	4										2	2			
Goeldichironomus	3					1					1	1			
Labrundinia	6								1		4	1			
Larsia	4		1									1	2		
Nanocladius	3								1			1		1	
Parachironomus	3								1			1		1	
Paramerina	5								1	1		2	1		
Polypedilum	14								2	1	5	6			
Rheotanytarsus	1						1								
Tanytarsus	50								10	5	16	13	4	1	1
Unknown Pentaneurini #3	2										2				
Total	**126**	**0**	**1**	**1**	**1**	**4**	**2**	**0**	**21**	**10**	**38**	**36**	**7**	**3**	**2**
Generic Richness	**16**	**0**	**1**	**1**	**1**	**2**	**2**	**0**	**7**	**5**	**7**	**12**	**3**	**3**	**2**
Percent Richness	**100**	**0**	**6.25**	**6.25**	**6.25**	**12.5**	**12.5**	**0**	**43.75**	**31.25**	**43.75**	**75**	**18.75**	**18.75**	**12.5**

Table 8. Chironomidae species richness from samples collected in Quebrada.

Quebrada	Total	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun	4-Jan	5-Jan	6-Jan	7-Jan	8-Jan	9-Jan	10-Jan
Beardius sp. 1	17				1				3	1	4	5	2	1	
Chironomus sp. 1	5			1	1	3									
Chironomus sp. 2	19								4	2	8	5			
Corynoneura sp. 3	1											1			
Cricotopus sp. 1	1						1								
Fittkauimyia crypta	4										2	2			
Goeldichironomus sp. 1	1											1			
Goeldichironomus sp. 3	1										1				
Goeldichironomus sp. 5	1					1									
Endotribelos sp. 1	3									1		2			
Labrundinia sp. 3	6								1		4	1			
Larsia sp. 1	1		1												
Nanocladius minimus	2											1		1	
Nanocladius sp. 1	1								1						
Parachironomus sp. 3	3								1			1		1	
Paramerina sp. 1	5								1	1		2	1		
Polypedilum sp. 2	1										1				
Polypedilum sp. 5	5									1	1	3			
Polypedilum sp. 7	1											1			
Polypedilum sp. 11	1								1						
Polypedilum sp. 12	5								1		2	2			
Rheotanytarsus sp. 1	1						1								
Tanytarsus sp. 3	19								2	3	8	5	1		
Tanytarsus sp. 7	5										5				
Tanytarsus sp. 10	24								7	2	2	8	3	1	1
Tanytarsus sp. 11	2								1		1				
Total	**135**	**0**	**1**	**1**	**1**	**4**	**2**	**0**	**20**	**10**	**35**	**35**	**5**	**3**	**1**
Species Richness	**26**	**0**	**1**	**1**	**1**	**2**	**2**	**0**	**10**	**6**	**11**	**14**	**3**	**3**	**1**
Percent Richness	**100.0**	**0.0**	**3.8**	**3.8**	**3.8**	**7.7**	**7.7**	**0.0**	**38.5**	**23.1**	**42.3**	**53.8**	**11.5**	**11.5**	**3.8**