ARTÍCULO DE INVESTIGACIÓN

Mayflies (Ephemeroptera) of the Pantepui biogeographical province

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ABSTRACT

The term Pantepui refers to a discontinuous biogeographical province formed by an assemblage of about 50 table mountain summits (tepuis) in southern Venezuela, northern Brazil, and western Guyana. The elevation of the Pantepui ranges from 1,500 to 3,000 m a. s. l. and the total summit area extends up to 5,000 km^2. Until now, only 6 species from families Baetidae (*Parakari auyanensis*, *P. churiensis*), Leptophlebiidae (*Miroculis bicoloratus*, *Hagenulopsis minuta*, *Massartella devani*) and Oligoneuriidae (*Fittkauneuria carina*) had been described or reported from the Pantepui region. Three Venezuelan tepuis have been recently explored by several international speleological expeditions. As a result, an additional five genera of the family Baetidae (*Baetodes*, *Callibaetis*, *Camelobaetidius*, *Cloeodes*, *Spiritiops*), as well as the species *Fittkauneuria adusta* (Oligoneuriidae) and some undescribed representatives of the genera *Massartella*, *Miroculis* and *Hagenulopsis* are reported for the first time from the Pantepui province.

Key words: Ephemeroptera, mayflies, Neotropics, Pantepui, tepui, Venezuela.

RESUMEN

Efémeras (Ephemeroptera) de la provincia biogeográfica de Pantepui

El término Pantepui hace mención a una provincia biogeográfica discontinua formada por un conjunto de casi 50 montañas con cimas planas (tepuyes) en el Sureste de Venezuela, Noreste de Brasil y Oeste de Guyana. La elevación del Pantepui oscila entre los 1.500 y 3.000 ms.n.m. y el área total de las cumbres alcanza los 5.000 km^2. Hasta ahora, sólo seis

especies de las familias Baetidae (*Parakari auyanensis*, *P. churiensis*), Leptophlebiidae (*Miroculis bicoloratus*, *Hagenulopsis minuta*, *Massartella devani*) y Oligoneuriidae (*Fittkauneuria carina*) han sido descritas o citadas para la región Pantepui. Tres tepuyes venezolanos han sido recientemente explorados por unas expediciones espeleológicas internacionales. Como resultado de estas expediciones, cinco géneros de la familia Baetidae (*Baetodes*, *Callibaetis*, *Camelobaetidius*, *Cloeodes*, *Spiritiops*), más la especie *Fittkauneuria adusta* (Oligoneuriidae) y algunos individuos no descriptos de los géneros *Massartella*, *Miroculis* y *Hagenulopsis* son citados por primera vez para la provincia Pantepui.

Palabras claves: Ephemeroptera, moscas de mayo, Neotrópicos, Pantepui, tepui, Venezuela.

INTRODUCTION

The order Ephemeroptera is an ancient, worldwide distributed group of hemimetabolous pterygote insects. It comprises more than 3,000 described extant aquatic species ordered into 42 families and more than 400 genera (BARBER-JAMES *et al.*, 2008). The highest generic diversity, together with correspondingly high species diversity is known to be found in the Neotropics (DOMÍNGUEZ *et al*., 2006; BARBER-JAMES e*t al.*, 2008). South America has a unique mayfly biota composed of up to 450 species ordered into more than 100 genera and 14 families (DOMÍNGUEZ *et al.*, 2006). In spite of the progress made in the taxonomic and biogeographic research of South American mayfly fauna, there is still a lack of knowledge on Venezuelan mayflies, with only 33 species reported, representing 20 genera and 6 families (CHACÓN *et al.*, 2009). Nevertheless, this low number reflects the research history instead of the actual species richness. Several new taxa have been recently reported and/or described from Venezuela (DERKA *et al.*, 2009; CHACÓN *et al.*, 2010; MOLINERI *et al.*, 2011; NIETO *et al.*, 2011; NIETO & DERKA, 2011; 2012). MOLINERI *et al.* (2011) described two new species – *Caenis teipunensis* (Caenidae) and *Macunahyphes pemonensis* (Leptohyphidae), and reported the first finding of *Coryphorus aquilus* Peters, 1981, *Amanahyphes saguassu* Salles & Molineri, 2006 and *Tricorythopsis yucupe* Dias *et al*., 2008 in Venezuela. NIETO *et al.* (2011) reported 4 genera (*Cryptonympha, Harpagobaetis, Spiritiops* and *Zelusia*) and 9 species for the first time from Venezuela, thus the number of species and genera of the family Baetidae recorded in Venezuela has increased twofold. Most of these new findings were documented in the region of La Gran Sabana in the Venezuelan Guayana. High sandstone mesas (tepuis) are characteristic of the Guayana region of southern Venezuela, northern Brazil, and western Guyana. The tepuis are flat-topped and are isolated from the surrounding environment by several hundred meters high sheer cliffs, what makes them ecological islands with distinctive climatic conditions. The tepuis have been

formed by a long-term erosion caused by the major river systems in the area of a gigantic Precambrian plateau of the Roraima Formation – highly leached sandy sediments laid down 1.5 - 1.8 billions years ago (BRICEÑO & SCHUBERT, 1990). They are composed of quartzites and sandstones, overlaying the igneous metamorphic Guyana Shield (GIBBS & BARRON, 1993). The summit ecosystems of the tepuis are considered to form a distinct and discontinuous biogeographical province called Pantepui (MAYR & PHELPS, 1967). The Pantepui includes about 50 table mountains (topographic islands) with elevation ranging from 1,500 to 3,000 m a. s. l. The table-tops cover altogether an area of about 5,000 km^2, individually varying between 0.2 and 1,096 km^2 (BERRY *et al.*, 1995; HUBER, 1992; McDIARMID & DONNELLY, 2005). The Guayana region is well-known as an extraordinary diversity hotspot with high level of endemism, which is remarkable mainly on the isolated summits of the sandstone mesas (HUBER, 2005; RULL, 2005; McDIARMID & DONNELLY, 2005; BREURE, 2009; BREURE & SCHLÖGL, 2010). The uniqueness of the biota has been explained either as the result of a long history of evolution in isolation —by the Lost World hypothesis, or by alternating upward and downward displacements during the glacial–interglacial Quaternary cycles— by the Vertical Displacement hypothesis (cf. RULL, 2004; DÉSAMORÉ *et al.*, 2010). The hotspot designation seems to be applicable to the aquatic fauna, as well (SPANGLER & FAITOUTE, 1991; ČIAMPOR & KODADA, 1999; ISSA & JAFFE, 1999; KODADA & JÄCH, 1999; DE MARMELS, 2007; DERKA *et al.*, 2009; MAIER & SPANGLER, 2011). Due to the extremely difficult access, the remote summit area of tepuis remains, however, poorly explored. The flat-topped summits bear various types of aquatic habitats, including tiny phytotelmata and temporary pools in bare rocks, as well as the large wetland meadows and medium sized rivers. Black water streams with rocky bottom, cascades and waterfalls, and long and deep pools are the most common types of running water. The total absence of hyporheic environment is a characteristic feature of Pantepui streams, which surely has fundamental influence on the ecosystems functioning. Second important factor is very low water retention capacity of the watersheds, causing the violent discharge fluctuations (DERKA, personal observation). Moreover, the streams are extremely oligotrophic, mineral-poor (conductivity usually ranges between 10 and 20 $\mu S.cm^{-1}$), acid (pH = 3.5 – 5.5) and may contain high concentrations of organic compounds leached from vegetation (AUBRECHT *et al.*, 2011).

Considering even the most visited and explored tepuis, such as Mt. Roraima, Auyán-tepui or tepuis of the Chimantá massif, there is still a surprising lack of knowledge on the aquatic groups of insect. Other important

components of aquatic ecosystems, such as algae, were studied only over the last decade (KAŠTOVSKÝ *et al.*, 2011). The entire insect orders were practically unknown from the plateaus. E.g., the first mayfly records from Mt. Churí-tepu and Mt. Roraima were published only recently (DERKA *et al.*, 2009), although mayflies are common part of the tepui stream ecosystems. The same situation applies to the research of stoneflies, which had not been recorded in the Pantepui province until recently (DERKA *et al.*, 2010).

The great contribution to the research of aquatic fauna of the tepuis was made by the study of Cerro de la Neblina held by Charles Brewer-Carías (BREWER-CARÍAS, 1988). This study is still an information base carrying the most of the gathered knowledge on aquatic fauna of the Pantepui, including the mayflies (SAVAGE, 1987; PESCADOR & EDMUNDS, 1994; PETERS & DOMÍNGUEZ, 2001). Three species have been described or reported from localities above 1,500 m a. s. l., what is considered the lower altitudinal limit of Pantepui: *Miroculis bicoloratus* Savage, 1987, *Hagenulopsis minuta* Spieth, 1943 and *Fittkauneuria carina* Pescador & Edmunds, 1994. Some records and species descriptions refer to localities below 1,500 m a. s. l. e.g., the description of *Miroculis nebulosus* (SAVAGE, 1987), two new species of the genus *Farrodes* (DOMÍNGUEZ *et al.*, 1996), and the records of *Miroculis fittkaui* (SAVAGE, 1987) and *Hagenulopsis minuta* (PETERS & DOMÍNGUEZ, 2001).

The knowledge on mayflies from the Pantepui province still remains very limited. Only few species have been recently described or reported from the studied area. DERKA (2002) described the species *Massartella devani* from Tuná Deuta stream in Mt. Roraima massif. DERKA *et al.* (2009) also described a new species *Massartella hirsuta* (Leptophlebiidae) from La Gran Sabana and reported the occurrence of two undescribed *Massartella* species from Mt. Roraima and Churí-tepui. NIETO & DERKA (2011) published a discovery of new Baetidae genus *Parakari* with two substantiated species – the first one endemic to Churí-tepui (*P. churiensis*) and the second one to Auyán-tepui (*P. auyanensis*). Thus the number of mayfly species known from the region of Pantepui reached six. The aim of this study is to present new records of Ephemeroptera species collected during international speleological expeditions to Churí-tepui, Mt. Roraima and Auyán-tepui, and to review published data on Ephemeroptera of the Pantepui biogeographical province.

MATERIAL AND METHODS

Qualitative samples of nymphs were collected using a kick net (mesh size 0.5 mm) and individually from stones and woody debris. Adults were

collected by using entomological net, sampling individuals from foam accumulations in stream pools and light trapping. Some adult mayfly nymphs were reared to subimagos and adults in the field. All material was fixed by 98% alcohol. Morphological characteristics were studied using stereomicroscopes and microscopes. The material of mayflies was identified following DOMÍNGUEZ *et al.* (2006). Moreover, other articles regarding particular taxonomical groups used for material identification are cited in corresponding sections. Electric conductivity (EC) and pH values were measured in the field by the WTW pH/Cond 340i SET field device. Stream characteristics as mean width, depth, bottom substrate, temperature, etc. were measured and noted down directly at the sampling sites.

Sampling area and localities

Altogether 24 localities were sampled at Churí-tepui (C), Mt. Roraima (R) and Auyán-tepui (A). The study sites R1, R5, R6, A1 and A2 were not situated directly on the plateaus of Mt. Roraima and Auyán-tepui. However, they were situated within the massifs of individual tepuis at altitudes above 1,500 m a. s. l., what is the lower altitudinal limit for the Pantepui region (BERRY *et al.*, 1995), hence they were considered as a part of the Pantepui. The largest of the sampled tepuis was Auyán-tepui, with the surface area of 700 km^2. However, it was the lowest one, with sampling sites situated between 1,700 – 1,851 m a. s. l. The second largest was Churí-tepui, with the summit area of 47.5 km^2 and the sampling sites located between 2,100 – 2,450 m a. s. l. Churí-tepui is one of 12 tepuis forming the Chimantá massif with the total summit area of 623 km^2, and the slope area of 915 km^2 (McDIARMID & DONNELLY, 2005). Mt. Roraima has the smallest summit area of about 36 km^2 and reaches 2,700 – 2,800 m a. s. l.

Sampling localities at Churí-tepui (C), Mt. Roraima (R) and Auyán-tepui (A):

(C1) Quebrada Lila, a stream at the plateau above Cueva Charles Brewer – Churí-tepui plateau, 26. I. 2009, altitude 2,250 m a. s. l., N 05° 14′ 57.6′′ W 62° 01′ 36.5′′, pH = 4.35, EC =14 μS.cm^{-1}, T = 14 °C, depth 0.02 – 1.5 m, width 1 – 3 m. Cascade stream shadowed by surrounding forest. Bedrock bottom, only locally with small depositions of gravel and stones and submerged tree roots and mosses.

(C2) Cueva Charles Brewer – Churí-tepui plateau, 15. I. 2009, altitude ca 2,200 m a. s. l., pH = 4.58, EC = 9 μS.cm^{-1}, T = 14 °C, depth

0.02 – 1.5 m. Cave stream with bedrock bottom, locally with small depositions of gravel and stones.

(C3) Spring streams below Cueva Charles Brewer – Churí-tepui plateau, 17. I. 2009, altitude ca 2,200 m a. s. l., pH = 4.5, EC = 9 $\mu S.cm^{-1}$, T = 13.6 °C. Bedrock bottom, locally with small depositions of gravel and stones.

(C4) Stream above Pozo Capuchino – Churí-tepui plateau, 15. I. 2009, altitude ca 2,200 m a. s. l., T = 15 °C, depth up to 1.8 m, width 2 – 6 m. Bedrock bottom, with the depositions of sand, woody debris and submerged roots.

(C5) Río Olinka, a stream above waterfall above Cueva Juliana – Churí-tepui plateau, 28. I. 2009, altitude 2,115 m a. s. l., N 05° 14' 40.9" W 062° 02' 05.5", pH = 4.48, EC = 9 $\mu S.cm^{-1}$, T = 17 °C, depth up to 1 m, mostly up to 0.2 m, river bed width 10 – 15 m. Bedrock bottom, only locally with small depositions of gravel and stones, and patches of mosses. Discharge fluctuations are distinct and frequent. During low discharges, the bottom is almost entirely dry; the water is restricted to the transversal crevices and pools and is only barely connected by drying streams.

(C6) Cueva Juliana – Churí-tepui, 23. I. 2009, altitude 2,300 m a. s. l., pH = 4.38, EC = 18 $\mu S.cm^{-1}$, T = 14.3 °C, depth up to 0.5 m, width = 0.3 – 1 m. A shallow stream flowing inside the cave, bedrock bottom and some sand accumulations and stones.

(C7) Spring stream below the waterfall at Río Olinka originated in Cueva Juliana - Churí-tepui, 20. I. 2009, altitude ca 2,100 m a. s. l., T = 14.3 °C, depth 0.01 – 0.3 m, width 0.3 – 1 m. Bottom formed by bedrock, coarse gravel, mosses and roots.

(C8) River below Cueva Juliana – Churí-tepui, 20. I. 2009, altitude ca 2,100 m a. s. l., pH = 3.3, conductivity = 25 $\mu S.cm^{-1}$, T = 17.5 °C, depth up to 1.5 m, mostly up to 20 cm, river bed width 1 – 4 m. Sandy bottom with tree roots, woody debris and stones.

(C9) Middle reach of the Western river – Churí-tepui plateau, 24. I. 2009, altitude 2,399 m a. s. l., N 05° 15′ 39.8′′ W 62° 00′ 44.0′′, pH = 4.56, conductivity = 11 $\mu S.cm^{-1}$, T = 22.4 °C, depth up to 1.5 m, mostly up to 10 cm, width 0.1 – 1.5 m. Bedrock bottom, in pools, there are small depositions of gravel and stones and submerged tree roots.

(C10) Springs of the Western river – Churí-tepui plateau, 23. I. 2009, altitude ca 2,400 m a. s. l., pH = 3.75 – 4.58, conductivity = 2 – 17 $\mu S.cm^{-1}$, T = 16.8 – 17.6 °C, depth 0.1 – 0.7 m, width 0.2 – 1.5 m. Pools in a wetland meadow connected by small rapids, with abundant Cyanobacteria, macrophyta and some stones.

(C11) Pools in wetlands in the northern part of Churí-tepui plateau – Churí-tepui plateau, 22. I. 2009, altitude 2,438 m a. s. l., N 05° 16′ 12.6′′ W 62° 00′ 58.8′′, pH = 2.7, conductivity = 46 µS.cm^{-1}, T = 27.8 °C. Peat swamp meadow with carnivorous plants and scattered pools with abundant cyanobacteria, depth up to 0.3 m.

(C12) Cueva Colibrí – Churí-tepui, 26. I. 2009, altitude about 2,300 m a. s. l. A shallow stream flowing inside the cave, bedrock bottom, some sand accumulations and stones.

(R1) Tuná Deuta, a spring stream below southwestern wall of Mt. Roraima at "La Rampa", – Mt. Roraima massif, 4. II. 2009, altitude 2,346 m a. s. l., N 05° 09′ 58.0′′ W 60° 46′ 72.4′′, pH = 4.76, conductivity = 19 µS.cm^{-1}, T = 14.1 °C. Stream originates as a small waterfall in the Mt. Roraima wall, bottom is covered with boulders, stones and the mosses. It is surrounded by forest.

(R2) Tuná Damú – Mt. Roraima plateau, 6. II. 2009, altitude 2,700 m a. s. l., N 5º 10.289' W 60º 45.629', T = 16,8 °C, pH = 5.05, depth 0.05 – 0.5 m, width 1 m. Stream flowing through a small cave bellow the path to Punto triple. Bottom covered by stones and siliceous crystals.

(R3) Cueva de los Pemones - Mt. Roraima plateau, 4. II. 2009, altitude ca 2,700 m a. s. l., T = 12 °C, pH = 4.78, depth up to 0.5 m, width 0.3 – 3 m. Stream flowing inside the cave, bedrock bottom with some accumulations of sand, gravel and stones.

(R4) Spring stream in a crevice close to Tuná Damú - Mt. Roraima plateau, 7. II. 2009, altitude ca 2,700 m a. s. l., T = 14.3 °C, depth up to 0.3 m, width 0.5 – 1 m, stony bottom.

(R5) Spring stream at "La Rampa" of Mt. Roraima, ca 100 altitudinal meters below the plateau - Mt. Roraima massif, 7. II. 2009, altitude ca 2,600 m a. s. l., T = 13.1 °C, depth up to 0.3 m, width up to 1 m, stony bottom.

(R6) Stream above Mt. Roraima Base camp - 7. II. 2009, altitude 1,840 m a. s. l., T = 16 °C, width 2 m, depth up to 0.8 m. Stream completely shadowed by a dense cloud forest. It has rocky and stony bottom with sand accumulations in pools.

(A1) Tuná Terciopelo a stream ca 20 min below El Peñón camp – Auyán-tepui massif, 7. I. 2010, altitude 1,733 m a. s. l., N 5º 44' 23.3" W 62º 32' 18.5", T = 16.5 °C. Montane stream in a cloud forest, with the bottom covered by stones and gravel.

(A2) Quebrada El Peñón in camp El Peñón - Auyán-tepui massif, 7. I. 2010, altitude 1,832 m a. s. l., N 5º 44' 40.4" W 62º 32' 29.7", T = 14.6 °C, width 2-5 m. Montane stream with bedrock bottom in a cloud for-

est. There are the gravel and leaves accumulations in pools and submerged tree roots.

(A3) Springs of Río Churún – Auyán-tepui plateau, 8. I. 2010, altitude 1,851 m a. s. l., N 5º 46' 15.1" W 62º 32' 7.9", T = 25.4 °C, width = 15 – 20 m. Almost entirely dried up bedrock bottom. During low discharges, the water is restricted to much reduced stream.

(A4) Río Oso in El Oso Camp – Auyán-tepui plateau, 9. I. 2010, altitude 1,733 m a. s. l., N 5º 47' 1.4" W 62º 32' 12.5", T=14.9 °C, width 2 – 4 m. Stream surrounded by tepui forest, bedrock bottom. Numerous pools with some stones, woody debris and tree roots.

(A5) Río Churún, ca 30 min above El Oso Camp – Auyán-tepui plateau, 10. I. 2010, altitude ca 1,740 m a. s. l., T = 21.1 °C, width 18 – 20 m. Bedrock bottom, during low discharges the bottom is almost entirely dry. The water is restricted to pools and transversal crevices connected by much reduced stream.

(A6) Río Churún, close to El Lecho Camp – Auyán-tepui plateau, 10. I. 2010, N 5º 49' 34.6" W 62º 32' 27.9", altitude 1,730 m a. s. l., T = 19.7 °C, width 6 – 15 m, depth up to 2 m. A montane river with long and deep polls and bedrock riffles. In pools, there is a bedrock and sandy bottom with large woody debris.

RESULTS AND DISCUSSION

The mayfly nymphs form a common part of aquatic communities of the streams of Churí-tepui and Auyán-tepui plateaus. On the other hand, they are very rare on Mt. Roraima plateau (Table I). Representatives of families Baetidae and Leptophlebiidae were found on the plateaus of all three tepuis. Moreover, nymphs of *Fittkauneuria adusta* from the family Oligoneuriidae, were discovered in a stream in Auyán-tepui massif. Streams on Auyán-tepui plateau showed the highest mayfly generic diversity reaching 9 genera, in comparison with Churí-tepui with only 7 genera recorded from the plateau. On Mt. Roraima plateau, the mayflies were represented only by one undescribed species from the genus *Massartella* restricted to spring streams (recently known from two streams) and cave streams in Cueva Ojos de Cristal and Cueva de los Pemones; and Spiritiops tepuiensis known from a single exuvia. The other findings were documented from the spring streams at "La Rampa" within the cliffs of Mt. Roraima and in the streams above Mt. Roraima base camp. Altogether 7 mayfly genera were recorded in Mt. Roraima massif: one species from genera *Baetodes*, *Cloeodes*, *Spiritiops*, *Hagenulopsis*, *Miroculis* and *Fittkauneuria*, and two *Massartella* species.

Table I. Ephemeroptera taxa sampled at 3 tepuis (for the abbreviations of localities see Sampling area and localities).
Tabla I. Taxones de Ephemeroptera encontrados en los 3 tepuyes (abreviaturas de las localidades en Área de muestreo y localidades).

Locality	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	R1	R2	R3	R4	R5	R6	A1	A2	A3	A4	A5	A6
Baetidae Leach, 1815																								
Baetodes sp.																		+		+		+	+	+
Callibaetis sp.	+		+						+	+	+													+
Camelobaetidius sp.																						+		+
Cloeodes sp.	+																	+	+	+	+	+		+
Parakari auyanensis																			+	+		+	+	+
Parakari churiensis	+	+	+	+	+	+	+			+														
Spiritiops tepuiensis	+		+	+	+	+	+		+				+				+	+	+	+	+	+	+	+
Leptohlebiidae Banks, 1900																								
Hagenulopsis sp.	+	+		+				+										+				+		
Massartella devani													+					+						
Massartella sp.1														+	+	+	+							
Massartella sp.2	+	+	+	+	+	+	+					+												
Massartella sp.3																			+	+	+	+	+	+
Miroculis sp. 1	+	+								+														
Miroculis sp. 2																							+	
Miroculis sp. 3																		+						
Oligoneuriidae Ulmer, 1914																								
Fittkauneuria adusta																		+	+					

The lower number of species recorded at Mt. Roraima in comparison with Churí-tepui and Auyán-tepui can be explained by higher altitude, as well as by much lower surface area of Mt. Roraima. Notes on the distribution of the taxa discovered in the study area, together with some ecological information are given below (explanatory note: N – nymph).

Family Baetidae Leach, 1815

The family Baetidae has a worldwide distribution and includes at present almost 100 genera (BARBER-JAMES *et al.*, 2008). In South America, the diversity of this family currently comprises of 28 genera and more than 130 species (NIETO & DERKA, 2011). Most of these genera were described in the last decade of the 20th century, with the genus *Parakari* being the last genus described in this region (NIETO & DERKA, 2011). The nymphs of Baetidae inhabit a variety of lotic and lentic habitats with sandy, rocky or organic substrates. Representatives of 6 genera were found at the tepui plateaus.

Genus *Baetodes* Needham & Murphy, 1924

The genus *Baetodes* includes more than 40 species known from North, Central and South America (NIETO *et al.*, 2011). With 27 species being described from South America, it is considered one of the most species rich genera in the Neotropics (DOMÍNGUEZ *et al.*, 2006; SALLES & POLEGATTO, 2008; DE SOUZA *et al.*, 2011). Four species are known from Venezuela (NIETO *et al.*, 2011). The nymphs were very abundant in streams on Auyán-tepui plateau, especially in the strong current sections. The nymphs were not documented in the streams of Churí-tepui and Mt. Roraima plateaus.

Material examined: *Baetodes* sp.: A2 – 2N, A4 – 6N, A5 – 239N, A6 – 175N, R6 – 18N.

Genus *Callibaetis* Eaton, 1881

This genus is distributed from North America to Argentina. In South America, 16 species are known – described on the basis of discovered adults, especially female imagos. Only in 8 cases, the associated nymphs are known, as well (NIETO, 2008; CRUZ *et al.*, 2009). BLANCO-BELMONTE *et al.*

(2009) reported the representatives of this genus from Orinoco and Caura rivers. Nymphs thrive in various habitats, generally in lentic water bodies. The nymphs were found in stream pools in both, Churí-tepui and Auyán-tepui. In the pools of peat swamps meadows at Churí-tepui, these nymphs represented the unique but abundant group of mayflies.

Material examined: *Callibaetis* sp.: C1 – 1N, C3 – 1♀ subimago, C9 – 3N, C10 – 36N, C11 – 7N, A6 – 53N.

Genus *Camelobaetidius* Demoulin, 1966

Nymphs of this genus are easy to recognize by spatulate tarsal claws with a fan-shaped row of denticles – a unique character among Neotropical mayflies. This genus is widely distributed in North, Central and South America. There are 29 known species from South America (BOLDRINI & SALLES, 2009). Five species are known from Venezuela (NIETO *et al.*, 2011).

Material examined: *Camelobaetidius* sp.: A4 – 7N, A6 – 5N.

Genus *Cloeodes* Traver, 1938

The genus *Cloeodes* shows a widespread pantropical distribution in South America, Central and North America, Africa, Madagascar, Southeast Asia and Australia. Seventeen species are known from South America, one of them being reported from Venezuela (NIETO & EMMERICH, 2011; SALLES & CAVALCANTE DO NASCIMENTO, 2009).

Material examined: *Cloeodes* sp.: C1 – 5N, 1♂, 1♀; A1 – 1N; A2 – 1N; A3 – 94N; A4 – 7N; A6 – 4N; R6 – 2N.

Genus *Parakari* Nieto & Derka, 2011

The genus *Parakari* has been described by NIETO & DERKA (2011) from the material collected at Churí-tepui and Auyán-tepui plateaus. The habitats of nymphs cover spring streams, bigger mountain rivers, as well as a stream flowing inside the cave Cueva Charles Brewer. The nymphs can tolerate a wide range of water temperature and thus thrive in various types of environment, from oligostenothermal cave streams with stable tem-

peratures around 14 ºC to wide and shallow streams with distinct diurnal fluctuations of temperature.

Material examined: *Parakari churiensis*: C1 – 91N, 3♂♂, 12♀♀, 11♂♂ subimagos, 3♀♀ subimagos; C2 – 167N, 1♂, 8♂♂ subimagos, 10♀♀ subimagos; C3 – 1N, 1♂, 3♀♀, 7♂♂ subimagos, 7♀♀ subimagos; C4 – 52N; C5 – 1N; C6 – 3N; C7 – 15N; C10 – 1N; *Parakari auyanensis*: A1 – 5N, A2 – 14N, A4 – 21N, A5 – 17N, A6 – 31N.

Genus *Spiritiops* Lugo-Ortiz & McCafferty, 1998

This monotypic genus was described only on the basis of nymphs. SALLES & NIETO (2008) described the adult from Brazil. *S. silvudus* was reported from Brazil, Colombia, Surinam and French Guiana (DOMÍNGUEZ *et al.*, 2006). Recently, NIETO *et al.* (2011) found nymphs of this species in the streams of La Gran Sabana region in Venezuela. We have discovered one undescribed species in the streams of all three tepuis (NIETO & DERKA, 2012). The nymphs inhabit a wide range of streams, preferring habitats with stronger currents, even the splash zones of waterfalls.

Material examined: *Spiritiops tepuiensis*: A1 – 18N; A2 – 23N; A3 – 6N; A4 – 236N, 1♀ subimago; A5 – 35N; A6 – 124N; R1 – 6N; R5 – 6N; R6 – 86N; C1 – 22N, 15♀♀; C3 – 1♀ subimago, 1♂ subimago; C4 – 70N; C5 – 39N, 1♀; C6 – 8N; C7 – 9N; C9 – 5N.

Family Leptohlebiidae Banks, 1900

This is the most diverse mayfly family in the Neotropics. In South America, it includes approximately 40 genera and more than 150 species, all belonging to the subfamily Atalophlebiinae (DOMÍNGUEZ *et al.*, 2006). In Venezuela, 19 species belonging to 8 genera were reported (CHACÓN *et al.*, 2009; DERKA *et al.*, 2009). BLANCO-BELMONTE *et al.* (2009) reported other 4 genera and one undescribed genus.

Genus *Hagenulopsis* Ulmer, 1920

Eight species of this dipterous genus are currently known, 5 of them occur in South America, as well (DOMÍNGUEZ *et al.*, 2009). But only the species *H. minuta* Spieth, 1943 is known from Venezuela (CHACÓN *et al.*, 2009). PETERS & DOMÍNGUEZ (2001) rediscovered this species and

reported the nymphs and male adults from Cerro de la Neblina base camp (140 m a. s. l.), and one male adult from 1,800 m a. s. l.

Material examined: *Hagenulopsis* sp.: C1 – 1♂, 1♀, 1♂ subimago; C2 – 1N; C4 – 1N; C8 – 7N; R6 – 3N; A4 – 1N.

Genus *Massartella* Lestage, 1924

This genus recently consists of 5 described species, 2 of them occur in Brazil and 3 in Venezuela (DERKA *et al.*, 2009). One undescribed species was reported from north-eastern Argentina (PESCADOR & PETERS, 1990). DERKA (2002) described *M. devani* from Mt. Roraima (R1). Later, this species was found in some other streams at Mt. Roraima foothills. Material collected on Mt. Roraima plateau and locality R5 belong to an undescribed species. *Massartella* nymphs and adults collected on different localities on Churí-tepui belong to another undescribed species. This species was commonly sampled at the entrance of the Cueva Charles Brewer (Boca de Mamut). Numerous rests of adults were observed in spider webs deeply inside the Cueva Charles Brewer, as well, where they had to fly in an absolute darkness. Nymphs were collected also in other caves of Churí-tepui. Other undescribed species was sampled at Auyán-tepui and in a stream below Salto Angel waterfall. In the Pantepui, *Massartella* nymphs inhabit exclusively cold stenothermal streams with temperatures ranging between 14 – 18 ºC. They prefer pools in streams, where they can hide below rocks and stones. Female subimagos were observed flying before the sunset.

Material examined: *Massartella devani*: R1 – 12N, R6 – 1N; *Massartella* sp. 1: R2 – 52N; R3 – 5N; R4 – 6N; R5 – 9N; *Massartella* sp. 2: C1 – 18N, 7♀♀; C2 – 25N, 2♂♂, 8♀♀, 1♂ subimago, 3♀♀ subimagos; C3 – 3N, 1♀, 2♂♂ subimagos, 2♀♀ subimagos; C4 – 2N; C5 – 1N; C6 – 23N; C7 – 10N; C12 – 70N; *Massartella* sp. 3: A1 – 13N; A2 – 27N; A3 – 3N, 1♂ subimago; A4 – 30N, 1♀ subimago; A5 – 7N; A6 – 4N.

Genus *Miroculis* Edmunds, 1963

The genus *Miroculis* comprises 15 species, with distributional area ranging from north-eastern Argentina to Trinidad (DOMÍNGUEZ, 2007; PETERS *et al.*, 2008; SALLES & LIMA, 2011). Three species have been recorded in Venezuela (SAVAGE, 1987). *M. nebulosus* Savage, 1987 and *M. fittkaui* Savage & Peters, 1983 were collected by the Cerro de la Neblina base camp (145 m a. s. l.). PETERS *et al.* (2008) recorded *M. nebulosus* in

Serranía de Chiribiquete in Colombian Amazonia belonging to the Guyana Shield. SAVAGE (1987) described Pantepui species *M. bicoloratus* from the Camp II at Cerro de la Neblina (ca 2,100 m a. s. l.). The material collected at both Churí-tepui and Auyán-tepui is similar to *M. bicoloratus*, however it belongs to different, yet undescribed species.

Material examined: *Miroculis* sp. 1: C1 – 9N, 2♂♂, 2♂♂ subimago, 2♀♀ subimagos; C2 – 1N; C10 – 2N; *Miroculis* sp. 2: A5 – 23N, 3♀♀; *Miroculis* sp. 3: R6 – 3N.

Family Oligoneuriidae Ulmer, 1914

This family includes 6 recent genera in South America. The only known genus from Venezuela, *Fittkauneuria*, is distributed also in Brazil (CHACÓN *et al.*, 2009; DOMÍNGUEZ *et al.*, 2006).

Genus *Fittkauneuria* Pescador & Edmunds, 1994

Two species are known from this genus. The first one, *F. adusta* Pescador & Edmunds, 1994 was described from southeastern Venezuela and northern Brazil. This species is relatively common in small streams of La Gran Sabana region. Although it was not recorded at tepui plateaus, it was sampled above 1,800 m a. s. l. The second species, *F. carina* Pescador & Edmunds, 1994 was sampled in several streams at Cerro de la Neblina at altitude ranging from 750 to 1,820 m a. s. l. (PESCADOR & EDMUNDS, 1994), and therefore both species can be still considered as of the Pantepui province.

Material examined: *Fittkauneuria adusta*: A1 – 4N, R6 – 1N.

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