

Chironomidae (Insecta: Diptera) of Ecuadorian high-altitude streams: a survey and illustrated key

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Abstract

Chironomidae (Diptera) are among the most diverse and widespread aquatic insects, with roughly 5,500 described species inhabiting an enormous variety of aquatic ecosystems, ranging from moist soils to lakes and rivers, and even marine ecosystems. Despite its ubiquity, the group remains underrepresented in studies addressing aquatic insect assemblages of high-altitude systems, either glacier-fed or non-glacial, particularly in South America. Glacier-fed streams possibly are one of the harshest ecosystems in nature, and present a distinct downstream pattern in species distribution and diversity away from the constraining influence of the glacier. In this context, the goal of our study was to provide data on the chironomid fauna of glacier-fed streams, together with neighboring non-glacial streams in Ecuador, in order to contribute to the overall knowledge of tropical fauna in high Andean regions. Also, we sought to provide an identification key and photography material for future studies. Collections of non-biting midges were made in Ecuador during Jan 2008. In total, 1,412 specimens belonging to 16 genera and at least 23 species within the subfamilies Chironominae (3 taxa), Diamesinae (3 taxa), Podonominae (3 taxa), Orthoclaadiinae (13 taxa), and Tanypodinae (1 taxon) were found. The subfamilies Podonominae and Orthoclaadiinae predominated in terms of abundance. *Parochlus* was the most widespread genus of Chironomidae, while *Cricotopus* was the most diverse. This study contributes to the knowledge of the chironomid fauna in the high-altitude streams in Ecuador, and hopefully will motivate further studies in the area.

Key Words: non-biting midges; high Andes; Neotropical; Antisana volcano; glacier-fed streams; non-glacial streams

Resumo

Chironomidae (Diptera) estão entre os mais diversos e difundidos insetos aquáticos, com cerca de 5.500 espécies descritas, habitando uma enorme variedade de ecossistemas aquáticos, desde solos úmidos, lagos e rios, até mesmo ecossistemas marinhos. Apesar de sua onipresença, o grupo continua sub-representado em estudos que abordam assembléias de insetos aquáticos de sistemas de alta altitude, seja de origem glacial ou não, particularmente na América do Sul. Riachos glaciais são possivelmente um dos ecossistemas mais severos da natureza e, portanto, apresentam tipicamente um padrão espacial distinto na distribuição e diversidade das assembleias de espécies a jusante e longe da influência limitadora da geleira. Neste contexto, o objetivo do nosso estudo foi fornecer dados sobre a fauna de Chironomidae de alguns riachos glaciais e não-glaciais no Equador, a fim de contribuir para o conhecimento global da fauna tropical nas regiões andinas de alta latitude, além de fornecer uma chave de identificação e um catálogo fotos para futuros estudos. Durante o mês de janeiro de 2008, as coletas de Chironomidae foram realizadas no Equador. No total, 1.412 espécimes pertencentes a 16 gêneros e pelo menos 23 espécies pertencentes às subfamílias Chironominae (3 táxones), Diamesinae (3 táxones), Podonominae (3 táxones), Orthoclaadiinae (13 táxones) e Tanypodinae (1 taxon) foram encontrados. As subfamílias Podonominae e Orthoclaadiinae predominaram em termos de abundância. *Parochlus* foi o gênero mais difundido, enquanto *Cricotopus* o mais diversificado. O presente estudo contribui para o conhecimento sobre a fauna de Chironomidae nos córregos de alta altitude no Equador e espera-se que motive estudos adicionais na área.

Palavras Chave: quironomídeos; Alto Andes; Neotropical; vulcão Antisana; riachos glaciais e não glaciais

Non-biting midges (Insecta: Diptera: Chironomidae) are true flies, and the most widely distributed free-living holometabolous insects (Ferrington 2008). Chironomids inhabit an enormous variety of aquatic ecosystems, ranging from moist soils to pools in tree-holes, and from low-oxygen lake sediments to fast-flowing mountain streams (Ferrington et al. 2008). The adult life stage of chironomids is ephemeral, and most of the lifespan is spent in the larval stage (Thienemann 1954; Tokeshi 1995). The countless species and habitat diversity makes this family a valuable indicator species for lentic and lotic aquatic ecosystems, but also they are particularly well suited for phylogenetic and biogeographical investi-

gations (Silva & Ekrem 2016). Nevertheless, in order to obtain the most biologically informative data, it is fundamental to identify taxa to species, because within a single genus, species may respond in a distinct manner to environmental changes (Lenat & Resh 2001). Generally, the lack of descriptions and keys to a local fauna precludes species determination, or workers choose to overlook the chironomids in favor of groups (e.g., Ephemeroptera, Plecoptera, Trichoptera) that are more limited in number and diversity (Spies et al. 2009).

Approximately 900 chironomid species are recognized from the Neotropical region (Martin Spies, personal communication). This

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number has been increasing in recent years thanks to intense taxonomic work being conducted, particularly in Brazil and Argentina (e.g., Oliveira et al. 2013; Trivinho-Strixino et al. 2013, 2015; Andersen & Pinho 2014; Silva et al. 2014a, b; Andersen et al. 2015; Silva & Wiedenbrug 2015; Siri et al. 2015; Parise & Pinho 2016; Silva & Oliveira 2016; Silva & Ferrington 2018). When it comes to Ecuador, the chironomid fauna and its diversity remain poorly known (e.g., Brundin, 1966; Roback & Coffman 1983; Prat et al. 2010, 2011), most likely due to the insufficient number of scientists working with this group in the region.

High-altitude streams, especially those fed by glaciers, are possibly one of the harshest ecosystems in nature, and therefore typically present a distinct spatial pattern in the distribution of diversity and species assemblages downstream and away from the constraining influence of the glacier (Sæther 1968; Steffan 1971). Glacier-fed streams are characterized by a unique fluctuation pattern in discharge that is significantly different in temperate/arctic and tropical/equatorial glacier-fed streams (Milner & Petts 1994; Jacobsen et al. 2010). Although the ecology (see Britain & Milner 2001) and fauna (e.g., Füreder et al. 2000; Lods-Crozet et al. 2002; Robinson et al. 2001; Lencioni et al. 2002) of temperate glacier-fed streams have been studied intensely, only a few studies were dedicated to the fauna of these ecosystems in the tropics (Jacobsen et al. 2010; Kuhn et al. 2011). In this context, the goal of our study was to provide data on the chironomid fauna of Ecuadorian high-altitude streams, both glacier-fed and non-glacial, in order to contribute to the overall knowledge of the tropical fauna in high-elevation Andean regions. Additionally, we also provide an identification key along with a photography catalogue of the chironomid larvae recorded in this study.

Materials and Methods

SITE DESCRIPTION

The Río Antisana is a headwater of the River Napo, a main tributary of the upper Amazon River. It originates at an altitude of 4,730 masl from the ‘Crespo’ glacier on Mount Antisana in the eastern Cordillera of the Andes of Ecuador (0.460000°S, 78.150000°W). Predominant soil types are hydrandepts and dystrandepts (both Andosols) with high volcanic ash content, low density and high phosphorous binding capacity (Buringh 1979). Air temperature, humidity, and solar radiation do not vary systematically during the year, whereas precipitation, cloud cover, and wind speed present more seasonal variability in the study region (Cadier et al. 2007). Mean annual precipitation is about 800 mm, falling mainly as snow and hail (Maisincho et al. 2007). Air temperature varies from about 3.7 °C at the lowest site to 1.3 °C at the upper site (Maisincho et al. 2007). The vegetation of the lower part of the study area is covered by low ‘páramo,’ a moorland type of vegetation with scattered

bushes typical of the northern Andes. Above about 4,600 masl, vegetation is characterized as sporadic tufts of grasses and cushion plants. For more information on the study area, see Jacobsen et al. (2010).

COLLECTION AND IDENTIFICATION

Collections were made from a total of 17 sites in Jan 2008, 10 glacially influenced and 7 without glacial influence. The glacier-fed sites were located along a 4.3 km stretch of 3 streams originating side-by-side from 3 glaciers on Antisana (Fig. 1). On each of these streams, 3 sites were selected at varying distance from the glacier snout, and situated between 4,051 and 4,835 masl. At each site, 5 quantitative Surber samples (0.05 m², mesh size 200 µm) were collected randomly from pebble/cobble substratum in riffle/run habitats. In addition, a qualitative search was made for about 20 to 30 min in other microhabitats. The 5 non-glacial streams (7 sites, 3,925–4,105 masl) were sampled using only qualitative sampling (kicking technique). All samples were field-preserved using 70% ethanol. At each site, basic environmental variables were measured (Table 1). For detailed description of the methods used, see Kuhn et al. (2011). In the laboratory, the samples were rinsed through a 200 µm sieve, and larvae and pupae of Chironomidae were sorted under a stereoscopic microscope at 10× magnification, dehydrated in 96 and 99% ethanol, and slide-mounted in Euparal (ASCO Laboratories, Manchester, England) for species identification. Morphological identification was made based on the keys of Ruiz-Moreno et al. (2000), Epler (2001), Prat et al. (2011), Andersen et al. (2013), Trivinho-Strixino (2014), and, occasionally, original descriptions. Voucher specimens are deposited in the Biology Department, University of Copenhagen, Copenhagen, Denmark.

Results

A total of 1,412 specimens were collected, and identified as 23 species (Table 2) belonging to 16 genera and 5 subfamilies: Orthoclaadiinae (13 taxa), Chironominae (3 taxa), Diamesinae (3 taxa), Podonominae (3 taxa), and Tanypodinae (1 taxon). Larvae of the subfamilies Orthoclaadiinae and Podonominae highly predominated in terms of abundance, comprising 60 and 39% of the total abundance, respectively. Chironominae were sampled seldomly and always in small numbers. Only 1 genus was recorded for Tanypodinae, *Pentaneura* Phillippi. *Parochlus* Enderlein was the most widespread genus of Chironomidae, while *Cricotopus* van der Wulp was the most diverse. In total, 21 taxa were recorded in glacier-fed streams, and 13 in non-glacial streams. Eight taxa occurred exclusively in glacier-fed streams, 1 taxon was exclusive for non-glacier streams, *Orthocladius* (*Euo.*) sp.; however, it was common in non-glacial streams. *Parochlus* sp. B and *Podonomus* Phillippi were typical for glacially influenced streams, and were rarely collected or not collected in the streams without glacial influence.

Key to subfamilies (only subfamilies recorded in the study are included)

- 1. Antenna retractile into the head capsule, prementum with well-developed ligula (Fig. 23) Tanypodinae
- 1.— Antenna not retractile, ligula never developed 2
- 2. Ventral part of mentum laterally developed into ventromental plates of different shape, usually striate and never with beard Chironominae
- 2.— Ventromental plates, if developed, never striated and sometimes with beard beneath 3
- 3. Procerci obvious, minimum 3× as long as wide, usually much longer (8–10×). Premandibles absent (Figs. 7–9) Podonominae
- 3.— Procerci less than 3× as long as wide, usually much less or reduced. Premandibles present 4

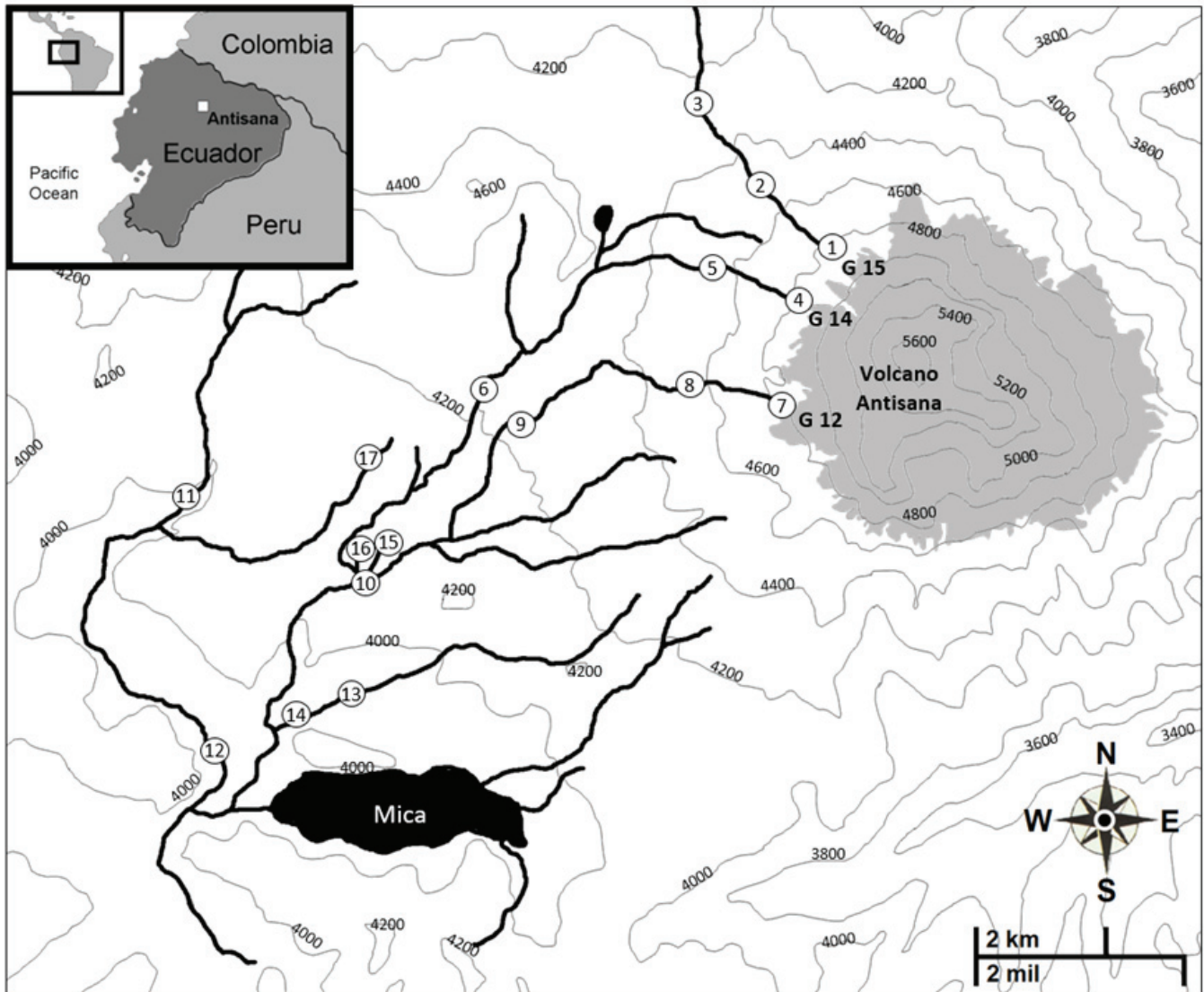


Fig. 1. Map of the Antisana stream system. For site codes see Tables 1 and 2. Glaciated area is marked with grey. Sites 1 to 10 are glaciated, sites 11 to 17 are non-glacial.

4. Prementum with 3 dense brushes of hair-like processes. Usually with distinctive 'collar' (occipital margin of the head). Mentum either very wide, with 2 narrow medium teeth and > 8 lateral teeth of similar size (Figs. 5–6), or with 1 very broad median tooth and 5 laterals (Fig. 4). Head dark brown, body 'fleshy' Diamesinae (Heptagyini)
- 4.— Prementum with lamellae rather than brushes. Mentum usually narrower, with at most 3 median teeth. Body of various coloration ... Orthoclaudiinae

Notes: The only Tanypodinae recorded in the studied streams was *Pentaneura* sp. (Fig. 23). There was 1 specimen in the Surber samples of the Glacier stream 14, site 3 (farthest from the glacier terminus), and it is apparently very rare in the region.

Subfamily Chironominae

1. Antennae long, placed on pedestals (Fig. 3) Tanytarsini
- 1.— Antenna shorter, growing directly from head (Chironomini, Pseudochironomini) 2
2. Mentum with a single broad median tooth, ventromental plates slender, scarcely separated medially. Anal tubules elongate, manifold exceeding the length of parapods (Fig. 2) *Manoa*
- 2.— Mentum with paired median teeth, first laterals shorter than median and second lateral teeth, ventromental plates widely separated. Anal tubules shorter than parapods *Polypedilum*

Notes: The only Tanytarsini collected was 1 specimen of *Tanytarsus* sp. (Fig. 3) in stream 14, site 3. One individual of *Manoa* sp. (Pseudochironomini) was recorded in Glacier stream 15, site 3. Both taxa are particularly rare.

Table 1. Basic environmental variables of the studied streams. For details see Kuhn et al. (2011).

Site code	Glacial stream sites										Non-glacial stream sites						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Stream	G 15	G 15	G 15	G 14	G 14	G 14	G 12	G 12	G 12	Rio Antisana							
Site	S 1	S 2	S 3	S 1	S 2	S 3	S 1	S 2	S 3		S 1	S 2	S 1	S 2			
Altitude (masl)	4,835	4,521	4,335	4,789	4,535	4,196	4,728	4,496	4,225	4,051	4,000	3,925	3,960	3,958	4,070	4,058	4,105
UTM	817040	815887	814882	816356	815255	811885	816375	815013	812563	810143	807352	808047	809341	808958	810177	810142	809926
UTM	9947921	9948823	9950099	9947100	9947505	9945676	9945638	9945884	9945513	9943562	9944435	9940533	9941401	9941122	9943613	9943789	9944383
Catchment (km ²)	0.46	1.02	1.47	0.65	1.12	14.27	2.13	3.21	4.33	14.55	17.29	41.69	9.27	9.51			
Glacier cover in catchment (%)	94	45	31	92	67	10	100	66	49	13	0	0	0	0	0	0	0
Distance to glacier (m)	100	1500	3500	200	1500	5600	50	1500	4300	7600	6	6	5	6	2	1	1
Min. turbidity (NTU)	812	211	65	181	111	58	285	442	411	37	6	6	7.98	7.96	7.88	7.15	7.78
Max. pH	7.98	7.07	6.44	6.31	7.04	7.96	7.47	6.36	6.39	8.38	7.59	8.74	9.91	9.17	7.33	7.88	9.80
Max. Conductivity (μS cm ⁻¹)	3	8	24	11	10	47	5	10	14	162	139	237	254	254	148	142	227
Mean temperature (°C)	1.56	4.20	5.05	2.48	4.31	7.42	1.59	2.86	5.38	7.94	8.39	9.91	9.17	9.17	7.33	7.88	9.80
CV temp. (%)	111	102	63	126	80	34	180	46	51	21	16	16	14	14	11	11	9
Mean max. temperature (°C)	4.38	12.35	10.65	9.47	10.70	11.26	5.44	5.21	10.94	10.93	10.66	12.36	11.46	11.46	9.35	9.90	9.90
Mean min. temperature (°C)	0.47	0.30	1.56	0.00	0.60	4.32	0.00	1.36	2.62	6.24	6.85	8.10	7.77	7.77	5.80	7.20	8.20
Mean depth (cm)	5	6	10	6	10	18	3	13	19	33	56	19	66	43	18	32	19
CV depth (%)	52	84	69	18	20	30	110	35	27	12	25	66	7	11	6	3	6
Substrate types (nr.)	6	8	6	5	6	8	5	6	10	6	5	9	3	7	7	8	6
Substrate type div. (H')	1.63	1.88	1.52	1.60	1.70	1.95	1.05	1.60	2.11	1.72	1.39	1.96	1.00	1.58	1.70	1.35	0.96
Mean current (m s ⁻¹)	0.24	0.11	0.13	0.25	0.24	0.19	0.22	0.38	0.21	0.58	0.31	0.61	0.17	0.42	0.31	0.28	0.10
Mean width (cm)	67	59	63	72	133	133	39	204	158	146	60	181	223	228	56	356	531
Slope (cm m ⁻¹)	11.7	9.7	7.3	24	10.8	2.2	1.4	8.7	9	2.3	1.5	3.2	0.4	4.1	9.6	6.8	1.7
Stability index	9	18	25	15	21	31	16	24	21	45	42	35	44	47	39	48	58
Chlorophyll (mg m ⁻²)	0.14	3.92	2.63	0.55	6.17	1.85	0.27	3.15	0.99	10.937	1.957	13.049	1.981	22.031	23.090	27.142	16.424

Abbreviations: UTM – Universal Transverse Mercator coordinate system; AFDM – ash-free dry mass; CV – coefficient of variation.

Table 2. Chironomid taxa recorded in the surveyed streams in the Antisana region, Ecuador, in Jan 2008. Numbers indicate summary abundance in 5 Surber samples; + indicate records in qualitative samples.

Site code	Glacial stream sites										Non-glacial stream sites						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Stream	G 15	G 15	G 15	G 14	G 14	G 14	G 12	G 12	G 12	Rio Antisana	Jatunhuayco	Jatunhuayco	Micahuayco	Micahuayco	Spring stream	Humboldt	Yacupampa
Site	S 1	S 2	S 3	S 1	S 2	S 3	S 1	S 2	S 3		S 1	S 2	S 1	S 2			
Chironominae																	
<i>Manoa</i> sp.	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Polypedium</i> sp.	—	—	—	—	—	3	—	—	—	+	+	+	+	—	—	—	—
<i>Tanytarsus</i> sp.	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—
Diaresinae																	
<i>Limaya</i> sp.	—	—	—	—	—	—	—	—	—	+	—	—	—	—	+	—	—
<i>Paraheptagytia</i> sp. A	—	1	+	—	2	—	1	+	—	+	—	+	+	—	—	—	—
<i>Paraheptagytia</i> sp. B	—	—	—	—	1	—	—	+	—	+	—	—	+	—	—	—	—
Orthocladinae																	
<i>Corynoneura lobata</i> gr.	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—
<i>Cricotopus</i> sp. A	—	9	+	—	—	—	+	+	+	—	—	—	—	—	—	—	—
<i>Cricotopus</i> sp. B	—	55	98	6	28	32	+	37	18	—	+	+	+	+	+	+	+
<i>Cricotopus</i> sp. C	—	2	7	—	15	230	—	1	88	+	+	+	+	+	+	+	+
<i>Cricotopus</i> sp. D	—	—	—	—	—	16	—	—	—	+	—	—	—	—	—	—	—
<i>Linnophyes</i> sp.	—	6	—	1	40	7	2	5	3	+	—	+	+	+	—	—	+
<i>Metriocnemus fuscipes</i> gr.	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Metriocnemus eurynotus</i> gr.	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Oncocnema</i> sp.	—	—	—	—	—	—	—	—	—	+	—	—	—	—	—	—	—
<i>Orthocladus</i> (<i>Euo.</i>) sp.	—	—	—	—	—	—	—	—	—	—	+	+	+	+	+	+	+
<i>Parakiefferiella</i> sp.	—	—	1	—	+	126	—	—	2	+	—	—	—	—	—	—	—
<i>Pseudosmittia</i> sp.	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Smittia</i> sp.	—	—	2	—	2	—	—	—	—	—	—	—	—	+	—	—	—
Podonominae																	
<i>Parochlus</i> sp. A	16	24	20	13	177	37	49	46	3	+	+	—	+	—	+	+	+
<i>Parochlus</i> sp. B	+	1	5	1	2	2	14	—	—	—	—	—	—	—	—	—	—
<i>Podonomus</i> sp.	28	4	1	71	2	18	20	3	1	+	+	—	+	—	—	—	+
Tanypodinae																	
<i>Pentaneura</i> sp.	—	—	—	—	—	1	—	—	—	—	+	—	—	—	—	—	—



Figs. 2–7. *Manoa* sp.: 2a. Labrum-epipharyngis. 2b. Antennae. 2c. Mentum, mandibles and ventromental plates. 2d. Posterior parapods and anal tubules, lateral view. *Tanytarsus* sp.: 3a. Mandible. 3b. Mentum and ventromental plates. 3c. Head capsule, ventral view. 3d. Labro-epipharyngeal region (arrow indicates pre-mandibles with 3 teeth). *Limaya* sp.: 4a. Mandible. 4b. Mentum. 4c. Antenna. 4d. Labro-epipharyngeal region. *Paraheptagyia* sp. A: 5a. Head capsule, dorsal view. 5b. Mentum and mandibles. 5c. Head capsule, ventral view, arrow indicates occipital margin. *Paraheptagyia* sp. B: 6a. Mentum. 6b. Mandibles. 6c. Anal end of body, lateral view. 6d. Head capsule, ventral view, arrow indicates occipital margin. *Parochlus* sp. A: 7a, e. Anal end with posterior parapods, procercus and anal setae, lateral and dorsal view. 7b. Mentum and mandibles. 7c. Claws of posterior parapods (note the 2 types of claws indicated by arrow). 7d. Antenna.

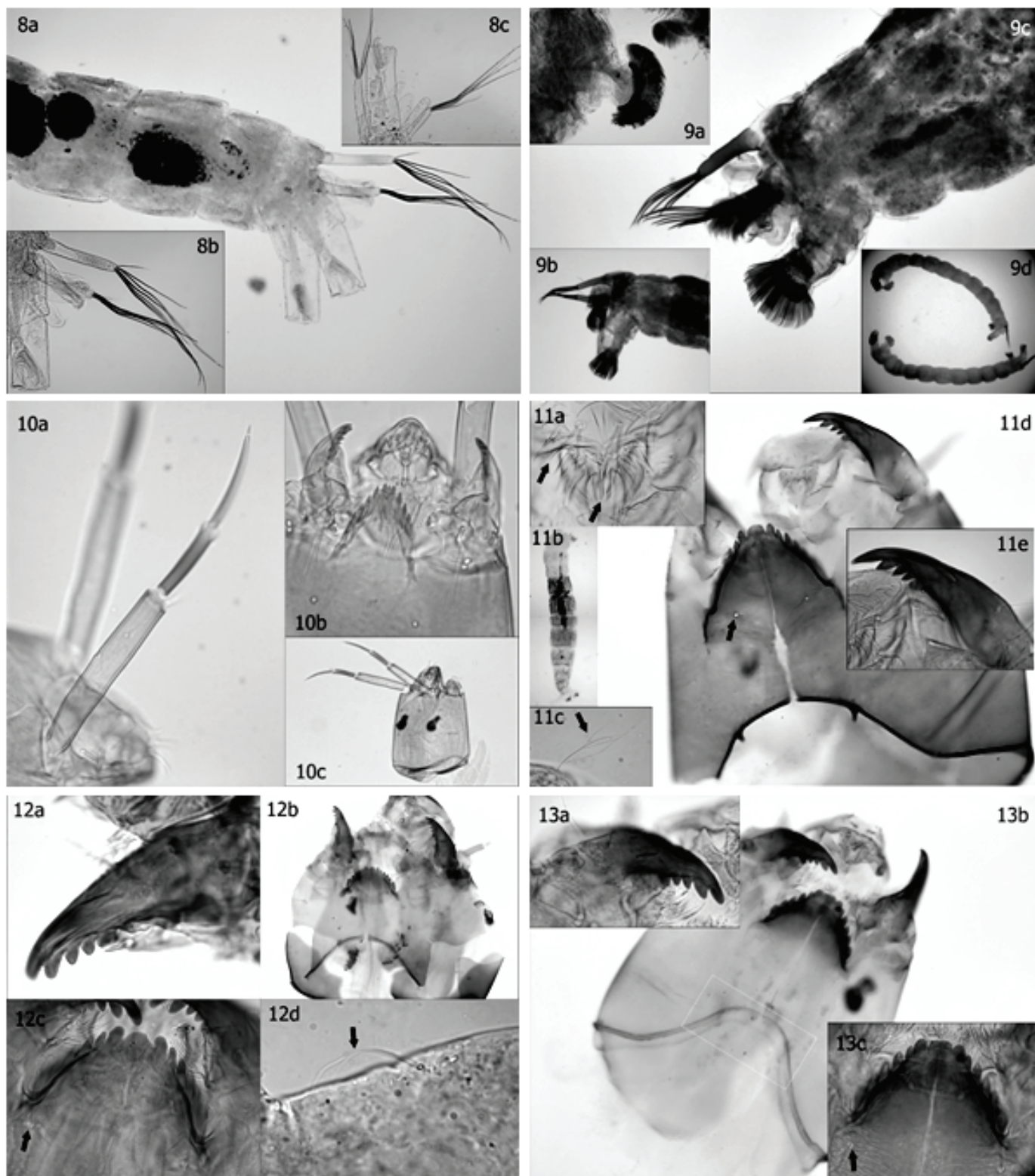
Subfamily Diamesinae

1. Mentum with a very broad middle tooth and 5 lateral teeth, occipital margin moderately developed (in the fourth instar larva) (Fig. 4) *Limaya*
- 1.— Mentum with 2 slightly smaller but non-recessed median teeth and more than 8 pairs of lateral teeth 2
2. Occipital margin very strong, dark brown to black, close to 30% of the head (Fig. 5) *Paraheptagyia* sp. A
- 2.— Occipital margin narrow, dark brown (Fig. 6) *Paraheptagyia* sp. B

Notes: Both *Paraheptagyia* types occur together in middle stream sites, and *P.* type B could be just a younger instar of *P.* type A.

Subfamily Orthoclaadiinae

1. Anal end without procercus, or if present, without distinct anal setae and posterior parapods 2
- 1.— Procercus present, posterior parapods well developed 3
2. Anterior parapods basally fused, with numerous fine spines on basal part. Posterior parapods reduced but separate and bearing simple claws, there is a line of fine claws beneath. Mentum with a single median tooth with a nipple and 5 pairs of lateral teeth (Fig. 22) *Smittia*
- 2.— Anterior and posterior parapods missing. Mentum with a single broad media tooth and 5 pairs of laterals. Mandible with 4 inner teeth, second is smaller than first and third (Fig. 21) *Pseudosmittia*
3. Antenna subequal to, or longer than head capsule, 4 segmented (Fig. 10) *Corynoneura*
- 3.— Antenna shorter than half length of head, with 5 to 6 segments 4
4. Antenna about one-third as long as head capsule, head prolonged. Body setation strong and obvious even under small magnification (Fig. 18) *Onconeura* sp.
- 4.— Antenna shorter, body setation weak, head more round 5
5. Mentum with 2 or more median teeth 6
- 5.— Mentum with 1 median tooth 8
6. Median mental teeth higher and broader than first lateral teeth. Wedge shaped darkly pigmented tubercle below outermost lateral teeth (Fig. 15) *Limnophyes*
- 6.— Median teeth smaller and shorter than first laterals. No such structure below outermost lateral teeth 7
7. Antenna reduced, basal segment at most as long as wide, usually shorter. Median teeth minute, much lower than first and second lateral teeth (that are at least 2× as long as other laterals) (Fig. 17) *Metriocnemus fuscipes* gr.
- 7.— Antenna not reduced, basal segment longer than wide, median teeth the same level or just a bit lower than the first laterals. First and second lateral teeth less than twice as long as other laterals (Fig. 16) *Metriocnemus eurynotus* gr.
8. Median tooth broad, ≥ 3× wider than the first lateral teeth and of triangular shape, ventromental plates well developed, extending well beyond lateral margin of mentum. Antenna with 6 segments; segment 6 hair-like (Fig. 20) *Parakiefferiella*
- 8.— Median tooth < 3× wider than first lateral teeth 9
9. Median tooth obviously higher than first lateral teeth. Second lateral teeth reduced, pressed against first lateral teeth. Mentum and mandibles dark brown to black, outer margin of mandibles crenulated (Fig. 14) *Cricotopus* sp. D
- 9.— Median tooth subequal to first lateral teeth, mandibles and mentum light- to dark brown 10
10. Median tooth and first lateral teeth are equal in size, first laterals rounded, taller and broader than the rest of lateral teeth that are subequal and pointy. Head capsule dark (Fig. 19) *Orthocladus* (*Euo.*) sp.
- 10.— Median tooth broader than first lateral, head capsule yellow to brown 11
11. Seta submenti located well anterior to posterior margin of ventromental plates (Fig. 11) *Cricotopus* sp. A
- 11.— Seta submenti located beyond posterior margin of ventromental plates 12
12. Occipital margin broad and transparent, the same color as head capsule; ventral opening of occipital margin of trapezoidal shape (Fig. 13) ... *Cricotopus* sp. C
- 12.— Occipital margin narrow, darker than head capsule; ventral opening wide, without trapezoidal shape (Fig. 12) *Cricotopus* sp. B



Figs. 8–13. *Parochlus* sp. B: 8a to c. Anal end with posterior parapod, procercus and anal setae, lateral (a, b) and dorsal view (c). *Podonomus* sp.: 9a. Anterior parapod with fan shaped arrangement of claws, lateral view. 9b, c. Anal end with posterior parapod, procercus, and anal setae, dorsal and dorsolateral view. 9d. Larvae under low magnification. *Corynoneura lobata* group: 10a. Antenna. 10b. Mentum, mandibles, and labro-epipharyngeal region (arrows indicate bifid SI and pecten). 10c. Head capsule, dorsolateral view. *Cricotopus* sp. A: 11a. Labro-epipharyngeal region. 11b. Body. 11c. Body setation (indicated by arrow). 11d. Head capsule, ventral view (position of seta submenti indicated by arrow). 11e. Mandible. *Cricotopus* sp. B: 12a. Mandible. 12b. Head capsule, ventral view (position of seta submenti indicated by arrow). 12c. Mentum view (position of seta submenti indicated by arrow). 12d. Body segment with seta (indicated by arrow). *Cricotopus* sp. C: 13a. Mandible. 13b. Head capsule, ventral view. 13c. Mentum (arrow indicates position of seta submenti).

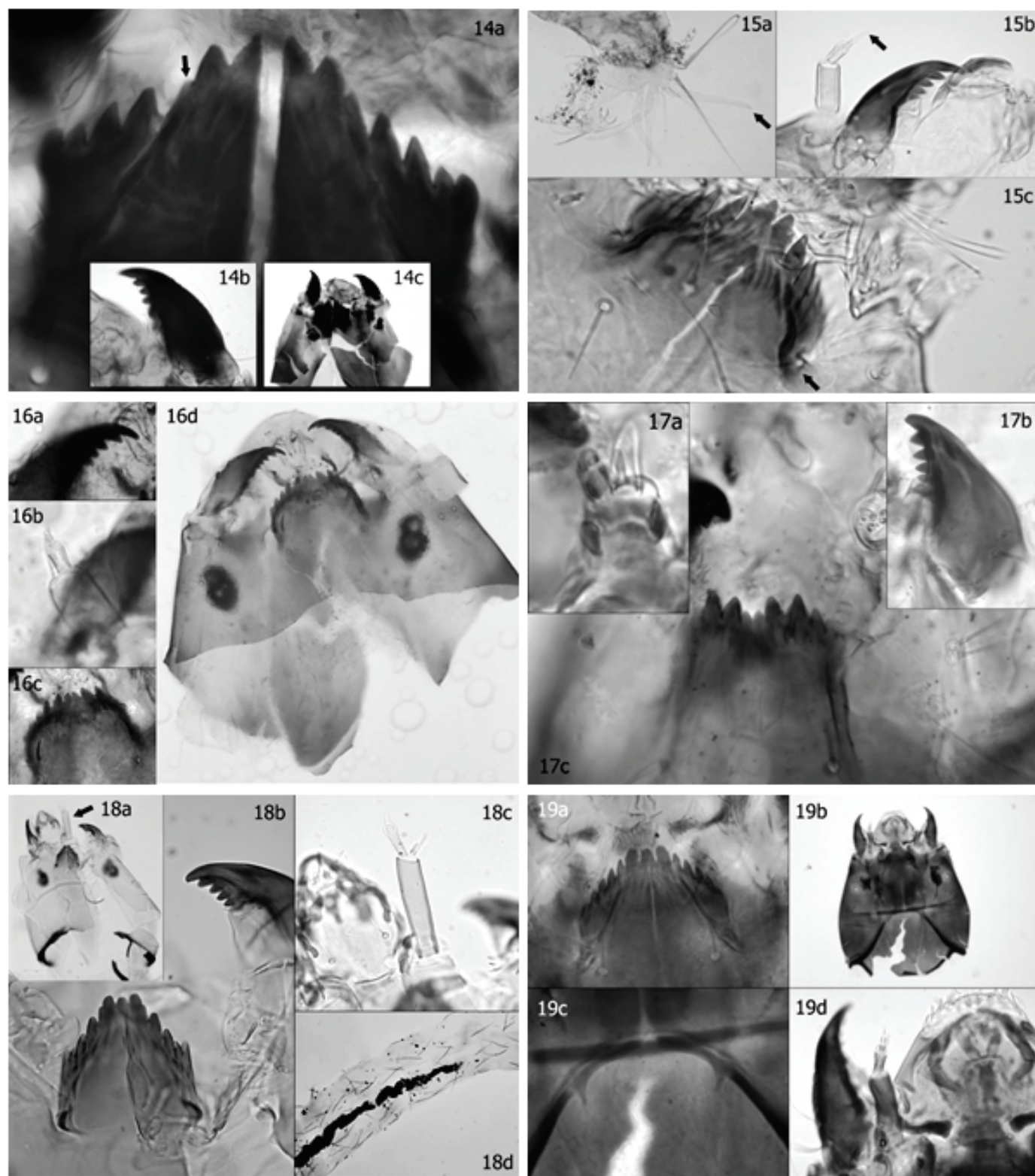
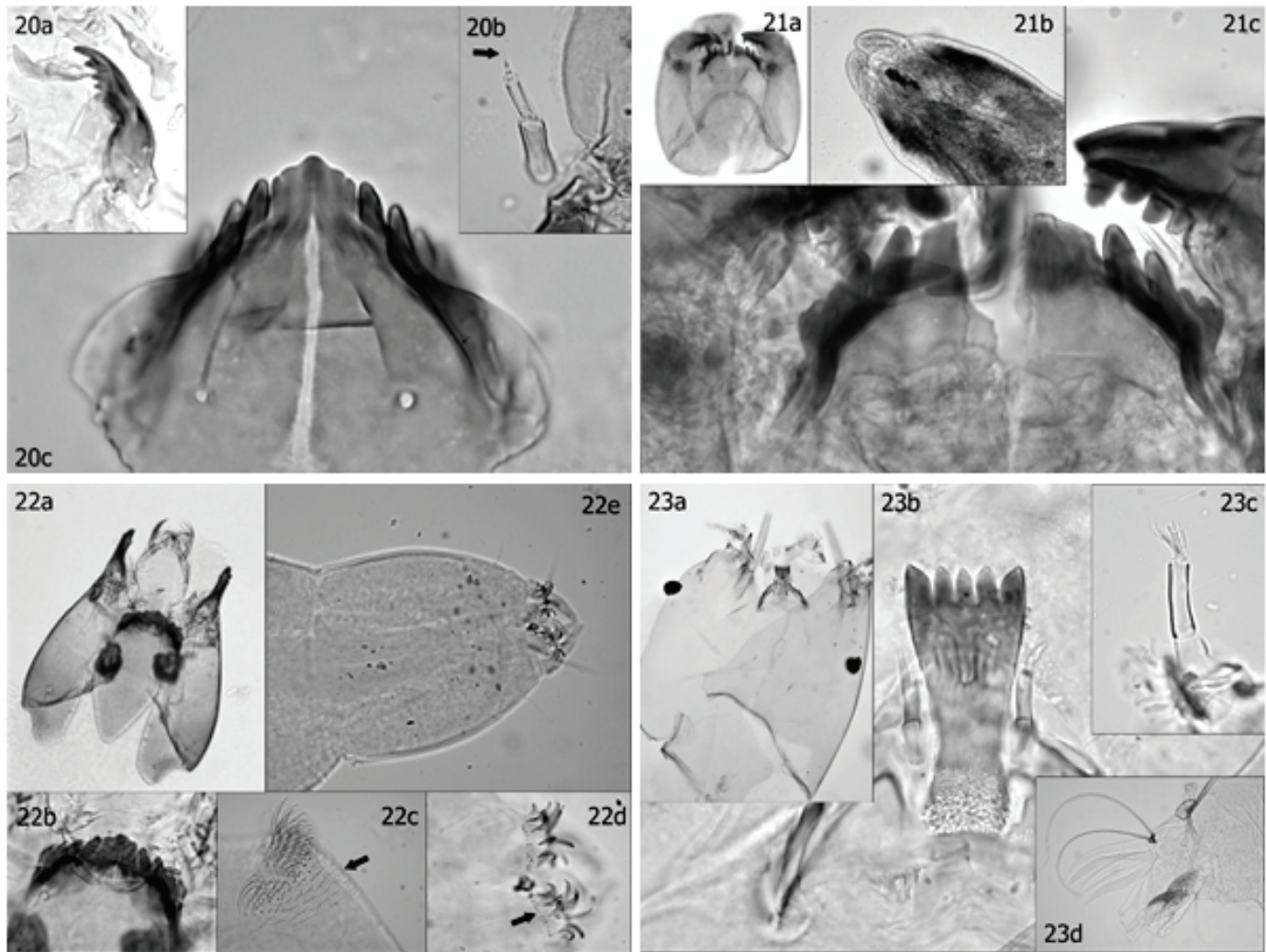


Fig. 14–19. *Cricotopus* sp. D: 14a. Mentum. Arrow indicates the reduced second lateral tooth. 14b. Mandible. 14c. Head capsule, ventral view. *Limnophyes* sp.: 15a. Anal end of body, anal tubules are indicated by arrow. 15b. Antenna and mandible, arrow indicates long antennal blade. 15c. Mentum with wedge shaped tubercle (indicated by arrow). *Metriocnemus eurynotus* group: 16a. Mandible. 16b. Antenna. 16c. Mentum. 16d. Head capsule, ventral view. *Metriocnemus fuscipes* group: 17a. Antenna. 17b. Mandible. 17c. Mentum. *Onconeura* sp.: 18a. Head capsule. Arrow indicates antenna. 18b. Mentum and mandible. 18c. Antenna. 18d. Body segments with strong setation. *Orthocladius* (*Euo.*) sp.: 19a. Mentum. 19b. Head capsule, ventral view. 19c. Detail of occipital margin. 19d. Antenna and mandible.



Figs. 20-23. *Parakiefferiella* sp.: 20a. Mandible. 20b. Antenna. Arrow indicates vestigial sixth segment. 20c. Mentum. *Pseudosmittia* sp.: 21a. Head capsule, ventral view. 21b. Anal end, ventral view. 21c. Mentum and mandible. *Smittia* sp.: 22a. Head capsule, ventral view. 22b. Mentum. 22c. Basally fused anterior parapods, with 2 types of claws (fine spines are indicated by arrow), lateral view. 22d. Posterior parapods (detail), ventral view. Arrow indicate a row of minute claws below regular size claws. 22e. Anal end of the body, ventral view. *Pentaneura* sp.: 23a. Head capsule, ventral view. 23b. Ligula and paraligula. 23c. Maxillary palp with sensilla. 23d. Anal end of body.

Notes: The most common orthocladids are *Cricotopus* sp. A, *C. sp. B*, and *C. sp. C*. Even though these morphotypes are very similar, they can be distinguished as follows: *Cricotopus* sp. A (Fig. 11) has a characteristic body coloration; the first 3 body segments are pale, while the remaining are purple. Seta submenti is situated between ventromental plates. The head is dark brown, the mentum, mandibles, and occipital margin are dark brown to black. The apical tooth of mandible long and pointy. Abdominal segments with a pair of setal tufts (Fig. 11c) (also occurs in *Cricotopus* sp. B), but may be weak and easily overlooked. *Cricotopus* sp. A is common, most abundant in the uppermost site, also occurs at lower elevations, but much less frequently. The most obvious difference between *Cricotopus* sp. B (Fig. 12) and *C. sp. C* (Fig. 13) is the color and shape of occipital margin; although occipital margin of *C. sp. B* is narrow and slightly darker than head capsule, *C. sp. C* has broad and pale occipital margin, about the same color as head capsule. In addition, ventral opening of occipital margin in *C. sp. C* has a characteristic trapezoidal shape, while that of *C. sp. B* is wide, without trapezoidal shape. Abdominal segments of *C. sp. B* bear very weak setal tufts (Fig. 12d); however, they could be easily overlooked. Both types are common in the glacier-fed sites; however, *C. sp. B* is most abundant in the middle ones, while *C. sp. C* is absent in the uppermost ones, and its abundance increases with decreasing altitude, and is most abundant in the lowermost sites.

Subfamily Podonominae

1. Dark brown to black head capsule and proceri, claws of anterior and posterior parapods arranged in comb shape, anal setae compact (Fig. 9). Common in all sites, most abundant in the uppermost ones, close to the glacier terminus *Podonomus*
- 1.— Pale to light brown head capsule, proceri and body 2
2. Light brown body with obvious setae, proceri 3 to 4× as long as broad, anal setae arranged in fan shape, head slightly curved (Fig. 7) *Parochlus* sp. A

- 2.— Body, head and proceri pale, proceri much longer than in the previous species, anal setae long and compact (parallel), body without setae (Fig. 8) *Parochlus* sp. B

Notes: *Parochlus* sp. A was common and abundant in all sites. *Parochlus* sp. B was much less frequent than *Podonomus* and *Parochlus* sp. A, and occurred at higher locations.

Discussion

The most abundant genus was *Parochlus*, occurring in almost all sampled sites. This is a cold-stenothermic genus with a wide ecological valence in running waters of high latitudes and high altitudes. The main habitats are different types of mountain streams, but several species prefer springs, and some occur among mosses in shallow tarns and other small water bodies (Wiederholm 1983). The genus seem to be confined to the southern temperate zones, included the Andean mountain chains and the South Shetland Islands in true Antarctic latitudes. In our study, 2 morphotypes of *Parochlus* were determined. Other commonly sampled Podonominae was *Podonomus*. Larvae of *Podonomus* are found inhabiting mainly cold streams and brooks. The genus in the southern hemisphere occurs from the highest areas of the Bolivian Andes to the Strait of Magellan in South America, as well as in Tasmania, New South Wales, and New Zealand in the Australian region (Brundin 1966).

The subfamily Orthoclaadiinae was represented by 8 genera, comprising 13 morphotypes. *Cricotopus*, represented by 4 morphotypes, was the most widespread orthoclad, occurring in all sites. The genus is one of the largest in the Orthoclaadiinae, comprising 5 subgenera, with worldwide distribution (Cranston et al. 1989, Ashe & O'Connor 2009), except for Antarctica. *Cricotopus* larvae occur in all types of water bodies, including some saline and coastal waters. The group often is recorded in association with aquatic macrophytes, algae, and sometimes cyanobacteria. Some larvae mine in macrophytes, many graze on the surfaces (Wiederholm 1983). *Metriocnemus* van der Wulp is a worldwide genus with more than 60 Holarctic species (Cranston et al. 1989) and 5 endemic species from the Neotropical region (Spies & Reiss 1996; Donato & Paggi 2005). However, none of the specimens from glacier-fed streams in Ecuador could be ascribed to any of the previously described species. The genus occurs in one of the widest biotope ranges of any dipteran genus (Sæther 1989), ranging from mosses and higher vegetation, pitcher plants and hollow trees, to margins of springs, ditches, streams, damp soils, and hygropetric biotopes, and occasionally also lakes and rock pools (Cranston & Judd 1987; Sæther 1989, 1995).

The subfamily Diamesinae was represented by 2 genera, *Limaya* Brundin and *Paraheptagyia* Brundin. The latter presented at least 2 morphotypes; however, *Paraheptagyia* sp. B might be just a lower instar of *P.* sp. A. Larval *Paraheptagyia* usually can be found in thin water films alongside waterfalls, or in the splash zone of streams.

Chironominae was the second least widespread subfamily sampled in this study, and always was collected in small numbers. The group was represented by only 3 genera: *Manoa* Fittkau, *Polypedilum* Kieffer, and *Tanytarsus* van der Wulp. The lack of Chironominae in our samples might be largely related to the preference for tropical and subtropical lowlands exhibited by most members of this subfamily. Furthermore, it is important to call attention to the first record of *Manoa* in high Andean regions. The genus was described from all stages from Amazonia, and a second adult species has been described from East Africa. Recently, the group was recorded from China (Qi et al. 2017) and the Dominican Republic (Silva et al. 2015). In the Everglades, Florida, USA, larvae of *M. paha-yokeensis* Jacobsen & Perry are found in shallow water areas subject to fluctuating water levels and seasonal drying (Jacobsen & Perry 2002).

In our study, Tanypodinae were particularly rare; only 1 genus was recorded, *Pentaneura* Phillippi. This is a common genus occurring in the Nearctic and Neotropical regions (Ashe & O'Connor 2009), including some islands from the Caribbean region (Williston 1896; Ferrington et al. 1993, Silva et al. 2015). Larval *Pentaneura* have been recorded inhabiting a variety of aquatic systems, from ponds and lakes, associated with vascular hydrophytes and detritus, to small streams and large bodies of running water, usually living in erosion and depositional areas (Ferrington et al. 2008; Andersen et al. 2013). In the Neotropical region, *Pentaneura* often has been reported in greatest abundance from high-altitude headwater streams (Watson & Heyn 1992; Tejerina & Molineri 2007; Acosta & Prat 2010), ranging from 2,000 to 4,440 masl (Silva & Ferrington 2018).

The higher number of taxa recorded in glacier-fed streams (21) compared to non-glacial ones (13) is interesting, but the different methods of collection prevent us from comparison and general conclusions. However, 8 taxa occurred exclusively in glacier-fed streams (compared to only 1 taxon in non-glacier streams), which emphasizes the unique character of glaciated systems. However, in general, the most common taxa were the same in both stream types. The potential types of insect life cycles in glacier-fed streams are limited by the cold temperatures and marked seasonality. This biotope, known as kryal (Steffan 1971), is distinguished by very cold temperature (near 0 °C), highly turbid, and fast-flowing waters with low channel stability and seasonal flow regimes with high diel peaks in summer (Lods-Crozet 2002). In general, research on glacier-fed streams has not focused on the chironomid fauna. Therefore, even though the generic richness documented here seems to be lower than the actual richness of chironomids in glacier-fed streams in Ecuador, particularly considering the limited duration and extension of our study, our results represent an advance in the understanding of the chironomid communities in glacial meltwater streams. Comparing our results with Lods-Crozet et al. (2002), who sampled in 6 European glacier-fed streams, we could expect that some widespread cold-stenothermic species of the following genera are still found in aquatic ecosystems of high Andean regions in Ecuador: *Diamesa* Meigen, *Eukiefferiella* Thienemann, *Orthocladus* van der Wulp, and *Thienemannia* Kieffer. Even though our inventory documents a relatively species-poor chironomid community in glacier-fed streams in Ecuador, we believe that collections in different periods and broadening the variety of sampling habitats and geographic area may reveal a greater diversity than currently detected. While recent years have seen increased activity concerning the chironomid fauna in the Neotropical region, the knowledge of the diversity and taxonomy as well as biogeography and phylogeny, especially in the high Andean regions, remains fragmentary (Acosta & Prat 2010). Thus, additional inventories are required to discover and analyze possible areas of endemism in Ecuador and the surrounding areas. The present study contributes to the knowledge of chironomid fauna in high-altitude glacier-fed and non-glacial streams in Ecuador and will hopefully motivate further studies in the area.

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