

*TAXONOMICAL AND ECOLOGICAL ASPECTS OF WATER MITES
(ACARI:HYDRACHNIDIAE) FROM TOTA STREAM BOYACÁ-COLOMBIA*

ELISA JIMENO CALLE

*UNIVERSIDAD DE BOGOTÁ JORGE TADEO LOZANO
FACULTAD DE CIENCIAS NATURALES E INGENIERÍA
MAESTRÍA EN CIENCIAS AMBIENTALES
BOGOTÁ D.C.
2017*

*TAXONOMICAL AND ECOLOGICAL ASPECTS OF WATER MITES (ACARI:HYDRACHNIDIA)
FROM TOTA STREAM BOYACÁ-COLOMBIA*

ELISA JIMENO CALLE
Biólogo

Trabajo presentado como requisito para optar al título de
Magister en Ciencias Ambientales

Director:
MARIA ISABEL CASTRO REBOLLEDO
Bióloga, M.Sc., Ph.D.

UNIVERSIDAD DE BOGOTÁ JORGE TADEO LOZANO
FACULTAD DE CIENCIAS NATURALES E INGENIERÍA
MAESTRÍA EN CIENCIAS AMBIENTALES
BOGOTÁ D.C.
2017

General Introduction

Rivers and streams are systems that provide economic and social benefits. However, the fast-growing industries, populations, and variations in the river banks, due to changes in ground use, are increasing the volume of contaminants dumped in this type of systems. This not only affects the capacity of auto-purification and species diversity but also the availability of clean water (Castro, 2012). Simultaneously, the shift in species dominance and energy pathways, has a direct repercussion in ecosystem structure and function (Davis, Rosemond, Eggert, Cross, & Wallace, 2010).

Due to specific ecological requirements along their complex life cycle, water mite species interact and depend on various components of their environment, a feature that is not shared by most other aquatic animals (Gerecke & Di Sabatino, 2007). In many habitats there may be around 75 species and their densities may reach up to 2000 individuals per square meter (Goldschmidt, 2016; Melorose, Perroy, & Careas, 2015). Even so, water mites are still little documented for the Neotropics and Colombia, there are few investigation of species description (Cook, 1974; Lundblad, 1953) and no published information on environmental parameters except for Goldschmidt (2004) and Goldschmidt, Helson, & Williams (2016) in Panama and Costa Rica.

There is a tradition for long-term studies regarding water quality available for fish, terrestrial macroinvertebrates and fresh water macroinvertebrates as part of monitoring of water quality (Jackson & Füreder, 2006) nevertheless these long-term studies often forget water mites. Goldschmidt (2016) and Proctor (2007a) describe mites as being neglected because a considerable amount of papers and research literature on water quality with macroinvertebrates, either identify mites simply “Hydracarina” or “Acari”, or do not mention them at all. These circumstances, in which fresh water ecologists are

ignoring a rich and diverse taxon, make it difficult to extract and use relevant information about mite ecology and extrapolate it to assess health of a water body regarding its functionality, stability and vulnerability (Gerecke & Di Sabatino, 2007). Long term ecological , physical and chemical monitoring in Europe where its water mite fauna is relatively well known have demonstrated that water mites are sensible indicators of water quality (Boboescu & Park, 2010)

This study was part of a wider project called the Effects of Nutrient Enrichment on the Macroinvertebrate Composition in a Tropical Mountain Stream; that aimed to observe the effects of anthropogenic pressure, such as increase of nutrients, on the structure and function of the fluvial community (Castro , 2012). For this project, macroinvertebrates belonging to Orders Ephemeroptera, Plecoptera, Odonata, Hemiptera, Trichoptera, Lepidoptera, Coleoptera and Diptera were identified to genus level but here mites were identified to species level when possible.

The main objectives of the present investigation are to identify and describe the water mite community and therefore add information to the current state of knowledge related to water mite species for Tota stream. Correspondingly, correlate their distribution along river Tota with physical and chemical parameters.

Water mites (Acari: Hydrachnidiae) from Tota Stream, Boyacá, Colombia

Elisa Jimeno-Calle¹, María Isabel Castro-Rebolledo^{2*}

¹Maestría en Ciencias Ambientales Universidad Jorge Tadeo lozano

²Universidad La Salle, Departamento de Ciencias Básicas, e-mail:micastro@unisalle.edu.co

Abstract

Water mites from the Tota Stream were examined, various genera are treated. The species *Atractides tanutus*, *Limnesia abenda* and *Clathrosperchon punctatus* are new records for Colombia. New species for the genera *Corticacarus*, *Hygrobates* and *Neotorrenticola* and a new subspecies for *Hygrobates plebejus* is reported. Ecological characteristics of the river area sampled and ecological preferences of the analyzed species are discussed.

Key words. Water mites, new species, neotropical river

Resumen

Los ácaros acuáticos del Río Tota fueron examinados, se discuten varios géneros. Las especies *Atractides tanutus*, *Limnesia abenda* y *Clathrosperchon punctatus* son nuevos registros para Colombia. Se reportan nuevas especies para los géneros *Corticacarus*, *Hygrobates* y *Neotorrenticola* y una nueva subespecie para *Hygrobates plebejus*. Se discuten las características ecológicas del área muestreada y las preferencias ecológicas de las especies analizadas.

Palabras clave Ácaros acuáticos, nuevas especies, río, neotrópico,

Introduction

Water mites are considered a diverse group within the macroinvertebrates. There are around 6000 described species, nevertheless, they are frequently neglected specially in tropical environments (Di Sabatino, Gerecke, & Martin, 2000; Di Sabatino et al., 2008; Goldschmidt, 2016; Walter & Proctor, 1998). Few works have been developed of this group in Colombian ecosystems, which has led to a generalized unawareness of its diversity and taxonomy.

A series of papers were published as a first contribution to Colombian water mite fauna by Walter (1912) who sampled in Cundinamarca, followed by Lundblad (1941). Then the later author Lundblad, (1953) published the results of field collection conducted between 1936 to 1940 in which he reported 75 species with a total of 56 new species, however, this study was developed in five sampling sites in the Departments of Huila and Cauca. Subsequently, Viets (1956) published two new species for Colombia, from Atlántico. Rosso de Ferradás & Fernández, (1995, 2005, 2009) published a list of species with biogeographic data and illustrated taxonomic keys for the main families and genera of aquatic mites (Hydrachnidiae) of South America. The next contribution to the knowledge of aquatic mite species in Colombia was not made until 2010 when the species *Wandesia (Partnuniella) lehmanni* from the department of Boyacá was described (Pesic, Chatterjee, Herrera-Martinez, & Herrando-Perez, 2010). Finally, in 2012, Combata, Ospina, & Jimeno published a checklist of water mites from Colombia.

Since there is little knowledge of water mite fauna in Colombia and no constant investigations in this group are conducted, detailed studies are required to fill the list of water mite species. Hence, the

aim of this study is to document the aquatic mites found in Tota stream and thus enlarge the knowledge of this group for the country.

Materials and methods

Area examined

The Tota stream originates in the eastern mountain range, in Las Alfombras paramo located in the department of Boyacá (Colombia) at 2540 m.a.s.l (Castro Rebolledo, 2012). During the time of sampling (December 2006-March 2012) the Temperature range was between 7-15°C: The precipitation was between 200-600 mms (IDEAM, 2006-2012). The drainage basin covers an area of 150 km². Due to the different uses of land, four sampling stations were selected along the Tota stream. They ranged from well conserved to highly intervened lands (Figure 1).

Data about collection localities

The first location was Tota, located at 2834 m.a.s.l, in the medium high part of the stream basin in the municipality of Tota at 05°33'36" N and 73°02'45"W. It is characterized by low slope with an intensive use, primary for cattle, with native scrub vegetation and abundant *Eucaliptus globulus* planted in a scattered form. It represents an area with an almost intact fluvial habitat and the physical chemistry quality of the water is optimum.

The second point of the stream, named Control, was in the municipality of Cuítiva, with coordinates 05°58'15" N and 72°58'54" W at 273 m elevation. It corresponds to the medium low part of the stream basin. The bank is composed mainly of willows (*Salix humboldtiana*) and some alders (*Alnus acuminata*) planted but rather scant. Its slope is approximately 3%. In the sector, there are areas with a strong anthropic intervention, primarily for cattle and in a lesser proportion for cultivation. It represents a fluvial habitat with presence of nutrients in the water due to human activities, agricultural and ranching from the municipality of Cuítiva.

Batán, the third site, was located at approximately 695m downstream from the control reach. It has very similar characteristics to the second reach. The coordinates of this point are 05°58'61" N and 72°58'43" W and with an altitude of 2567 m elevation.

Iza, the last place, was in a lower part of the stream basin; its coordinates are 05°61'28" N and 72°58'20" W, with an altitude of 2529 m.a.s.l. In this section the banks of the river have trees, mainly willows and the slope is similar to that of the Cuítiva (Control) station. This section is subjected to the drainage of residual waters from the municipality of Iza. The surroundings correspond to the lower part of the river, where the valley is characterized by large plains where cattle is raised. It represents an altered fluvial habitat with presence of nutrients caused by the diverse activities in the municipality of Iza.

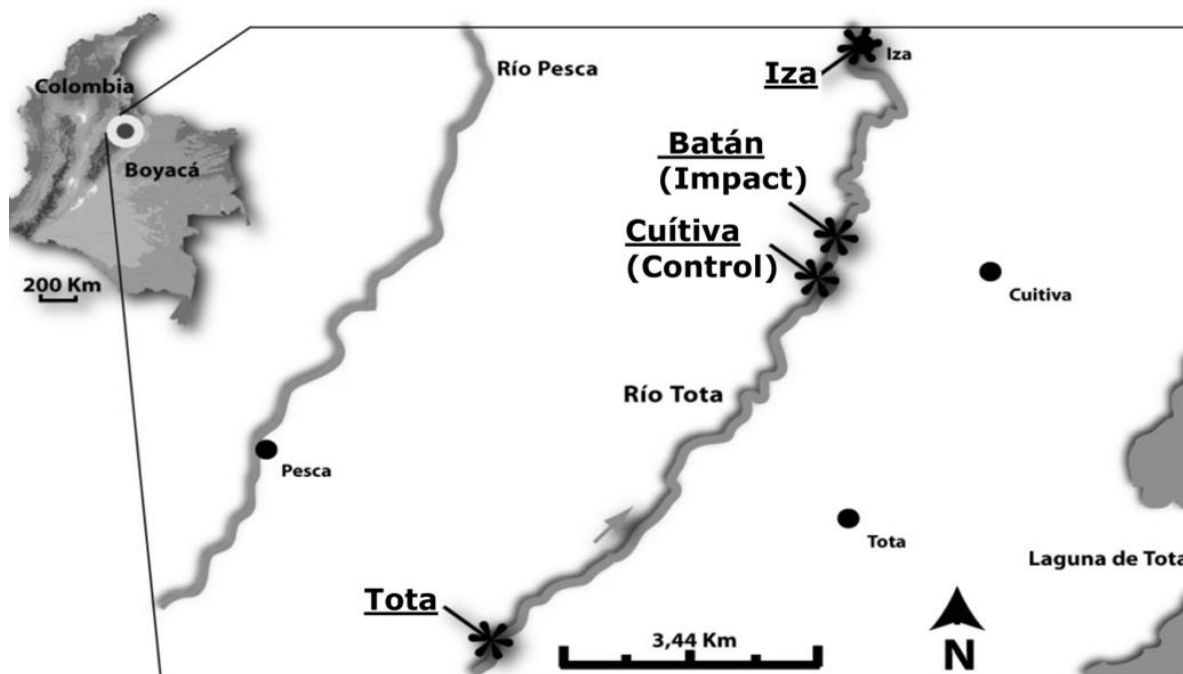


Figure 1 Tota stream and sampling locations (taken form Castro Rebolledo, 2012)

Taxonomy

Water mites were collected by Surber sampling method (200 µm mesh). Samples were cleaned with stream water and filtered through different sieves, (the smallest, 0.5 mm mesh size) and preserved in 70% alcohol. Organisms were sorted in the laboratory with the aid of a stereo microscope, cleared in

a solution of 55% of acetic acid, then either examined in excavated slides or mounted on microscopic slides in a Hoyer's solution and determined to species using a contrast microscope and available descriptions and keys (Cook, 1980; Lundblad, 1953; Rosso de Ferradás & Fernández, 2009). The species are deposited at the La Salle Museum in Bogotá Colombia and the new species are being described. Regular terminology is used to describe each species. Also taxonomic characteristics and measurements are based on the original descriptions. Finally, ecological information is given when available.

Results

Rhynchohydracaridae LUNDBLAND, 1936

***Clathrosperchon* LUNDBLAD, 1936**

Species from this genus are found in streams in south and north America. For Colombia, two species of *Clathrosperchon* are known *Clathrosperchon crassipalpis* and *Clathrosperchon minor* found in Cauca.

***Clathrosperchon punctatus* Cook, 1980**

The reviewed specimens agree well with the description given by Cook (1980).

Female. Body length 760 μ , with "numerous punctate or reticulate dorsalia, length of the postocularia platelets 192 μ . Postocularia located at anterior end of the platelet, postocularia platelets varying from two to four punctae in width" (Figure 2 C). Other platelets variable in the degree into which they are broken up by punctate or reticulations but they are never arranged in a radiating pattern from the central muscle attachment site. Area between the platelet either soft or tending to become reticulate. Genital field 140 μ in length 133 μ in width. Numerous genital acetabula. Large and crescent shape pregenital sclerite (Figure 2 B). Heavy seta at tip of P-V varying from somewhat stocky to relatively narrow (Figure 2 A).

Examined material. 2 females from Tota and 2 females from Batán. Only females were examined

Family SPERCHONTIDAE Thor, 1900

Genus *Sperchon* Kramer, 1877

Known from Africa and tropical south America (Cook, 1974, 1980; Smith, Cook, & Smith, 2010). In some species the larvae are parasites of Nematoceros Diptera and some trichopteran (Smith & Oliver, 1986). Some species of *Sperchon* commonly parasite backflies (Simuliidae) and may affect their fecundity (Gledhill, Cowley, & Gunn, 1982). In Colombia two species have been reported: *Sperchon (Mixosperchon) andinus* in Cauca and *Sperchon (Mixosperchon) andinus* in Huila

***Sperchon motasi* (Lundblad, 1953)**

The material examined agrees with the description given by Lundblad for the species.

Male. Body 845 μ long. Epimerans close to the external genital organ (

Figure 3 B). The dorsum with small shields, the biggest are the postocularia. The dorsal setae are thick.

The palp has on P.II a middle, slender projection ventrally. P. III has a bristle or a fine spine. Both pins of P. IV are inserted laterally (Figure 2 A). Epimers and legs with no special features. The latter present dorsal short, thick, and curved setae. Genital flaps 164 μ long. Behind the genital fields lies a small chitin plate.

Female: Most characteristics of the male. Body 1120 μ long. Palp's shape and armament, epimers, legs, and external genital organ coincide with those of the male. The flaps, however, which are slightly less bristly, reach a length of 186 μ . Before the genital opening lies a chitin plate.

Material examined: 3 males and 6 females from Tota.

Family TORRENTICOLIDAE Piersig, 1902

Genus *Torrenticola* Piersig, 1896

The subfamily Torrenticolinae includes many species of the genera *Torrenticola*. Most species are found in temperate areas of Eurasia and North America (Cook, 1974; Gerecke, 1996), but some are known from Africa (Cook, 1966), The Americas (Cook, 1980; Tom Goldschmidt, 2007), and Australia (Cook, 1986). In Colombia there are 7 species reported: *Torrenticola* (*Hetereatractides*) *serratrirostris*, *Torrenticola* (*Monoatractides*) *brevis brevis*, *Torrenticola* (*Monoatractides*) *brevis clavipes*, *Torrenticola* (*Monoatractides*) *hesperia*, *Torrenticola* (*Torrenticola*) *conirostris* in Cauca and *Torrenticola* (*Torrenticola*) *columbiana* in Huila.

***Torrenticola columbiana* (Lundblad) 1941**

Atractides columbianus Lundblad 1941

Torrenticola (*s.str.*) *columbiana*; LUNDBLAD, 1953.

T. (Torrenticola) columbiana; COOK, 1980

The material examined agrees well with the description given by Lundblad (1953) and Cook (1980).

Male. The frontal plates smooth and not hollowed as the main dorsal plate. The latter with a small prominent tip (Figure 4 B). Large main dorsal plate 542 μ long and 380 μ wide. The whole dorsal plate is 569 μ long. Front plates 129 μ , posterior 178 μ long. Relatively bulky palp, with ventral projections P. II-IV (Figure 4 C,D). The gland of EP. I opens near to the anterior end. The ventral plates, measured in Ep. I, is 706 μ long. Distance between the posterior end of the maxillary inlet and the anterior end of the genital field 225 μ . External genital organ 168 μ long. Width of each flap 64 μ . Anal opening and accompanying gland openings side by side (Figure 4 A).

Female. Anterior plates as in the male. Large main dorsal plate 690 μ long and maximum 569 μ wide. The whole dorsal shield is 732 μ long. Front plates 167, posterior 211 μ long. Ventral shield, as measured in the male, 885 μ long. Distance between the posterior end of the maxillary inlet and the

anterior end of the genital field 207 μ . External genital organ 196 μ long, width of each valve 79 μ . Excretion pore with adjacent gland openings as in the male (Figure 4 E).

Material examined 8 females from Tota and 1 female from Iza.

Comments: only females were observed in the material examined.

Family LIMNESIIDAE Thor, 1900

***Limnesia* (Koch 1836)**

Species from this genus can be found in streams, ponds lakes worldwide (Cook, 1974, 1980, 1986, 1988). Known larvae are parasites of Chironomidae (Smith & Oliver, 1986). In Colombia *Limnesia* three species have been found: *Limnesia (Limnesia) fuhrmanni* in Cundinamarca and Cauca, *Limnesia (Limnesia) Longipora* in Cauca and *Limnesia (Limnesia) pauciseta* in Antioquia.

***Limnesia abenda* (Cook, 1980)**

This species was described based solely on the female, on this sampling we found males that resemble body shape and palp.

Female. Length of body 775 μ dorsum with a small posteromedial platelet, a pair of small platelets bearing the postocularia and a pair of very small platelets located between the two above (Figure 5 B). First coxa close together but not fused. Posterior apodemes of anterior coxal group small. Medial seta of third coxae located posteriomedial to the Glandula Limnesiae, sockets of the fourth legs are large, genital field 207 μ in length, 163 μ in width. Three pairs of genital acetabula (Figure 5 A). Peg like seta on the ventral side of P-II short and thickened lying on a very short tubercle; two relatively long setae on ventral side of P-IV close together, with the more distal on a small tubercle.

Material examined: 1 female from Tota, 1 male from Iza and 1 female and 1 male from Batán.

***Neotorrenticola* (Lumblad, 1953)**

This genus has five species reported for Colombia for Cauca and Huila: *Neotorrenticola bidens*, *Neotorrenticola crassipes*, *Neotorrenticola papillata*, *Neotorrenticola plumipes*, and *Neotorrenticola walteri*.

***Neotorrenticola* n. sp.**

This material is under description. Measurements and drawings are under work.

Male very similar to *N. bidens* nevertheless the genital papillae are slightly different and palp setae longer.

Female. As the male is very similar to *N. bidens* but has an extra dorsal shield, genital papillae are slightly different and palp setae longer as in the male.

Material examined: 1 male, 1 female from Tota; 3 females, 1 male from Iza; 12 females, 2 males from Batán and 5 females, 1 male from Control.

Family HYGROBATIDAE

Within the Hygrobatidae, *Hygrobates* and *Atractides*, are among the dominant water mites in flowing water habitats in the Northern Hemisphere and they contain with the large numerous subgenera (Cook, 1974). In the southern hemisphere the family exhibits much greater diversity at the generic level (Cook, 1974, 1986, 1988).

***Hygrobates* (Koch, 1837)**

Hygrobates is a large genus with many species. Known hygrobatid larvae are parasites of Chironomidae (Smith & Oliver, 1986). In Colombia there are seven species: *Hygrobates* (*Hygrobates*) *ampliatius ampliatius*, *Hygrobates* (*Hygrobates*) *amplipalpis*, *Hygrobates* (*Hygrobates*) *obtusidens*, *Hygrobates* (*Hygrobates*) *plebejus plebejus*, *Hygrobates* (*Hygrobates*) *plebejus tamboensis*, *Hygrobates* (*Hygrobates*) *sterrodermus* and *distendens*.

***Hygrobates plebejus* (Lundblad) 1953**

Hygrobates plebejus Lundblad 1930

The material examined agrees with the generality of the species described by Lundblad.

Male. The body is 880 μ long. 725 μ wide. The skin without sculpture. Chelicera, including claw 296 μ long. The palp possesses a very small, punctuated cusp on the P-II (Figure 6 C). The P-III is also interiorly serrated. The epimers without special characteristics. External genital organ constructed according to the usual type 146 μ long and 175 μ wide. The genital acetabula close-together on triangle, not arc-oriented (Figure 6 D).

Female. Body 930 μ long. Skin soft, without sculpture. Palp as in the male, with small, toothed projection on P. II and a dentition on the posterior side of P. III (Figure 6 B). Epimers as in the males, with the inside curved Ep. IV. Legs slender. The acetabula of the external genital organ forming a triangle (Figure 6 A).

Material examined 2 females from Iza; 2 females, 1 male from Batán and 1 male, 1 female from Control.

Hygrobates* similar to *H. plebejus

This species has on P II two more setae on the dorsum and one of them distal. The general disposition of the body compared to *H. plebejus*, and although it may seem as *H. plebejus* var. *tamboensis* it lacks the lateral setae en P. IV and the epimera are not close together but arranged as in *H. plebejus*.

Material examined: 11 females, 14 males from Iza; 34 females, 26 males from Batán and 23 females and 15 males from Control.

***Hygrobates* n. sp.**

This species when compared with the previous two has shorter legs and bigger bodies. More examination needs to be made due to the fact that legs are rarely included in the descriptions. The disposition of the genital papillae similar to *H. plebejus* in the male but varies slightly in the female. Also, the epimers are distributed as in *H. plebejus* but the setal distribution does not match to the species revised.

Material examined 3 males, 3 females from Iza; 2 females, 1 male from Batán and 1 female from Control.

***Hygrobatella* Viets 1926**

This genus was erected by Viets and is characterized by free maxillary located between the anterior epigraphic groups, (Lundblad, 1953). For Colombia there are 10 species: *Hygrobatella* (*Hygrobatella*) *elegantula*, *Hygrobatella* (*Hygrobatella*) *longigenitalis elata*, *Hygrobatella* (*Hygrobatella*) *longigenitalis longigenitalis*, *Hygrobatella* (*Hygrobatella*) *papillata*, *Hygrobatella* (*Hygrobatella*) *puberula arcuata*, *Hygrobatella* (*Hygrobatella*) *puberula minuta*, *Hygrobatella* (*Hygrobatella*) *puberula montana*, *Hygrobatella* (*Hygrobatella*) *puberula validipalpis*, *Hygrobatella* (*Schwoerbelobatella*) *multiacetabulata* and *Hygrobatella* (*Schwoerbelobatella*) *polygramma* found in Cauca, Cundinamarca and Huila.

***Hygrobatella polygramma* Lundblad, 1953**

Hygrobatella polygramma (Beatriz Rosso de Ferradás, Fernández, & Rocabado, 2004) state that this species has only been registered in basins of Colombian Andes.

Males and females have about the same characteristics as describe in Lundblad, but measurements change: Palp with most of the ventral side of the P II dented P. IV has a broad bristle distal on the ventral side (Figure 7 B). The epimers are close together. The anterior groups end with

very elongated, somewhat curved, tongue-shaped and chitinous forte, rounded at the end, which surround the maxillary organ from behind and far out (Figure 7 A). Legs Slim, not particularly rich or roughly bristled, claws with claw leaf and ventral side teeth. Males Body 1079 μ long and gnatosoma relatively broad, 255 μ long. External genital organ with very large plates, which are briefly united before and behind the opening. These are all 330 μ wide, but only 196 μ long. They carry many papillae about the same size. Females Body 1120 μ long and. gnatosoma 278 μ long. External genital organ with two powerful, rounded outer, concave plates, each with many papillae. The genital field 465 μ measures between the plate outer edges (Figure 7 C).

Comments: *Hygrobatella polygramma* has registered it only In a basin of the Colombian Andes.

Material examined: 7 females and 5 males from Tota and 1 female from Control.

***Hygrobatella puberula* (Viets 1935)**

Even though only males were found , they agree well with the description made by Viets, (1935) of *Neohygrobates puberulus*, later synonymized by Cook 1980.

Female. Size and shape: body 815-895 μ long and 605-685 μ wide. The body is briefly elliptical The skin is dorsally and ventrally finely lined; dorsally has transversely running somewhat stronger lines, and intermediate cross-connections resembling a delicately net-like, but quite irregularly shaped. dorsal plates are absent. The ventral sides of P. II and P. III are delicately punctuated. P. II, on the distal side has a weak beaded corner present. P. II, P III with 5 dorsal setae. P IV has 2 bead bristles and the rest is abundantly 12 fine hairs as trimming (hence the species name) (Figure 8 D).

The epimers each form two separate groups. The anterior median corner of the first plates carries 3 bristles. The 3rd plates are Relatively small; They are medial of the 4th, essential Larger Medial in front of the 3rd is the large glandular pore (Figure 8 A).

The legs wear only thorns, no swimming hair. The genital organ consists of 2 weakly curved, 175 μ Long plates with 3 consecutive wells and Hair pores.

Male. It is slightly smaller than the female. The only difference is Genital plate of 183 μ length and 170 μ width. The genital Opening is 108 μ long and front (slightly ahead) 62 μ wide. The front edge of the plate is convex, the rear edge center notched. On each side 3 papillae lie behind each other. In front of the anterior margins of the genital opening lie 6 to 6 7 Hair pores with long hairs. The many remaining hairs are short (Figure 8 C).

Material examined: 1 male from Tota and 1 male from Control

***Corticacarus* (Lundblad 1936)**

This genus is known for south America, Southern north America, Australia and New Zealand. (Cook 1974b, 1980, 1983, 1986, 1988.). We found 16 species within this genus in Colombia collected in Cauca and Huila.

***Corticacarus multiporus* Lundblad (1953)**

Male. Body 520 μ long. Dorsum with 16 shields, all with glandular and hair, except for the two anterior ones, which are largest and carry the post ocular bristles (Figure 9 A). P. II with a well-developed, projection. Ventral side of P.III with small dentations (Figure 9 D). Between the epimers and the genital fields a hairy gland platelet and a small roundish chitin shield, external genital organ large, 250 μ broad, on each side with 6 papillae. Opening heart shaping. (Figure 9 B). Chitinous excretory pore located on the back.. Legs weakly contorted, ending with three-pronged claws.

Female. Body 672 μ long. Back with 16 plates, which are much smaller than those of the male. Between the plates the skin has a disguised structure (Figure 9 E). The palp differs from that of the male (Figure 9 H). External genital organ with 5-6 papillae on each side. The number of genital papillae varies somewhat. At times it can be reduced to at least 4, at least on one plate (Figure 9 F). Legs and anal pore like the male.

Material examined: 26 females, 2 males from Tota; 11 females, 2 males from Iza; 3 females ,7 males from Batán and 3 females, 7 males from Control.

Corticacarus* similar to *C. multiporus

The individuals have the general disposition of the ventral side but the dorsal plates are not arranged as *C. multiporus* and there are differences in the setal arrangement of the palps.

Material examined: 3 females, 2 males from Tota; 3 females from Iza; 2 females, 1 males from Batán and 3 females from Control.

***Corticacarus vietsi* (Lundblad 1953)**

This species was described based on males, in this sampling we found females that resemble the males.

Males. Body 430 μ long. Dorsum with a single, large shield 253 μ long and bearing 3 pairs of glands, of these, two are median. Both of the former have a Couple of short hair and there is a lateral long hair., the post ocular bristles are inserted in front of the dorsal shields. Behind the shield three gland plates, which are rather extensive and comparatively larger. chelicera 145 long. Palp with a long, slender, at the end weakly notched pin on P. II. Legs sparsely bristled, with three-pronged claws. External genital organ large, 200 μ broad.

Material examined: 3 females, 1 male from Tota; 4 females, 2 males from Batán and 5 females, 6 males from Control.

***Atractides* (Oudemans 1941)**

From this genus six species have been found in Cauca and Huila: *Atractides* (*Atractides*) *brasiliensis*, *Atractides* (*Atractides*) *plaumani novus*, *Atractides* (*Atractides*) *porosus columbianus*, *Atractides* (*Atractides*) *rostratus*, *Atractides* (*Atractides*) *schadei* and *Atractides* (*Atractides*) *sinuatipes*.

***Atractides tanutus* (Cook, 1980)**

Even though the description is not detailed the material examined agrees well with the description and the images provided by Cook (1980). No males were found for this species therefore the description remains only for the female.

Female. Body 638 μ posterior margin of fourth coxae more or less truncate. Length of pre- and postgenital sclerites 155 μ . Acetabular plates 96 μ in length, the entire genital field 107 μ in width three pairs of genital acetabula, these arranged in an arc. Dorsum soft and without dorsalia (Figure A-C).

Material examined: 4 females from Tota, 1 female from Iza, 4 females from Batán and 5 females from control.

Family ATURIDAE Thor, 1900

Genus *Aturus* Kramer 1875

Species in this genera are among the dominant mites in stream and spring habitats throughout temperate Eurasia and North America with a few species occurring in Africa and south America (Cook, 1974). *Aturus andinus* is the only species reported for the country and it was collected in Cauca.

***Aturus andinus* (Lundblad 1953)**

Only one individual was found of this species, but it agrees well with the description given by Lundblad for the female.

Female Body 384 μ long and 310 μ wide, dorsal plate 348 μ long and 275 μ wide, with 3 pairs of glands: one pair in the middle, accompanied by long bristles, a pair at the posterior margin, laterally, from the excretory pore and a pair of lateral and slightly further forward. The two rear pairs have very fine bristle hairs. Legs completely without swimming hairs. At the back of the body, there are about 13 genital papillae (Figure 11).

Material examined: 1 female from Control.

Discussion

15 species were described from the four sites examined. Most species belong to the family Hygrobatidae, in which *Corticacarus* and *Hygrobates* are represented with three species followed by *Hygrobatella* with two species. The other genera were represented by one species.

The highest abundance was reached by *Hygrobates* n. sp. (226 individuals) along the sampling period, followed by *Corticacarus multiporus* (127 individuals). In contrast, many species were found in low abundances ranging from 1 to 26 individuals.

The distribution of species reveals differences: the largest number of species was found in Control (Cuítiva) and Tota with 11 species each, followed by Batán with 10 species and finally Iza with 9 species. The highest abundance was found in Control, followed by Batán, Tota and Iza.

According to Rosso de Ferradás & Fernández (2005) the species found in these samples agree with the ones reported for high-land type ecosystems. Also, for Colombian highlands, a large amount of the species found here have been reported in Munchique (2200m) Coconuco and Purace (3500m) places located in Cauca Department.

From all the species reported and found, *Aturus andinus* is the only one that belongs to the genus recorded for Colombia. No new species for this genus was found in this study.

Many species within hygrobatoids, from different genera, have been reported for the country (Combata et al., 2012), among these is *Corticacarus* of which a new species was reported. This genus has at least 16 species in Colombia. Species from this genus are found along the Andean corridor from the austral end of south America up to the southern portion of north America, some can be found in fast moving waters from Southern Brazil and the center of Argentina. (Fernández & Rosso de Ferradás, 2001).

Likewise, *Hygrobatella* has ten species reported for Colombia including the ones here found, previously reported in Huila and Cauca. The genus *Hygrobates* has seven species encountered for Colombia; in this study, we found one new species and one subspecies. Finally, *Atractides* has six

species reported for Colombia but this is the first record for *Atractides tanutus*, which has only been reported for central America, México (Cook, 1980; Rosso de Ferradás & Fernández, 2005).

Similarly, *Limnesia* has three species reported for Colombia, one in Cundinamarca, one in Cauca and one in Antioquia. This is the first report for *Limnesia abenda* which had only been reported for central America, in Mexico (Cook, 1980). Alternatively, *Neotorrenticola* has five species reported for Colombia and in this study, we found a new species.

Within genus *Clathrosperchon* there have been two species reported for Colombia both in Cauca. This is the first report for *C. punctatus*. Whereas *Sperchon* has two species reported one in Cauca and one in Huila including *S. motasi*.

Finally, *Torrenticola* has seven species reported for Colombia in Cauca and Huila, including *T. Columbiana*, which was found in Tota stream. This species has been found in Mexico and other South American basins, along diverse aquatic ecosystems. It has been recorded in diverse aquatic ecosystems in the mountain ranges of Argentina and in the Bolivian river Suapi (Beatriz Rosso de Ferradás et al., 2004).

Conclusions

The water mite community along four sampling sites of Tota Stream was described. The examined points yielded altogether 15 species out of 10 genera and 6 families. From these, three species and potentially one subspecies are new to science. New records were made.

Acknowledgements

We would like to thank the project Diatom Diversity and Functional Measurements of a Mountain River of the Colombian Andes, Banco de la República-Universidad Nacional and Global Changes in Fluvial Systems: Effects On the trophic network, biodiversity and functional aspects (GLOBRIO), Fundación BBVA -Colciencias – Universidad de Colombia for financing this study. To Oscar Quesada and Ximena Castro for their comments on this research paper.

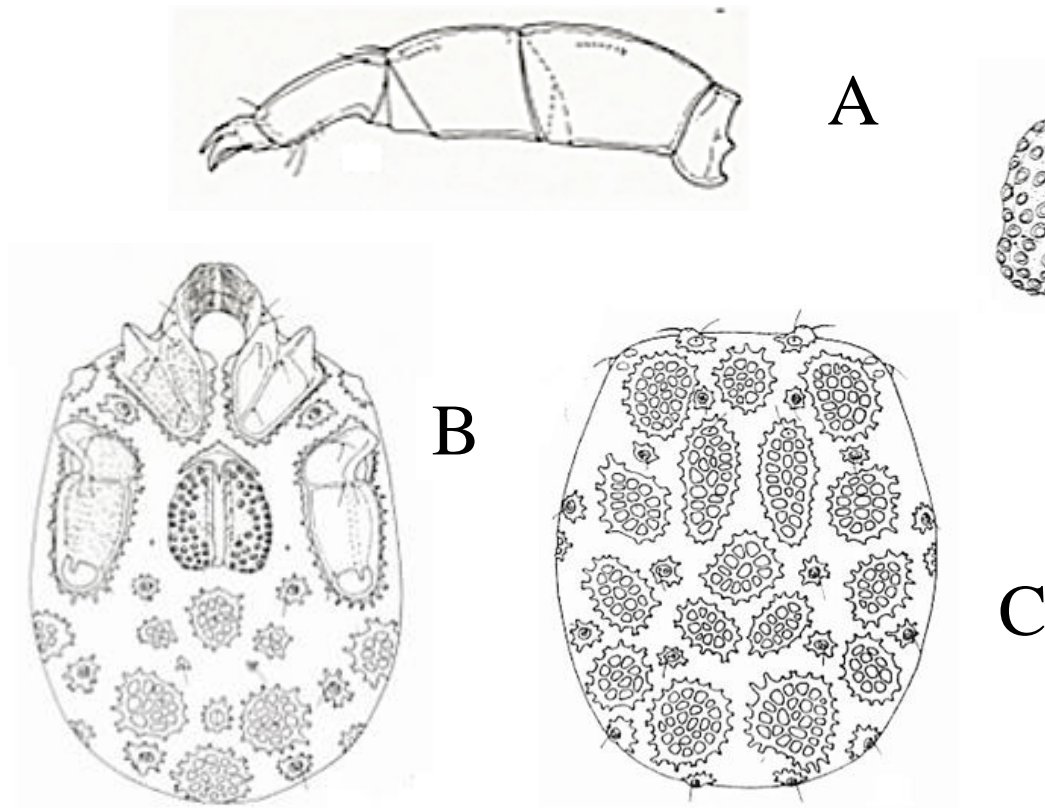


Figure 2. *Clathrosperchon punctatus*. A dorsal view, B ventral view, C genital plate,. (image taken from Cook, 1980)

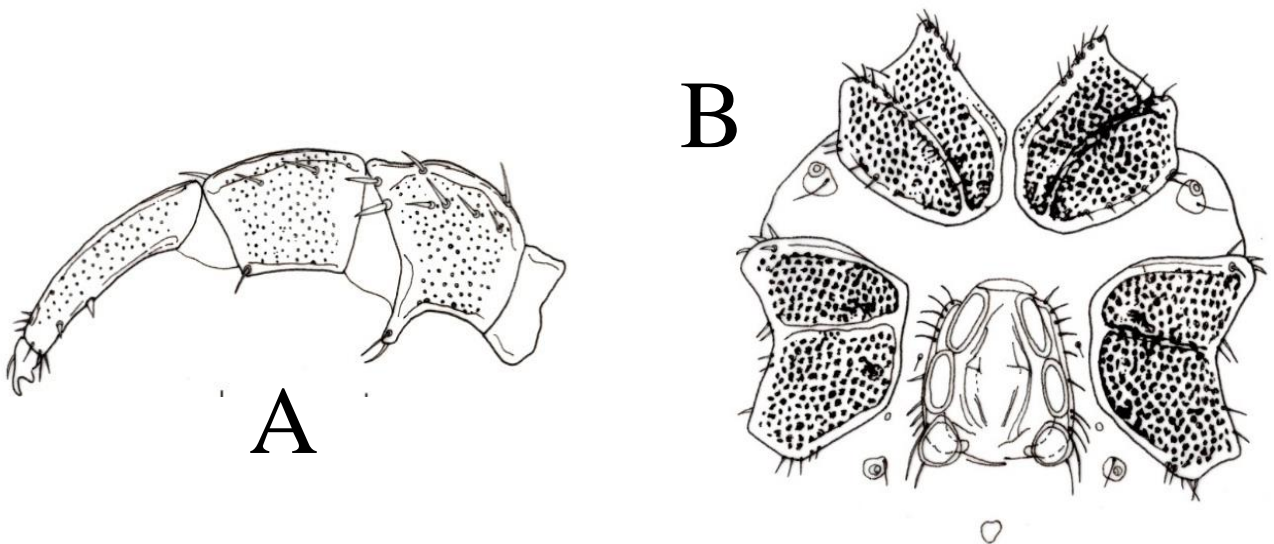


Figure 3 *Sperchon motasi* ♂, A palp, B Ventral view. Ink drawing by Combata (2000) from Lundblad 1953

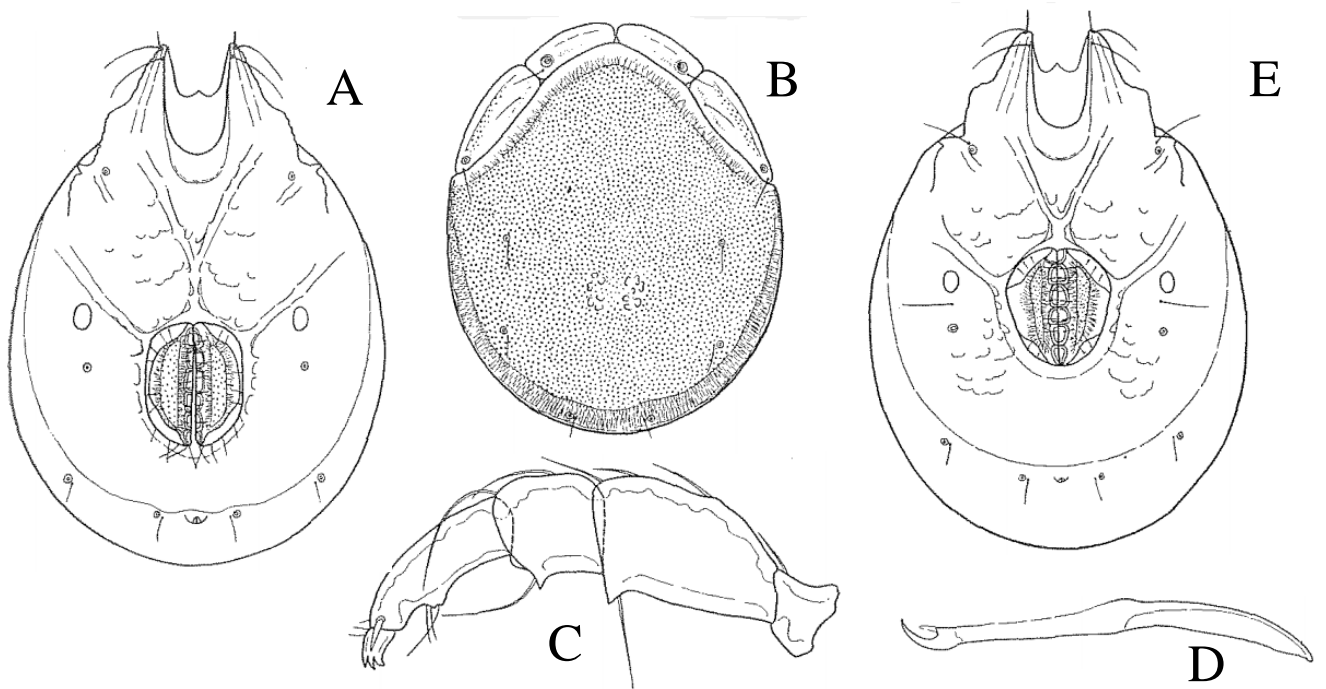


Figure 4 *Torrenticola columbiana* ♂ A. ventral view B Dorsal view C palp D chelicera ♀ E ventral view. (Image taken from Lundblad, 1953)

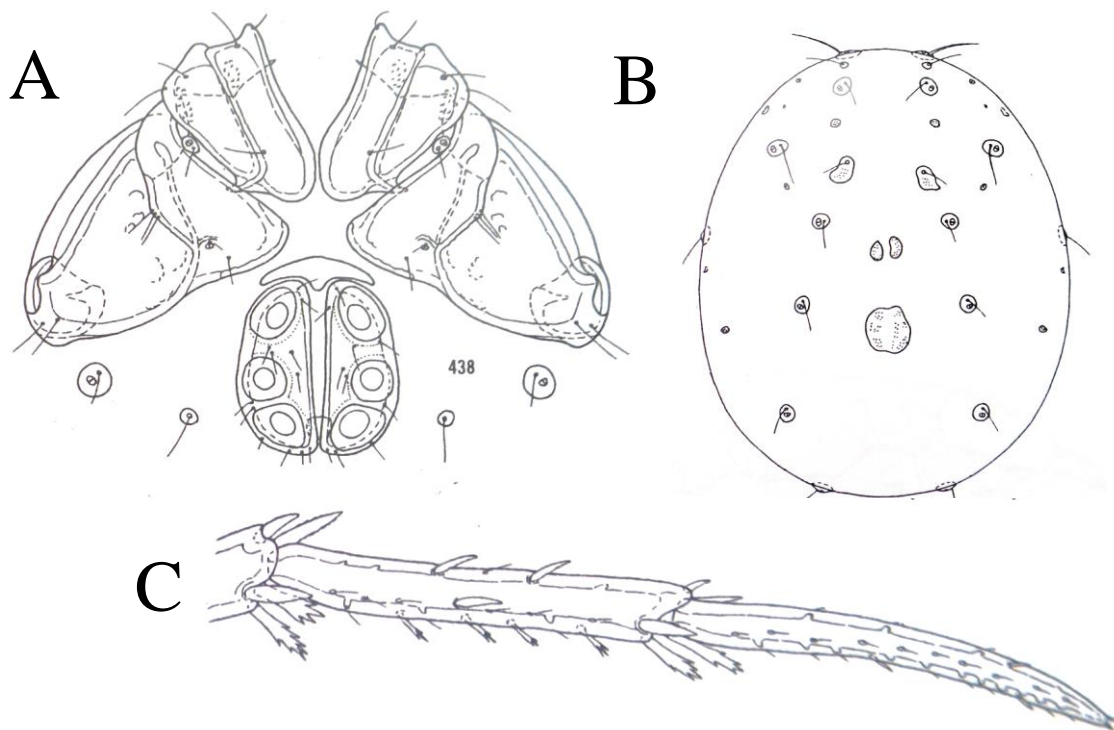


Figure 5. *Limnesia abenda*. Female A. Ventral view B. Dorsal view C. IV leg 5 and 6. (Image taken from Cook, 1980)

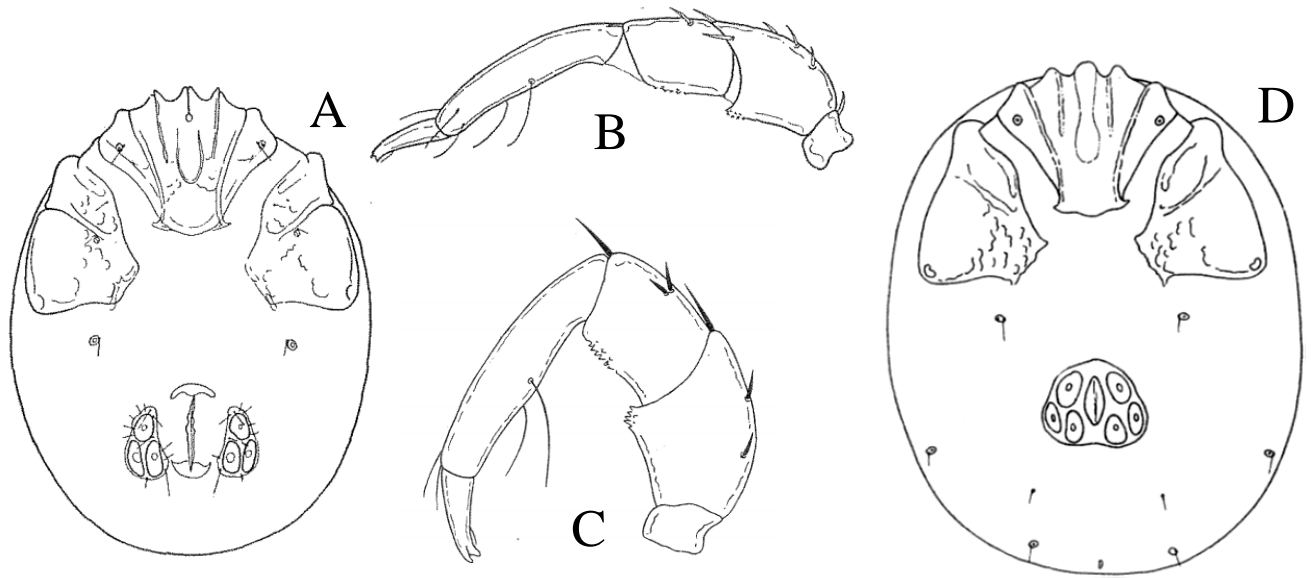


Figure 6 *Hygrobatella plebejus* ♀, A ventral view, B palp ♂ C. Palp and D Ventral view. Image taken from Lundblad (1930, 1953).

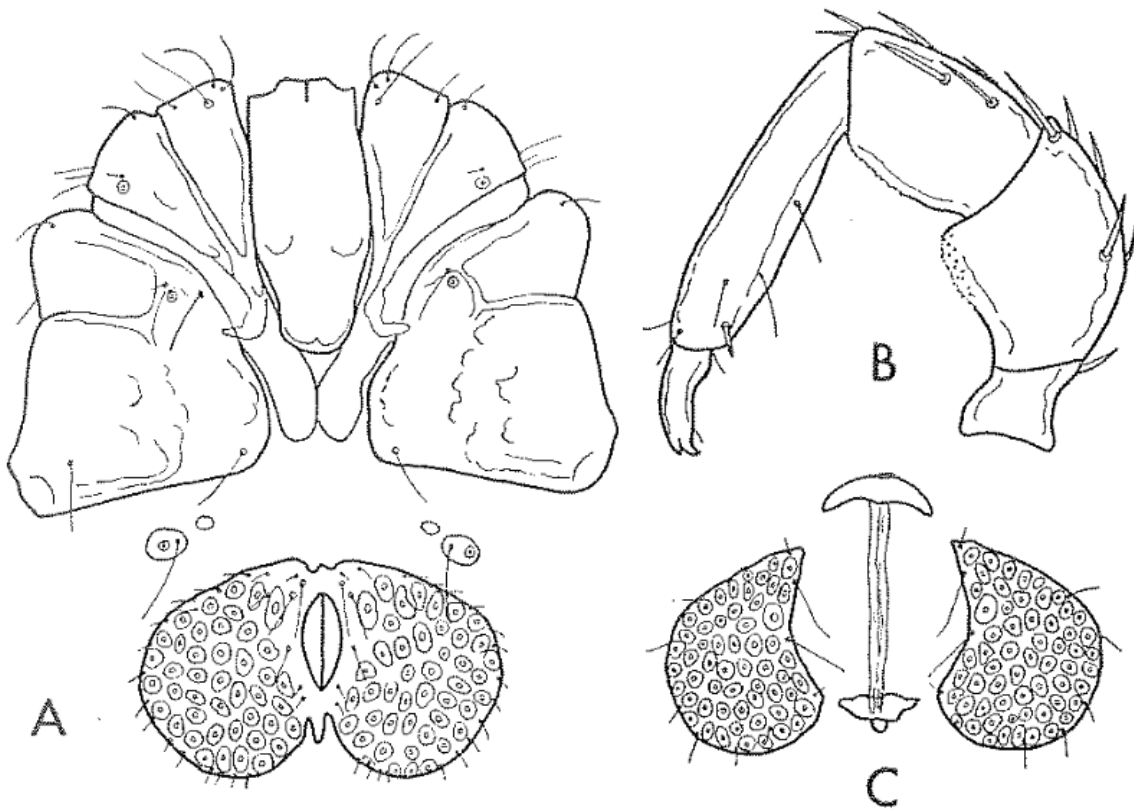


Figure 7 *Hygrobatella polygramma* Male: A epimeral and genital field; B palps. Female: C genital field. From (Image taken from Lundblad, 1953)

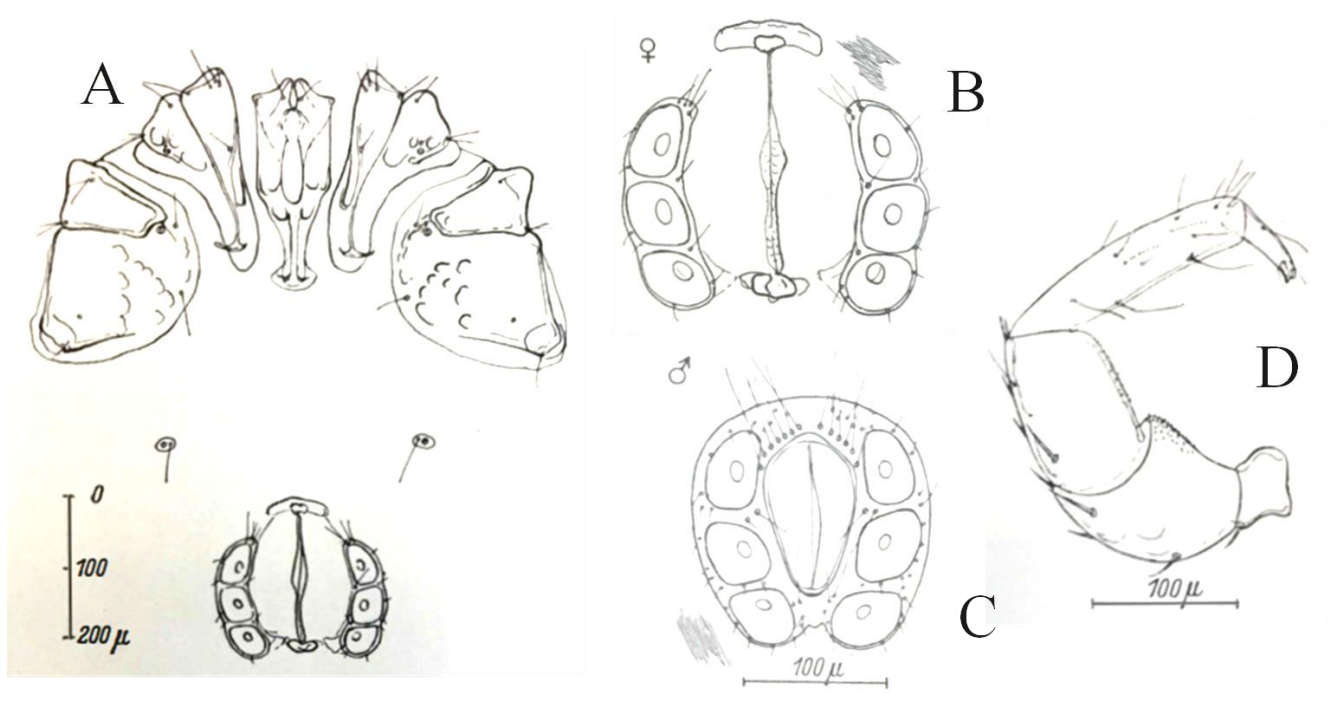


Figure 8. *Hygrobatella puberula* Female: A Ventral view, B genital, D. Palp field Male: C Genital plate (Image taken from Lundblad, 1941)

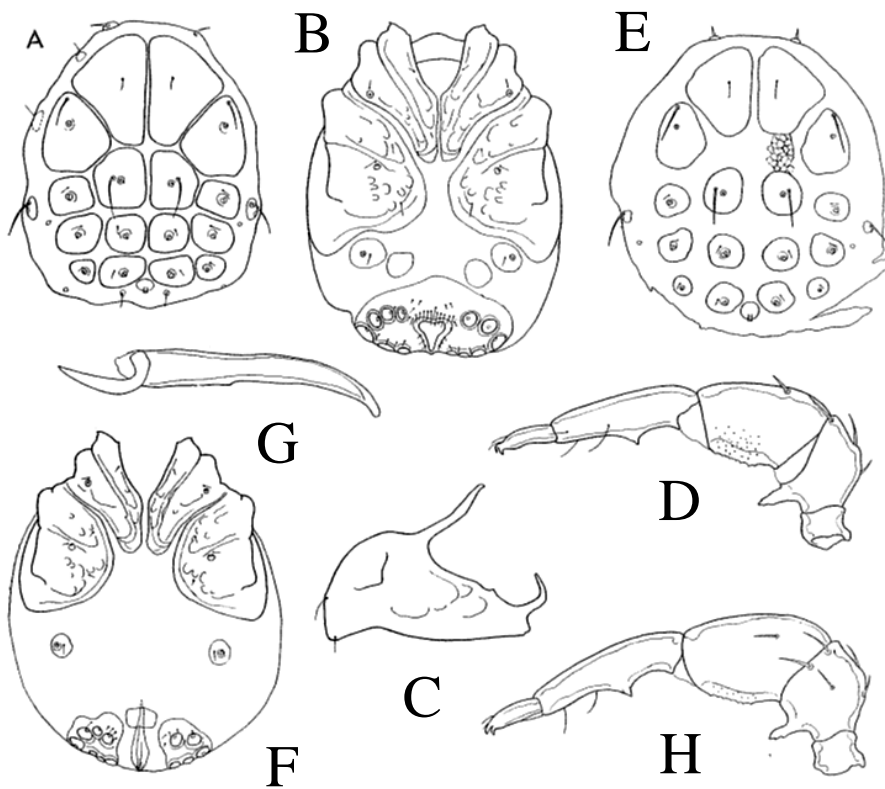


Figure 9 *Corticacarus multiporus*. Male: A. Dorsal view, B. Ventral view, C. gnatosoma, D. palp. female: E. Dorsal view, F. Ventral view G. Chelicera H. palp (Image taken from Lundblad, 1953)

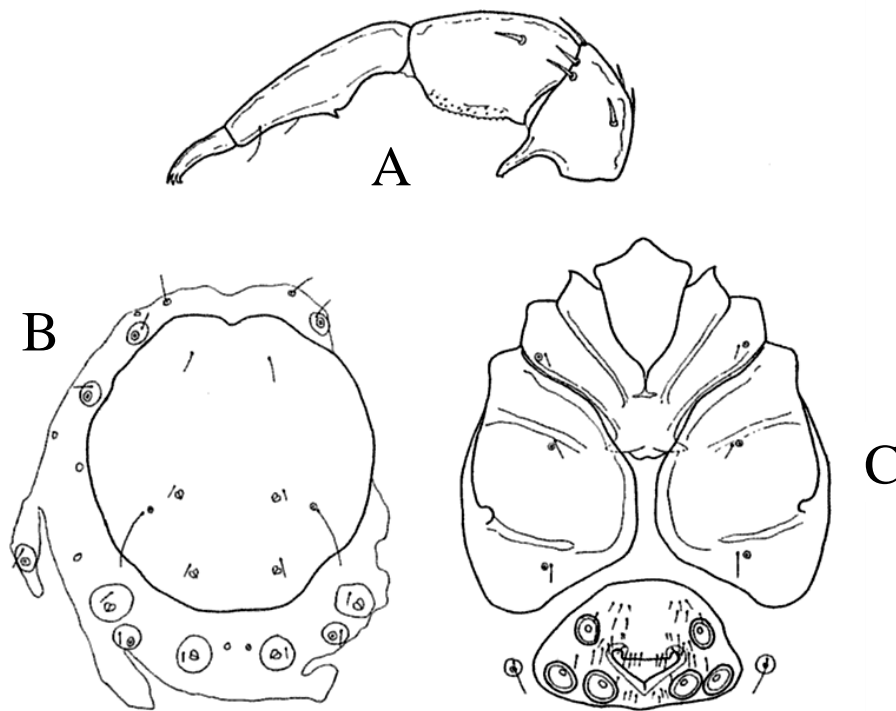


Figure 10 *Corticacarus vietsi*. Female A. Palp, B. Dorsal view C. Ventral view. (Image taken from Lundblad, 1953)

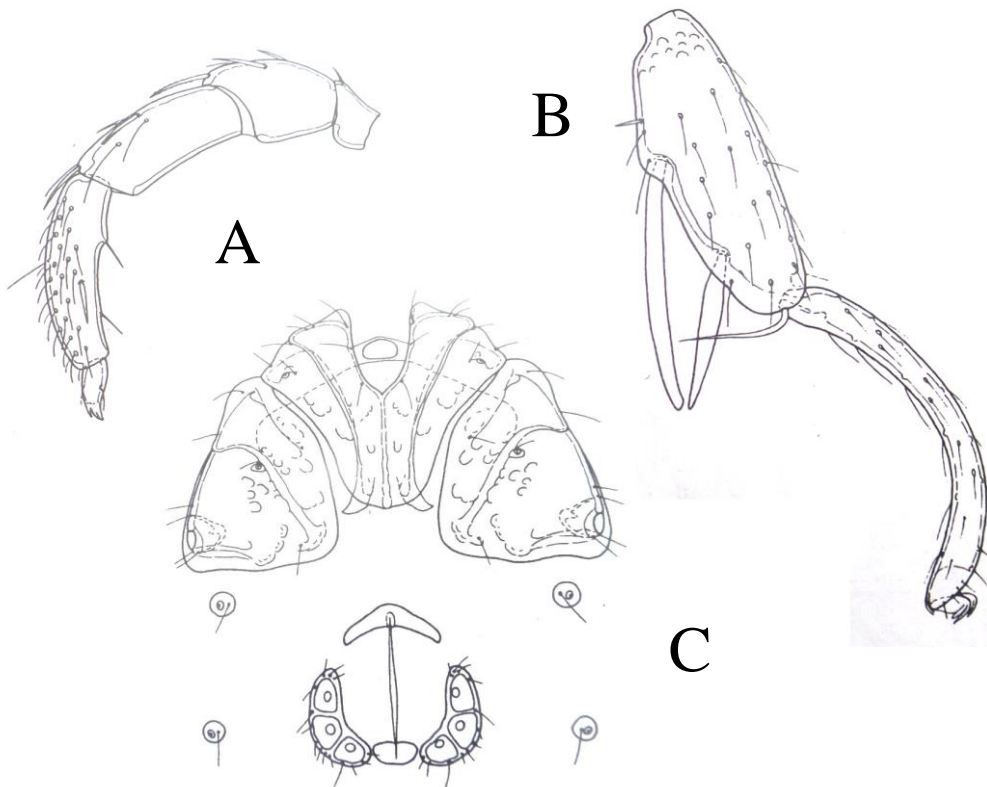


Figure *Atractides tanutus* Female: A. palp B. I-leg-6 and 6 C. ventral view (Image taken from Lundblad, 1953)

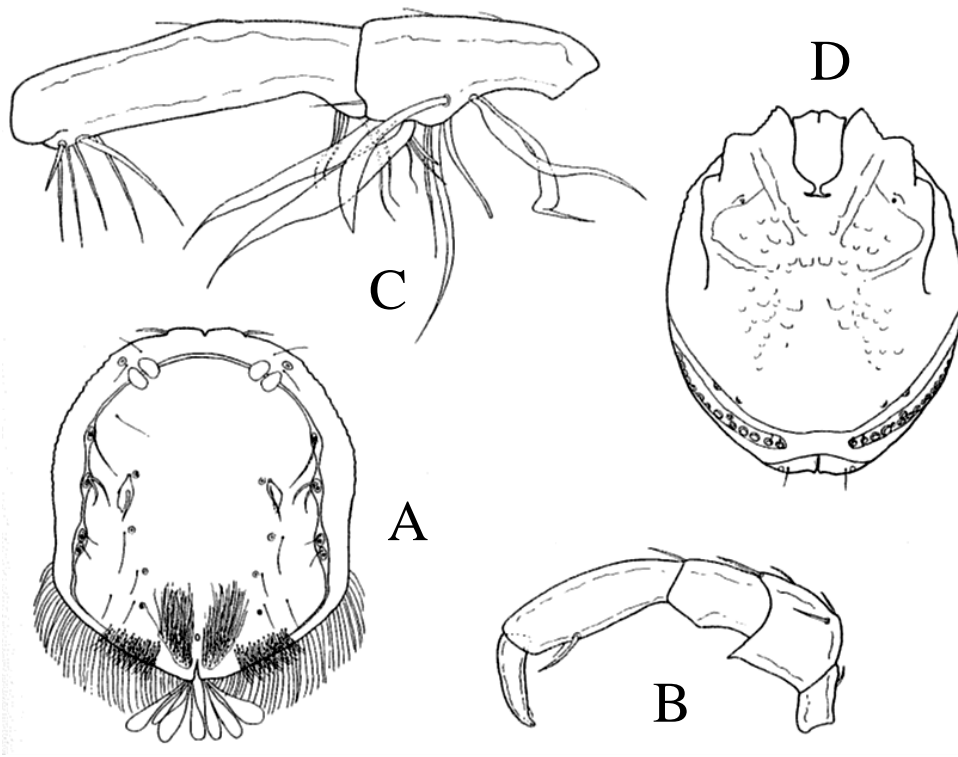


Figure 11. *Aturus andinus* Male A. Dorsal view, B. palp, C. Leg-I 5-6, female D. ventral view (Image taken from Lundblad, 1953)

ASSEMBLAGE OF WATER MITE COMMUNITY IN TOTA RIVER (BOYACÁ, COLOMBIA)

Short title Tota Stream Water mites

Elisa Jimeno Calle¹, María Isabel Castro-rebolledo^{2*} Alexander Sabogal-González³

¹Univerasidad Jorge Tadeo Lozano. estudiante Maestría en Ciencias Ambientales.

²Universidad La Salle, Departamento de Ciencias Básicas, e-mail: micastro@unisalle.edu.co

³ Ciacari Cll 152B No 55-45 Bogotá Colombia

Abstract Water mites are rarely included in biomonitoring programs. In this paper, we investigated the composition of water mites related to environmental parameters. Between 2006 and 2012 we sampled four points along Tota Stream bi-monthly. We measured 11 environmental parameters. 497 aquatic mites were collected organized in 10 families and 15 species. *Hygrobates* showed to be the most tolerant genus. In contrast, *Hygrobatella* was only found in clean waters. The analysis confirmed the potential of water mites as bioindicators for water quality.

Key Words. Hydrachna, Neotropics, Tota Stream, environmental parameters, RDA

Resumen. Los ácaros del agua rara vez se incluyen en los programas de biomonitoreo. En este artículo, se investigó la composición de los ácaros del agua relacionados con parámetros ambientales. Entre 2006 y 2012 se muestrearon cuatro puntos a lo largo del Rio Tota de modo bimensual. Se midieron 11 parámetros ambientales. Se recolectaron 497 ácaros acuáticos organizados en 10 familias y 15 especies. *Hygrobates* fue el género más tolerante. En contraste, *Hygrobatella* sólo se encontró en aguas limpias. El análisis confirmó el potencial de los ácaros del agua como bioindicadores para la calidad del agua.

Palabras clave Hydrachna, Neotrópico, rio Tota, Parámetros ambientales, RDA.

Introduction

Rivers in their natural state are the main supply for quality water for a large part of the world (Castro Rebolledo, 2012), nevertheless, as freshwater ecosystems they are constantly threatened by human population growth, industrial development and climate change. The result of these activities is an increase in nutrient mobilization that currently represents one of the greatest threats to global ecosystems with significant consequences for ecosystem structure and function (Davis et al., 2010). Consequently leading to modifications on the physical chemical and biological characteristics of these systems, resulting in reduced water quality and the severe loss of aquatic biodiversity (Allan, 2004; Allan & Flecker, 1993; Miccoli et al., 2013; Naiman, 2008 and Goldschmidt, 2016)).

Understanding the local and regional variability in stream water chemistry is a prerequisite for the determination of the impact of human activities on water quality. For these reasons, a comprehensive stream monitoring program typically involves the quantification of chemical, physical, and biological attributes within a stream. (Arscott, Eldridge, & Sweeney, 2010).

Most freshwater macroinvertebrates are not economically or medically important and their distribution and abundance have not been commonly measured (Jackson & Füreder, 2006). But is long known that stream insects respond strongly to weather conditions such as temperature and hydrologic regime (Jackson & Füreder, 2006). In this case, long term studies are useful to document population dynamics which provide insight into factors affecting distribution and abundance (Jackson & Füreder, 2006).

Within these studies there is evidence that water mites play an outstanding role within invertebrate communities in water ecosystems not only because of their species diversity, density and relevance in food webs but also because their rapid response to changes in the environment (Gerecke & Di Sabatino, 2007). Most Hydrachnidiae are very vulnerable to modifications of substrate water

quality and discharge. In an undisturbed natural spring, they are nearly always present and have high diversity.

Species of water mites are specialized to exploit narrow ranges of physical and chemical regimes, as well as the biological attributes (including physico-chemical constraints) of the organisms they parasitize and prey upon. Consequently, water mites should be exceptionally sensitive indicators of habitat conditions and the impact of environmental changes on freshwater communities (Boboescu & Park, 2010; Tom Goldschmidt, 2016). Preliminary studies of physical chemical and pollution ecology of the relatively well-known fauna of Europe have demonstrated that water mites are excellent indicators of habitat quality (Gerecke & Lehmann, 2005, Gerecke & Di Sabatino, 2007; Proctor, 2007; Di Sabatino et al., 2008; Proctor, 2009, Walter & Proctor, 2013, Goldschmidt, 2016) mites may change frequencies and composition related to nutrient discharge

The aim of this study was to report the species of water mite communities in relation with local environment conditions and a gradient of nutrient content in Rio Tota as well as assess ecological quality of Rio Tota based on the water mite community in a nutrient gradient.

Materials and methods

Study area

The Tota stream, a third order creek, originates in the eastern mountain range, in the Las Alfombras paramo located in the department of Boyacá, Colombia (5°35'N - 73°00'W). Its drainage basin covers an area of 150 Km². The range of temperature registered in the zone is between 10.5 y 11.8°C (and the annual precipitation is 730.5 mm. There are two rainy seasons, April to May and October to November and two dry seasons, December to January and August to September (Castro-Rebolledo, 2012).

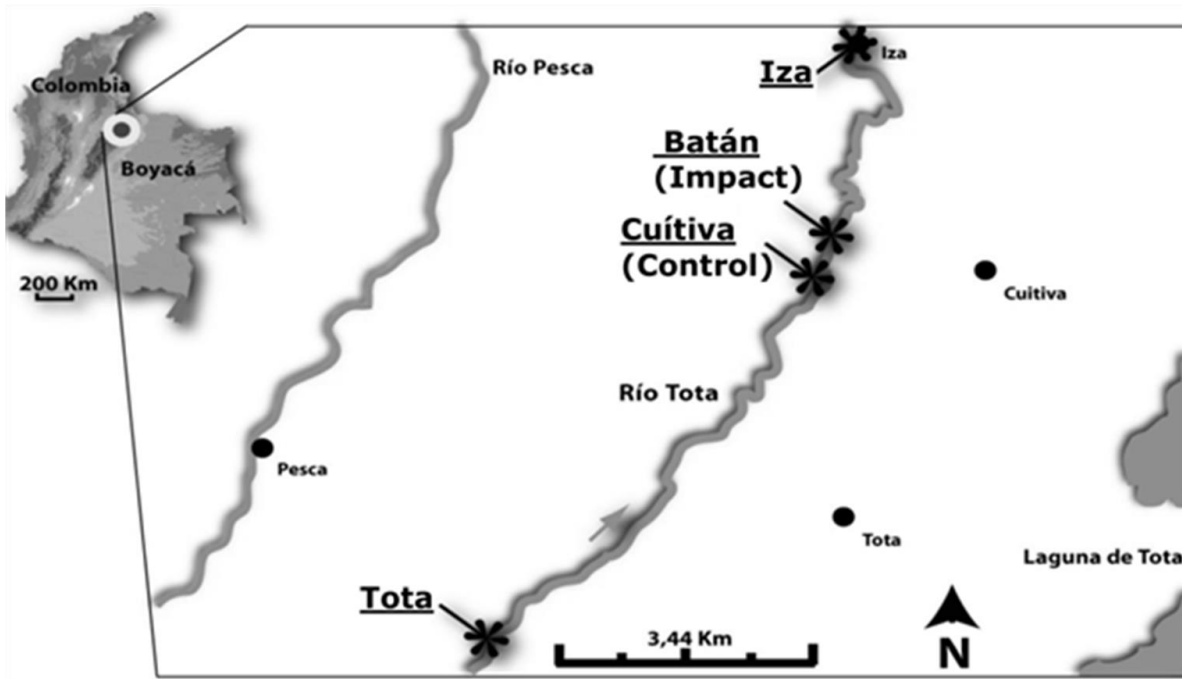


Figure 12 Sampling points along the Tota Stream (Castro Rebolledo, 2012)

Environmental sampling

Four sampling stations were selected along the stream. The high sample zone was taken in the municipality of Tota. In the mid zone two principal points were established, one in the municipality of Cuítiva named Control (C) and the second point Batán named Impact (I). the lowest sample point was in the municipality of Iza (Figure 12).

The streambed was composed by rocks, cobbles, boulders and a few deposits of sand and detritus. At each site, a 50 m reach was selected where were taken: 1) measurements of the descriptive environmental variables of the system, 2) studies of the composition and basic structure of the biological components and 3) estimations of the global measurements of the system.

A description of the general characteristics of each point is given below.

Tota

It is located at 2834m elevation. It has a low slope with an intensive use, primarily for cattle. There is native scrub vegetation in different states of development and abundant *Eucaliptus globulus* planted in a scattered form. It represents an area with an almost intact fluvial habitat and the physical chemistry quality of the water is optimum.

Cuítiva (Control)

At 2573m elevation, this point corresponds to the medium low part of the stream basin, the bank is composed mainly of willows (*Salix humboldtiana*) and some alders (*Alnus acuminata*) planted but rather scant. In the sector are areas with a strong anthropic intervention, primarily used for cattle and in a lesser proportion for cultivation. It is a fluvial habitat with the presence of nutrients in the water due to human activities, agricultural and ranching in the municipality of Cuítiva.

Batán (Impact)

Located at approximately 695m down waters from the control reach at 2567m elevation, it possesses characteristics like the previous reach.

Iza

Located in the lower part of the stream basin, it has an altitude of 2529 m. In this section, the banks of the river have few trees, mainly willows. This section is subjected to the drainage of residual waters from the municipality of Iza. The surroundings correspond to the lower part of the river, where the valley is characterized by large plains where cattle is raised. It represents an altered fluvial habitat with the presence of nutrients caused by the diverse activities in the Municipality of Iza.

Hydrological, Physical and chemical variables

Measurements were taken bi-monthly. Water temperature (°C), dissolved oxygen (mg l⁻¹ O₂), conductivity (µS cm⁻¹) and pH were measured in situ using a YSI multiparameter, model 5563-10 MPS. Water velocity was measured in situ using a Global digital flow meter and discharge (Q). The

concentrations of ammonium (NH_4^+), nitrate (NO_3^-), nitrite (NO_2^-), and phosphate (PO_4^{3-}) were determined following APHA methods (1998) with filtered water (Brand GF/F) APHA-AWWA-WEF (2005)

Hydrachnidiae sampling and identification

Samples of five substrates were taken in each collecting point monthly along 2008 to 2012. In each reach, we sampled the following habitats rocks, sediment, leaf litter, macrophytes and stream margins. Due to the absence of substrates in some sampling dates because of hydrological variations in the stream, two samples were collected from rocks and leaf litter and one for the rest of the habitats for each reach and sampling date.

Mites were sampled directly from the rocks by using a Surber net with a 900 cm^2 surface area and a $200\mu\text{m}$ net mesh size. Sandy substrate was sampled with a 54 cm^2 core. Leaf litter, macrophytes and stream margins were sampled with a Surber of 400 cm^2 . Samples were cleaned with stream water and filtered through different sieves, (the smallest, 0.5 mm mesh size) and preserved in alcohol (70 %). Morphospecies were sorted under a dissecting microscope (high magnification) and identified to species using a phase contrast microscope and specialized keys (Cook, 1980; Lundblad, 1941, 1953; Rosso de Ferradás & Fernández, 2009). Most of the material was observed using excavated slides, nevertheless individuals that belong to new species were mounted in PVA for identification. The material will have as final deposition La Salle University in Bogotá.

Data analysis

For all analyses, we removed all terrestrial mites as these are not considered "true" water mites. We express density results as individuals per m^2 , to standardize for all substrates, nevertheless the index calculations were performed using absolute abundance data. Years 2007, 2008 and 2009 were used for

the analyses diversity index since this had the most complete data set for assemblages as well as Physical and chemical parameters and we decided to ecologically take each year as a repetition of the climatic conditions.

Although there is literature that describes the rainy and dry season for the region, the actual season were given to each month based on the value measured for that specific month and year. Some of them varied for April 2007 in Batán it was considered a dry season while it is normally considered rainy season.

To examine Hydrachnidiae assemblage we measured species richness with Chao-Jost, alpha diversity with Shannon Exponential index, and Inverse Simpson index; Beta diversity with Bray-Curtis, for all we compared seasons, substrate and sampling years.

We calculated rarefaction curves to validate comparability of sampling sites based on abundance.

These analyses were performed in R Studio (2017), Spade and iNext except for the trees on Beta diversity that were calculated using R and PAST.

The graphic alpha indexes contain three relevant elements on the x axis. $Q=0$ that describes the total amount of species in each point (richness), $Q=1$ that describes the uniformity, meaning how the abundances are distributed, it assumes that all the species are represented in the samples along the species and finally $q=2$ that describes the dominant species.

Alpha diversity profiles (richness of species of a community) do not require significance tests since they encompass confidence intervals. If these intervals do not overlap, then there are differences between the sampling sites. Equally, Beta diversity does not require significance tests since it describes the degree of change or replacement in species composition between different communities in a landscape.

For the multivariate analysis, October Batán 2009 was not included in the analysis because there were no physical and chemical parameters to compare with the species collected. Also Control June 2007 because it has low information and was not related to any variable. Also, We removed NH₄, Silice, and total Nitrogen, there is no support in the literature that these may actually affect the composition of Hydrachnidiae.

We ran an RDA (Redundancy Analysis) to visualize the relationships that may exist between our variables. Before running the analysis, data set were converted. Species abundance and the environmental parameters using the formula +LOG(environmental_value+1). We unified because there are diversity values that are very contrasting and physical and chemical values vary in units and measurements.

We evaluated the significance of the assemble variation using a Monte Carlo test for the first and second axes to evaluate and whether the variation explained by the variables is higher than would be variation explained by the same number of randomly generated variables (R project, 2017). The RDA was run using Conoco 4.5 with 949 permutations.

Results

Physical and chemical parameters

The parameters show slight differences in all the points. The reaches showed changes in physical conditions but not between them. The reaches showed average values of temperature 14°C, Oxygen saturation 8.7 mg l-1, Conductivity 91.4µs cm-1, pH 7.4 and Discharge 0.7m³ s-1 (Table 1)

Table 1 Physical an chemical parameters for Tota Stream

<i>Parameter</i>	<i>Max</i>	<i>Min</i>	<i>Average</i>
<i>Temperature (°C)</i>	21.2	10.93	14.05
<i>Oxygen saturation (mg l-1)</i>	12.43	6.38	8.74
<i>Conductivity (µs cm-1)</i>	203	21	91.44
<i>Discharge (m³ s-1)</i>	2.24	0.02	0.72

pH	8.82	5.85	7.4
Salinity	0.11	0.02	0.05

Hydrachnidiae diversity

From 445 sampled mites, 45 were terrestrial, 2 larvae and one male that fitted no available description of the known water mites. These were also excluded from the analysis. Therefore, there were 497 "true" water mites organized in 10 genera and 15 species. The most abundant genera were *Hygrobates* (245 individuals) and *Corticacarus* (162 individuals) The most abundant species were *Corticacarus multiporus* followed by *Hygrobates plebejus* n. sub. sp. From all the samples, we found new species for the genera *Corticacarus*, *Hygrobates* and *Neotorrenticola* and a new subspecies for *Hygrobates plebejus*. Also, the species *Atractides tanutus*, *Limnesia abenda* and *Clathrosperchon punctatus* are new records for Colombia (Table 2).

Table 2. Composition and abundance of water mites in Tota Stream

Familia	Genero	Especie	Total aundance
Aturidae	<i>Aturus</i>	<i>Andinus</i>	1
Total Aturidae			1
Hygrobatidae	<i>Atractides</i>	<i>tanutus</i>	14
	<i>Corticacarus</i>	<i>multiporus</i>	127
		<i>n.sp</i>	14
		<i>vietsi</i>	21
	<i>Hygrobatella</i>	<i>Polygramma</i>	21
		<i>puberula</i>	2
	<i>hygrobates</i>	<i>n.sp</i>	10
		<i>plebejus</i>	9
		<i>n.Sub.Sp</i>	226
Total Hygrobatidae			444
Limnesiidae	<i>LIMNESIA</i>	<i>abenda</i>	4
	<i>Neotorrenticola</i>	<i>n.sp.</i>	26
Total Limnesiidae			30
Rhynchohydracaridae	<i>Clathrosperchon</i>	<i>punctatus</i>	4
Total Rhynchohydracaridae			4
Sperchontidae	<i>Sperchon</i>	<i>motasi</i>	9
Total Sperchontidae			9
Torrenticolidae	<i>Torrenticola</i>	<i>columbiana</i>	9
Total Torrenticolidae			9
Total			497

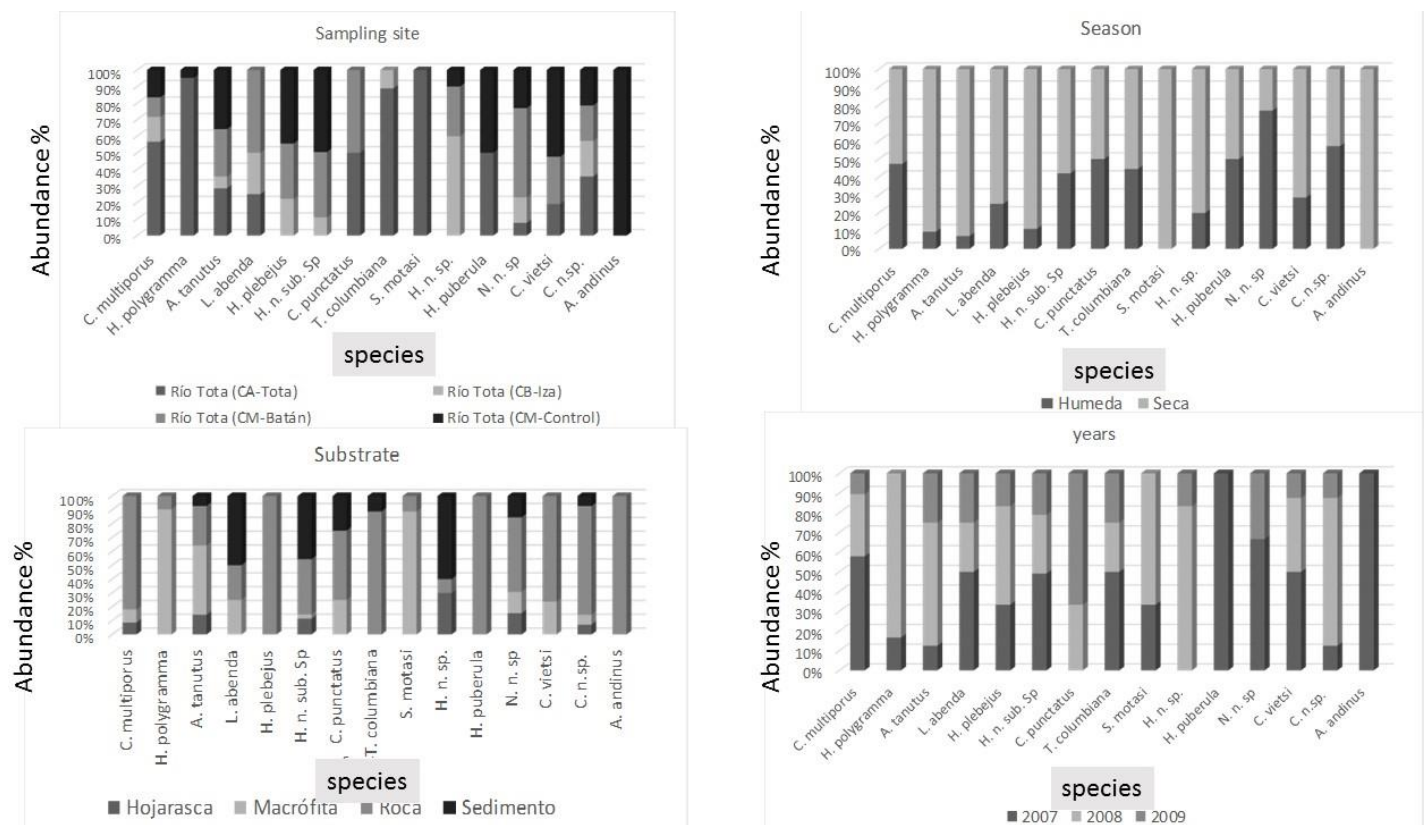


Figure 13 Abundance profiles comparison between sampling sites, season substrate, and years.

Assemblages

In general, in each point there were between 9 and 11 species of water mites, and species that were abundant in one point tended to be abundant in other sampling points. However, overall the greater number of water mites were found in control reach (166 individuals), followed by Batán (141 individuals), Tota (128 individuals) and finally Iza (62 individuals).

In Tota and Control 73% of the total species found were present. Also, each point had unique species *S. motasi* for Tota and *A. andinus* in Control. *C. multiporus*, *A. tanutus* and *Neotorrenticola n.sp.*, and *Corticacarus n.sp.*, were common to all sites. *C. multiporus* highest abundance was in Tota, *Neotorrenticola n.sp.* had its highest abundance in Batán. *A. tanutus* and *Corticacarus n.sp.* had similar abundances in all sampling sites.

Hygrobatella puberula and *H. polygramma* had their higher abundances in Tota. *H. puberula* had similar abundances where found but was neither found in Iza or Batán. *Hygrobatella*, the genus with

most individuals, had no presence in Tota and its abundances were higher in Control, Batán and Iza correspondently. *Corticacarus vietsi* had higher abundances in control and similar in Batán and Tota nevertheless it was not present in Iza

Torrenticola columbiana has an interesting pattern of appearances, it was found only in Iza and Tota sampling points considered to be the most affected and less affected.

Years 2007 to 2009, had the most number of mites, 2011 yielded no water mite probably due to El Niño and the rains were stronger than usual and its effects seemed to have extended until 2012 because of the low abundance of mites found (2 individuals) (Figure 13).

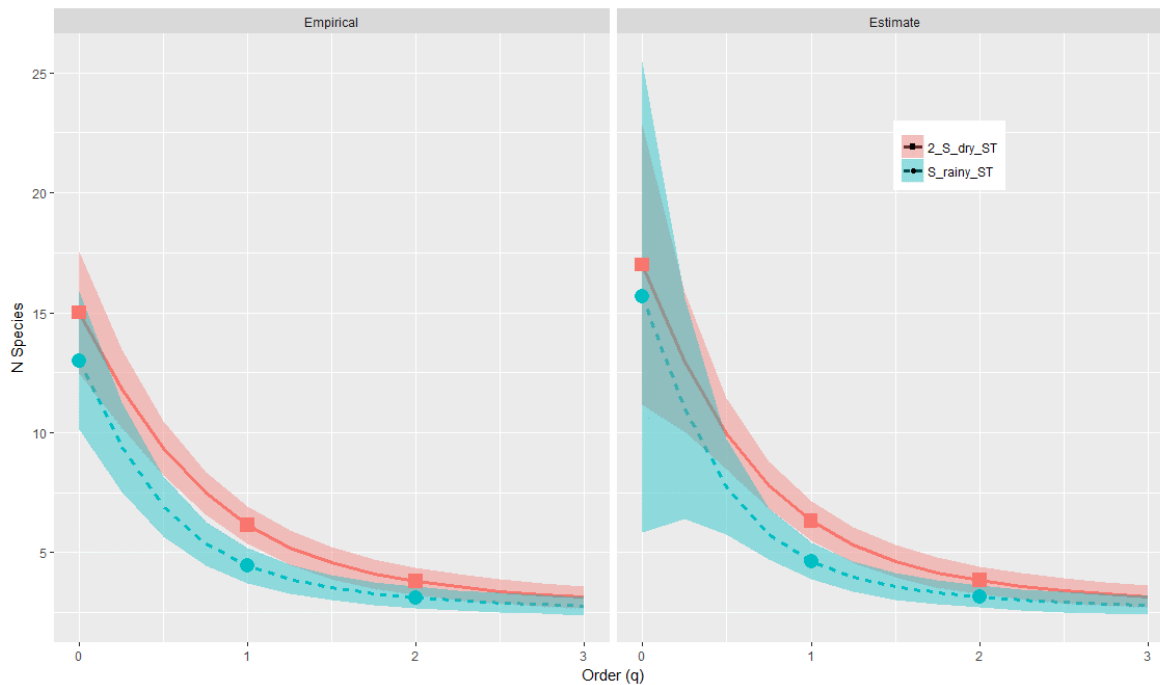


Figure 14 Alpha profile season dry and rainy

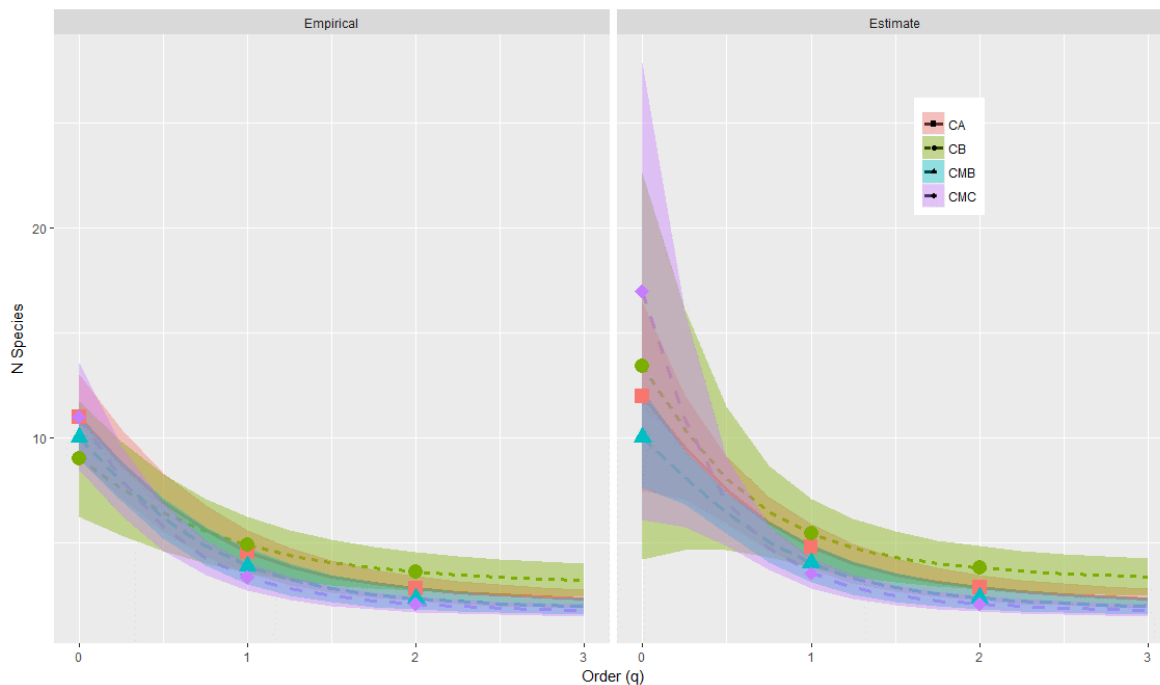


Figure 15 Alpha diversity profiles CA: Tota, CMB: Batán, CMC Control and CB Iza.

Overall alpha abundance showed no differences between sampling sites, at the same time, differences were found between seasons specially in its uniformity (Figure 14, Figure 15). In contrast, Beta diversity showed difference between sampling sites. Batán and control had an 80% similarity, Iza yielded a 50% similarity to the previous two and finally Tota has only a 30% similarity to the other sampling sites (Figure 16Figure 16).

In the RDA, the first two vectors explained most of the variance but for this set of data the first vector explains 59% and the second 23% more because there are many zeros. Never the less, we are explaining the 82% percentage of what was being evaluated. It is important to note that oxygen, temperature and pH are the variables that positively influence the distribution of variables, and the other hand conductivity, salinity, discharge and SO₄ are the ones that negatively influence the relationships.

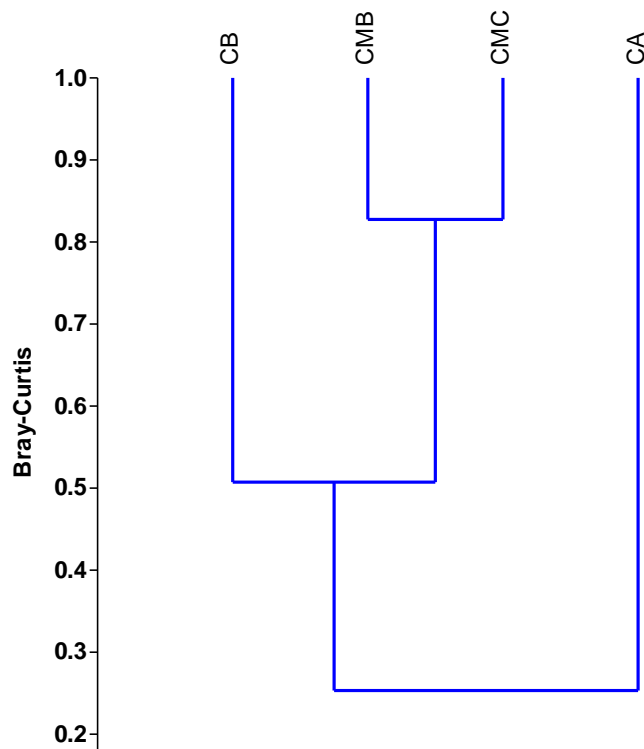


Figure 16. Beta profiles between points CA: Tota, CMB: Batán, CMC Control and CB Iza.

Discussion

Season, year and substrate

Abundance of Hydrachna was higher in dry season compared to rainy season. This corresponds well with the fact that the increase in water may wash up habitats and organisms within.

From the four substrates investigated the main were rock and sediment, leaf litter was not as represented because this is a resource that is not as stable and changed within seasons, supported by the fact that less organisms were found in rainy season (5 ind) compared to dry season (42 ind) for this specific substrate. This pattern of abundance is also shown for macrophytes and rock, never the less, sediment exhibited the opposite result, higher abundances in rainy season.

Walter & Proctor, (2013) cite a case by Bottger (1962) where he concluded that habitat choice is often correlated with swimming abilities, weakest swimmers are found near the shore vegetation while fast swimmers are found in open waters. Also in a study by Pieczynski, (1964) found that *Hygrobates*

nigromaculatus was the most motile Acari in a comparison among other species, this also could explain why sediment had higher numbers of mites, and was found in higher numbers in rock instead of vegetation.

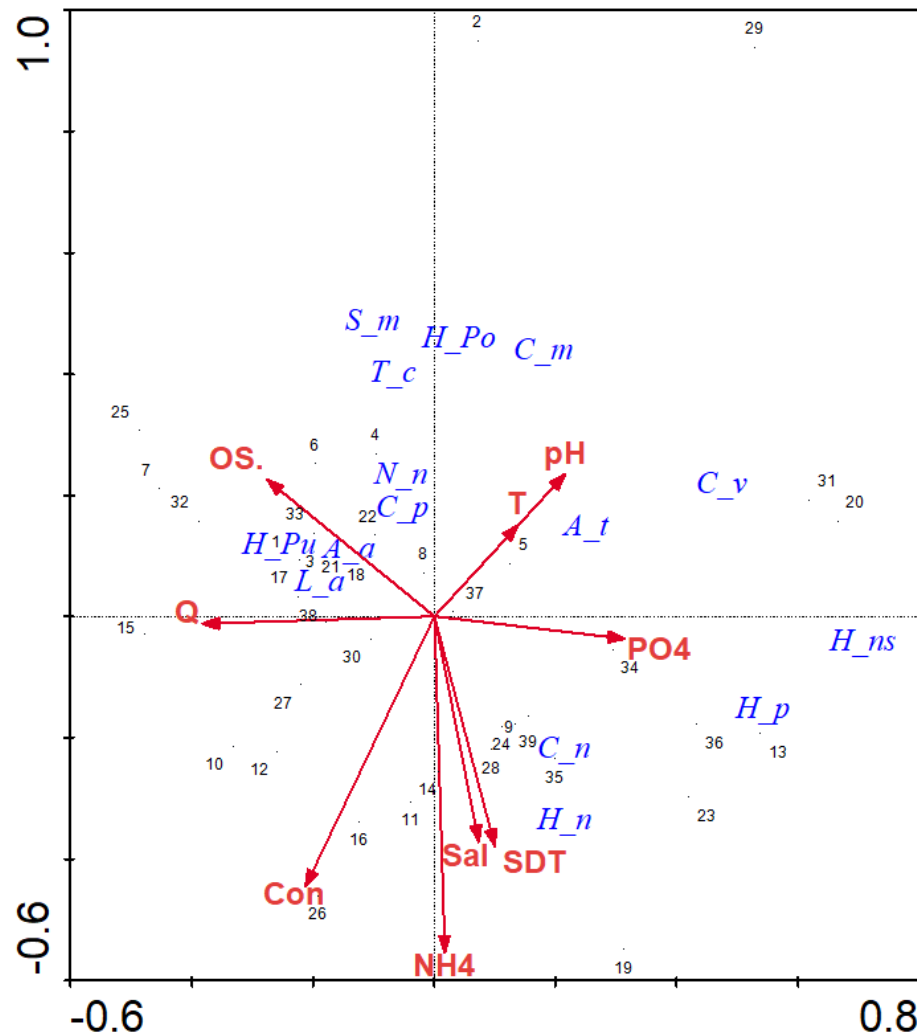


Figure 17 Code First letter name sampling point, Season (R Rainy, D Dry), month, year: 1 TR57, 2 TD87, 3 TR107, 4 TD28, 5 TR48, 6 TD98, 7 TD128, 8 TD19, 9 IR57, 10 ID87, 11 IR107, 12 ID127, 13 ID28, 14 IR48, 15 IR68, 16 ID98, 17 BD47, 18 BR57, 19 BR57, 20 BD87, 21 BR107, 22 BD127, 23 BD28, 24 BR48, 25 BR68, 26 BD98, 27 BR108, 28 BD19, 29 CD47, 30 CR57, 31 CD87, 32 CR107, 33 CD127, 34 CD28, 35 CR48, 36 CD98, 37 CR108, 38 CR128, 39 CD19. Species name: code first letter generic name, first letter specific name: N_n *Neotorrenticola nsp*; C_p *Clathrosperchon punctatus*; H_pu *Hygrobatella puberula*; A_a *Aturus andinus*; L_a *Limnesia abenda*; S_m *Sperchon motasi*; T_c *Torrenticola Columbiana*; H_po *Hygrobatella polygramma*; A_T *Atractides tanutus*; C_v *Corticacarus vietsi*; C_m *Corticacarus multiporus*; H_ns *Hygrobates n. sub. sp.*; H_p *Hygrobates plebejus*; C_n *Corticacarus n.sp.*; H_n *Hygrobates n.sp.* OS: dissolved oxygen, T: temperatura, SAL: salinity, SDT: total dissolved solids, Con conductivity, Q: discharge.

Assemblage

Regarding diversity Beta analysis, this described a 20% difference between control and Batán. This could be because the discharge is not truly affecting, as in distance they are the closest points or for the reason that they are composed mainly for tolerant species. Also, all genera accumulation curves reach almost the asymptote which reveals that further sampling shouldn't reveal many more species (Figure 18).

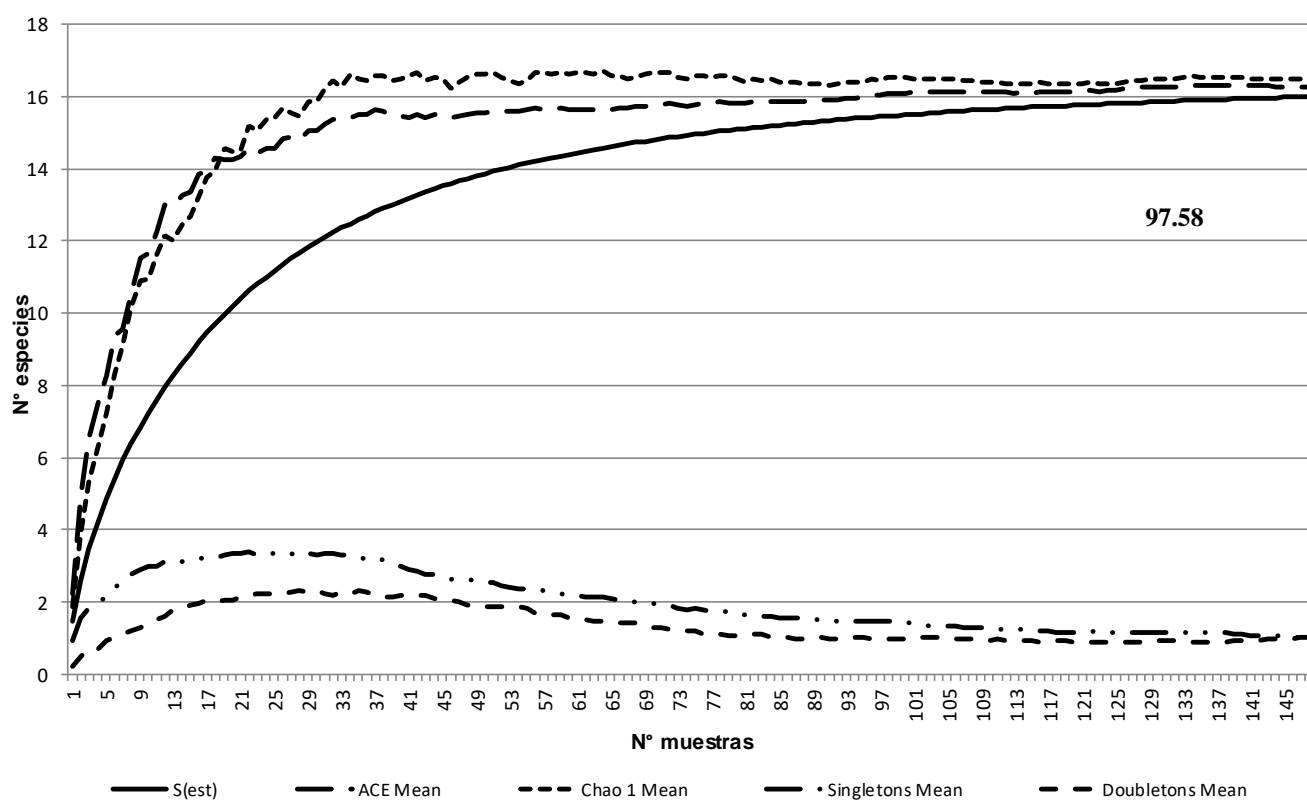


Figure 18. species accumulation curves

To be able to analyze the results, some of the information for Europe was taken into account but most comparison are made with the recent paper by Goldschmidt, Helson, & Williams, (2016) that published the first information on environmental variables associated to genus level in water mites. In this study, we further complete some information of genus missing from the list.

Values of temperature, discharge, pH, oxygen saturation and conductivity showed similar patterns among points. Sampling sites behaved as a continuum instead of displaying differences between most intervened to less intervened site which is consistent to finding in other studies the same studied above mentioned

Also, analysis supported relationships among species and temperature, oxygen saturation, conductivity and pH, that is consistent with other studies that have found that these physical and chemical parameters best relate to the distribution of water mites (de Ferradás, Kaisin, & Bosnia, 1987; Goldschmidt, 2004; Grown, 2001; Meleg, Cîmpean, & Pavelescu, 2009) (Figure 17).

Within *Hygrobates*, *Hygrobatella* is bound to unimpacted sites meanwhile, contrary to *Hygrobates* and *C. multiporus*, *A. Tanutus*, *Neotorrenticola n.sp.* and *Corticacarus n.sp.* displayed a larger tolerance. *Hygrobates* showed higher tolerance for places that had higher or had had nutrient enrichment. This same genus appears to be able to tolerate more disturbed sites and therefore is capable of growing larger populations and may also display a preference for places with higher organic input because it was not found in Tota considered the pristine site. This findings are opposite to the ones reported by Goldschmidt, Helson, & Williams, (2016) they found and report this genus as clean water. Also in Europe, *H. fluviatilis* shows high tolerance and its abundances increase when water quality lowers (Gerecke & Schwoerbel, 1991; Meleg, Cîmpean & Pavelescu, 2009) (**¡Error! No se encuentra el origen de la referencia.**).

The fact that *Hygrobates* (three species) are dominant also agrees with this findings because as pollution increases the dominance of the more tolerant species increases as well, although due to its behavior, some factors in Iza affected its appearance because it reaches its maximum abundance and in Iza it reaches its minimum revealing that species tolerate the intervened conditions of Batán but the

change in Iza starts to affect its community and a similar pattern is displayed by *C. multiporus* although is tolerant is a “clean” water species.

For *Limnesia* has been reported that it shows preference for pristine waters but also that it has low tolerance for salinity in water. In this study, no pattern could be established due to its low appearance and the fact that it was present in the opposite sites: the cleanest and the dirtiest sites. Nevertheless, A studies have found that Young and Rhodes (1974) some species of *Limnesia* can alter their oxygen consumption when the environmental concentration of the gas changes. That may lead to a tolerance to changes in oxygen concentrations compared to a more uniform condition. Although this is not the case because oxygen saturation was stable along the sampling sites and time.

Iza had the lowest richness, which this agrees well with the results of Gerecke & Schwoerbel (1991) who found that zones with pollution from domestic sewage increase species abundances and decreased species composition (Walter & Proctor, 2013).

It is important to note that results here presented give important information because observations distributed across several days or months may differ from those that span years or decades because longer studies have a greater probability of observing or helping to explain slow, rare, subtle or complex changes in natural environments (Jackson & Füreder, 2006).

Finally, water mites are constrained not only by their ranges of physical and chemical parameters but also by the biological conditions of their hosts -organisms they parasite and it is valid to address their quality as indicators because they are evidencing two phenomena at a time: the habitat conditions and the impact of environmental changes on fresh water communities (Thorp & Covich, 2001)

Conclusions

In south America, there are identification keys to determine organisms to genera (Cook, 1980; Lundblad, 1941, 1953, Rosso de Ferradás & Fernández, 1995, 2005, 2009) and although the list is not complete the knowledge is sufficient to use it to include mites in the biomonitoring studies. Regardless of this we still need to deepen in the ecological information and distribution related to water quality parameter and to use it.

Our findings support both statements genus level is sufficient to associate to water quality but in some cases species level might show differences in tolerance of the organisms that make up the assemblage in a given place.

When compared to European and Australian fauna (Gowns, 2001), and even though some genera might be present, the same behavior as genus changes and some genera that are analyzed were not collected in Tota stream, therefore this calls out for further investigation on this specific fauna.

Tom Goldschmidt et al. (2016) reports a series of genera and their distribution related to water quality from Panama, never-the-less, here we deepened in the knowledge of some genera of water mites regarding their condition of indicators of water quality.

We must consider that the results here found are measurements from many years but many climatic irregularities were present. Climate change may be influencing water mite community, 2010 was affected by heavy rain (el Niño) and its effects continued along 2011 where no mites were collected and again in 2012 mites were found again.

Acknowledgements

We would like to thank the projects Diatom Diversity and Functional Measurements of a Mountain River of the Colombian Andes, Banco de la República-Universidad Nacional and Global Changes in Fluvial Systems: Effects On the trophic network, biodiversity and functional aspects (GLOBRIO), Fundación BBVA -Colciencias – Universidad de Colombia for financing this study. To

Silvia Morales for her help with the samplings, Oscar Quesada and Ximena Castro for their comments on this research paper.

References

- Arscott, D. B., Eldridge, W., & Sweeney, B. W. (2010). A Preliminary Water Quality Study of the Rio Sierpe and its tributaries (Costa Rica) Prepared for the Blue Moon Foundation.
- Boboescu, I., & Park, N. (2010). Water Mites (Acari , Hydrachnidia) From the Vân   Tori Neam Ț Nature Park (Romania), 92–99.
- Castro Rebolledo, M. I. (2012). Efectos de la fertilización sobre la composición de macroinvertebrados en un arroyo de montaña tropical, 126. Retrieved from <http://www.bdigital.unal.edu.co/11533/>
- Combata, J. O., Ospina, R., & Jimeno, E. (2012). Lista de los ácaros acuáticos (Acari:Hydrachnidia) en Colombia. In *Acarología Latinoamericana. Congreso Latinamericano de acarología Ed. Estrada E, Equihua. A., Acuña-Soto, J., Chaires, P., Durán. G.* (pp. 343–348).
- Cook, D. R. (1966). The water mites from Liberia. *Memoirs of the American Entomological Institute* (Gainesville, FL.), 6.
- Cook, D. R. (1974). Water mite genera and subgenera. In *Mem. Amer. Entomol. Inst 21 Gainesville FL.*
- Cook, D. R. (1980). *Studies on Neotropical Water Mites. Mem. Amer. Ent. Inst.*
- Cook, D. R. (1986). Mites from Australia. *Memoirs of the American Entomological Institute* (Gainesville, FL.), 40.
- Cook, D. R. (1988). water mites from Chile. *Memoirs of the American Entomological Institute* (Gainesville, FL.), 42.
- Davis, J. M., Rosemond, A. D., Eggert, S. L., Cross, W. F., & Wallace, J. B. (2010). Long-term nutrient enrichment decouples predator and prey production. *Proceedings of the National Academy of Sciences of the United States of America*, 107(1), 121–6.

<http://doi.org/10.1073/pnas.0908497107>

- de Ferradás, B. R., Kaisin, F. J., & Bosnia, A. S. (1987). Seasonal variation of density and biomass of hydracarina (acari) in a north-patagonian reservoir (neuquén, argentina). *Studies on Neotropical Fauna and Environment*, 22(3), 113–127. <http://doi.org/10.1080/01650528709360725>
- Di Sabatino, A., Gerecke, R., & Martin, P. (2000). The biology and ecology of lotic water mites (Hydrachnidia). *Freshwater Biology*, 44(1), 47–62.
- Di Sabatino, A., Smit, H., Gerecke, R., Goldschmidt, T., Matsumoto, N., & Cicolani, B. (2008). Global diversity of water mites (Acari, Hydrachnidia; Arachnida) in freshwater. *Hydrobiologia*, 595(1), 303–315. <http://doi.org/10.1007/s10750-007-9025-1>
- Fernández, H. R., & Rosso de Ferradás, B. (2001). Hidracáridos del altiplano boliviano: la cuenca alta del río Suchez. *Physis*, 58, 29–36.
- Ferradás, B. R. de, Fernández, H. R., & Rocabado, B. G. (2004). Hidracáridos (Acari, Hydrachnidia) de la cuenca Andina del río Beni, Bolivia. *Iheringia. Série Zoologia*, 94(3), 307–314. <http://doi.org/10.1590/S0073-47212004000300014>
- Gerecke, R. (1996). Water mites of the family Torrenticolidae Piersig, 1902 (Acari, Actinedida, Hydrachnelliae) in springs and running waters of Sardinia and Corsica. *Archiv Fuer Hydrobiologie, Suppl 107*, 287–334.
- Gerecke, R., & Di Sabatino, A. (2007). Water mites (Hydrachnidia and Halacaridae) in Spring habitats: a taxonomical and ecological perspective. *Hydrobiologia*.
- Gerecke, R., & Lehmann, E. O. (2005). Towards a long-term monitoring of Central European water mite faunas (Acari: Hydrachnidia and Halacaridae) - Considerations on the background of data from 1900 to 2000. *Limnologica*, 35(1–2), 45–51. <http://doi.org/10.1016/j.limno.2004.09.001>
- Gerecke, R., & Schwoerbel, J. (1991). quality and water mites (Acari, Actinedida) in the Upper Danube region, 1959-1984 . In Dusbábek & V. Bukva (Eds), *Modern Acarology , Vol 1 , Academia Prague and SPB publ. , Th e Hague* (pp. 483–491).

- Gledhill, T., Cowley, J., & Gunn, R. J. M. (1982). Some aspects of the host-parasite relationships between adult blackflies (Diptera: Simuliidae) and larvae of the water mite *Sperchon setiger* (Acari: Hydrachnellae) in a small chalk stream in southern England. *Freshwater Biology*, 12, 345–357.
- Goldschmidt, T. (2004). Environmental parameters determining the water mite communities in Costa Rican freshwater habitats. *Experimental and Applied Acarology*, 34(1–2), 171–197.
- Goldschmidt, T. (2007). Studies on latin American water mites of the genus *Torrenticola* Piersig 1986 (Torrenticolidae, Hydrachnidia, Acari). *Zoological Journal of the Linnean Society*, 150, 443–678.
- Goldschmidt, T. (2016). Water mites (Acari , Hydrachnidia): powerful but widely neglected bioindicators – a review, 6808(May). <http://doi.org/10.1080/23766808.2016.1144359>
- Goldschmidt, T., Helson, J. E., & Williams, D. D. (2016). Ecology of water mite assemblages in Panama - First data on water mites (Acari, Hydrachnidia) as bioindicators in the assessment of biological integrity of neotropical streams. *Limnologica*, 59, 63–77.
<http://doi.org/10.1016/j.limno.2016.03.007>
- Growns, J. E. (2001). Aquatic mites as bioindicators, with an australian example. *Acarology*, (Harvey 1998), 136–142.
- Jackson, J. K., & Füreder, L. (2006). Long-term studies of freshwater macroinvertebrates: A review of the frequency, duration and ecological significance. *Freshwater Biology*, 51(3), 591–603.
<http://doi.org/10.1111/j.1365-2427.2006.01503.x>
- Lundblad, O. (1941). Neue Wassermilben aus Amerika, Afrika, Asien and Australien,. *Zool. Anz.*, 133(7–8), 155–160.
- Lundblad, O. (1953). *Die Hydracarin fauna von Colombia*. (A. F. zoologi B. 5nr 8, Ed.) (2nd ed.). Stockholm.
- Meleg, I., Cîmpean, M., & Pavelescu, C. (2009). Hyporheic fauna from interstitial of the Someş river basin (Transylvania, northwestern Romania). *Trav. Inst. Spéol. «Émile Racovitza»*, 48, 45–58.

- Melrose, J., Perroy, R., & Careas, S. (2015). *No Title No Title. Statewide Agricultural Land Use Baseline 2015* (Vol. 1). <http://doi.org/10.1017/CBO9781107415324.004>
- Pesic, V., Chatterjee, T., Herrera-Martinez, Y., & Herrando-Perez, S. (2010). *Wandesia (Partnuniella) lehmanni* - a new water mite species (Acari: Hydrachnidia, Hydryphantidae) from a high-altitude lake in the Colombian Andes. *International Journal of Acarology*, 36(February 2010), 53–58. <http://doi.org/10.1080/01647950903508508>
- Pieczynski, E. (1964). Analysis of numbers, activity, and distribution of water mites (Hydracarina), and of some other aquatic invertebrates in the lake littoral and sub- littoral. *EkoI. Pol. Ser.*, 12, 691–735.,.
- Proctor, H. C. (2007). *A c a r o l o g y XI* /, 105–117.
- Proctor, H. C. (2007). *Acarology XI*/---. In *Acarology XI. Proceedings of the international Congress* (pp. 105–117).
- Proctor, H. C. (2009). Hydrachnida (Water Mites), 2, 335–345.
- Rosso de Ferradás, B., & Fernández, H. R. (1995). 1995. Acari, Hydrachnidia. In *Loreto, E. y Tell, G. (Eds.). Ecosistemas de aguas continentales. Editorial Sur, Argentina.* (pp. 819–853).
- Rosso de Ferradás, B., & Fernández, H. R. (2005). ELENCO Y BIOGEOGRAFÍA DE LOS ÁCAROS ACUÁTICOS (ACARI, PARASITENGONA, HYDRACHNIDIA) DE SUDAMÉRICA. *Graellsia*, 61(2), 181–224.
- Rosso de Ferradás, B., & Fernández, H. R. (2009). Acari, Parasitengona, Hydrachnidia.. In *Domínguez, E. y Fernández, H. (Eds). Macroinvertebrados bentónicos sudamericanos. Sistemática y biología. Pp Fundación Miguel Lillo. Tucumán, Argentina.* (pp. 497–550).
- Smith, I. M., Cook, D. R., & Smith, B. P. (2010). Water Mites (Hydrachnidiae) and Other Arachnids. *Ecology and Classification of North American Freshwater Invertebrates*, 485–586. <http://doi.org/10.1016/B978-0-12-374855-3.00015-7>
- Smith, I. M., & Oliver, D. R. (1986). Review of parasitic associations of larval water mites (Acari:

parasitengona:Hydrachnidia) with insect hosts. *Can. Entomol.*, 118, 407–472.

Thorp, J., & Covich, A. (2001). *Ecology and Classification of North American Freshwater*

Invertebrates (second edi). San Diego, California, United States of America: Academic Press.

Viets, K. H. (1935). Mitteilungen von den Forschungsreisen Prof. Rahm's. - Mitteilung V. Eine neue

Waassermilbe aus den Hygrobatinae. *Zoologischer Anzeiger*, 112, 195–198.

Viets, K. H. (1956). Wassermilben (Hydrachnellae, Acari) aus Venezuela und Kolumbien. In

Ergebnisse der deutschen limnologischen Venezuela-Expedition 1952. Band 1. Deutscher Verlag der Wissenschaften, Berlin (pp. 315–327).

Walter, C. (1912). *Hydracarina de Columbie. En O. Fuhrmann, & G. Mayor, Voyage D'Exploration*

Scientifique en Colombie.

Walter, D. E., & Proctor, H. C. (n.d.). *Mites : Ecology , Evolution &*.

Walter, D. E., & Proctor, H. C. (1998). Predatory mites in tropical Australia: local species richness and complementarity. *Biotropica*, 30(1), 72–81.

Walter, D. E., & Proctor, H. C. (2013). *Mites: Ecology, evolution & behaviour: Life at a microscale:*

Second edition. Mites: Ecology, Evolution & Behaviour: Life at a Microscale: Second Edition.

<http://doi.org/10.1007/978-94-007-7164-2>

