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The Heteropterans (Gerromorpha and Nepomorpha) of Andean Lakes in Colombia: Composition and Biota Similarity*

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Abstract: The Nepomorpha and Gerromorpha heteropterans are highly diverse, mainly in Neotropical aquatic ecosystems; however, their composition in the lakes of the Tropical Andes is poorly known. This article presents the composition of aquatic and semiaquatic bugs and their geographical and altitudinal distribution in eight lentic ecosystems from the Cundinamarca department, Colombia. The similar aquatic heteropteran composition between these Andean lakes and its relationship with the geographical and altitudinal range from 1,585 to 3,700 m.a.s.l. in the Eastern Andes are also analyzed. To carry out this work, the collections and pertinent literature are reviewed, and biota similarity is compared by applying a UPGMA analysis. The results show the predominance of Nepomorpha with a total of 12 species, four genera, and two families: Corixidae (6), and Notonectidae (6). The second most common suborder is Gerromorpha with eight species, seven genera, and five families: Gerridae (3), Veliidae (2), Hebridae (1), Hydrometridae (1), and Mesoveliidae (1). The biota similarity is related to páramo ecosystems and forest type. This article is the first to consider aquatic and semiaquatic heteropterans as biota from the Andean and High Andean lakes in Colombia.

Keywords: Aquatic and semiaquatic Hemiptera; lentic ecosystems; Corixidae; Notonectidae; páramo

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Los heterópteros (Gerromorpha y Nepomorpha) de lagos andinos en Colombia: composición y similitud de la biota

Resumen: Los heterópteros Nepomorpha y Gerromorpha son muy diversos, principalmente en ecosistemas acuáticos neotropicales; sin embargo, su composición en los lagos de los Andes Tropicales es poco conocida. En este artículo se presenta la composición de insectos acuáticos y semiacuáticos, así como su distribución geográfica y altitudinal en ocho ecosistemas lénticos del departamento de Cundinamarca, Colombia. También se analiza la composición similar de heterópteros acuáticos entre estos lagos andinos y su relación con el rango geográfico y altitudinal de 1.585 a 3.700 msnm en los Andes Orientales. Para llevar a cabo esta labor, se revisaron las colecciones y bibliografía pertinentes, y se comparó la similitud de la biota empleando un análisis UPGMA. Los resultados demuestran el predominio de Nepomorpha con un total de 12 especies, 4 géneros y 2 familias: Corixidae (6), y Notonectidae (6). El segundo tipo más común de suborden es Gerromorpha con 8 especies, 7 géneros y 5 familias: Gerridae (3), Veliidae (2), Hebridae (1), Hydrometridae (1) y Mesoveliidae (1). La similitud de la biota está relacionada con los ecosistemas de páramo y tipo forestal. Este artículo es el primero en considerar a los heterópteros acuáticos y semiacuáticos como biota de los lagos andinos y altoandinos en Colombia.

Palabras clave: Corixidae; ecosistemas lénticos; hemípteros acuáticos y semiacuáticos; Notonectidae; páramo

Os heterópteros (Gerromorpha e Nepomorpha) de lagos andinos na Colômbia: composição e semelhança da biota

Resumo: Os heterópteros Nepomorpha e Gerromorpha são muito diversos, principalmente em ecossistemas aquáticos neotropicais; no entanto, sua composição nos lagos dos Andes Tropicais é pouco conhecida. Neste artigo, apresenta-se a composição de insetos aquáticos e semiaquáticos, bem como sua distribuição geográfica e altitudinal em oito ecossistemas lênticos do departamento de Cundinamarca, Colômbia. Também se analisa a composição similar de heterópteros aquáticos entre esses lagos andinos e sua relação com a faixa geográfica e altitudinal de 1.585 a 3.700 msnm nos Ande Orientais. Para realizar este trabalho, revisaram-se as coleções e bibliografia apropriadas, e comparou-se a semelhança da biota empregando uma análise UPGMA. Os resultados demonstram o predomínio de Nepomorpha com um total de 12 espécies, 4 gêneros e 2 famílias: Corixidae (6), e Notonectidae (6). O segundo tipo mais comum de subordem é Gerromorpha com 8 espécies, 7 gêneros e 5 famílias: Gerridae (3), Veliidae (2), Hebridae (1), Hydrometridae (1) e Mesoveliidae (1). A semelhança da biota está relacionada com os ecossistemas de páramo e tipo florestal. Este artigo é o primeiro em considerar os heterópteros aquáticos e semiaquáticos como biota dos lagos andinos e altoandinos na Colômbia.

Palavras-chave: Corixidae; ecossistemas lênticos; hemípteros aquáticos e semiaquáticos; Notonectidae; páramo

Introduction

The Andes of Colombia (Figure 1) are divided into three major mountain ranges, the Eastern, Central, and Western Cordilleras, in addition to independent systems such as the Sierra Nevada de Santa Marta and the Serranía de la Macarena. The Colombian Andes biota is characterized by its high biodiversity and rapid rate of habitat loss, resulting in the Andean region classification of "hotspot" (Myers, Mittermeier, Mittermeier, Fonseca, & Kent, 2000).

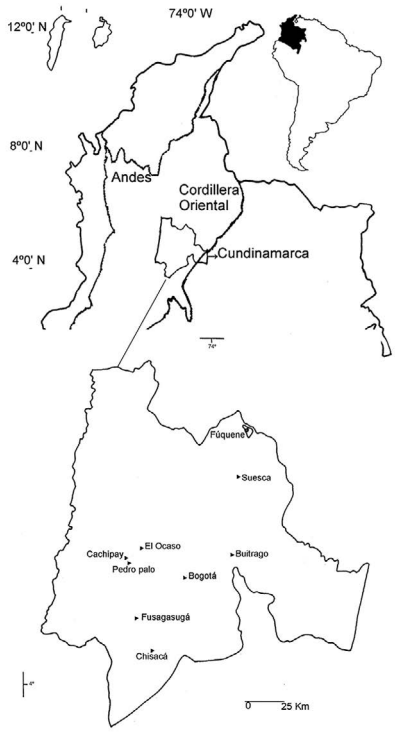

Figure 1. Geographical location of study lakes in Cundinamarca, Colombia.

Source: Own elaboration based on Padilla-Gil (1993).

The Eastern Cordillera possesses many lakes, followed by the Colombian Massif, the Ruiz-Tolima mountain range complex, and the Sierra Nevada de Santa Marta. In contrast, very few lakes are in the Western Cordillera. The lakes of the Eastern Cordillera are of glacial origin with the highest number found in El Cocuy and Sumapaz National Natural Parks (Florez & Ríos, 1998).

The ecosystem services of Andean aquatic habitats can be grouped according to three aspects: water supply, hydrologic flow regulation, and culture. In this regard, among the most important lakes are those from the Chingaza Páramo that provides 80 % of the drinking water for Bogotá (total number of inhabitants in 2018: 7,181,469), the Colombian capital (Corporación Autónoma Regional de Cundinamarca [CAR], 2018; DANE, 2020; Moreno, 2018).

The water resource of the Andes is also vulnerable to climate change and other anthropogenic impacts related to the hydrological regime, such as land-use changes for agriculture, mining, deforestation, extensive cattle ranching, and an increased supply of water for domestic and rural uses, threatening the long-term provision of this service (Instituto de Hidrología, Meteorología y Estudios Ambientales [IDEAM], 2020; Poveda, Álvarez, & Rueda, 2011).

The lakes of this study are in the Andean forest, High Andean forest, and páramos (alpine tundra). Colombia harbors 49 % of all the páramos in the world and gives origin to many hydrographic basins that supply 70 % of the population (Cabrera & Ramírez, 2014; Luteyn, 1999; Morales-Rivas *et al*., 2007; World Bank, 2012).

The Andean forest, high Andean forest, and páramo ecosystems have suffered anthropic intervention because of agriculture, deforestation, cattle ranching, mining, and climate change, resulting in degradation and decrease of natural and water resources, loss of biodiversity, and the reduction and contamination of lakes and the underlying water table. It is estimated that the percentage of loss due to climate change and a doubling of CO_2 concentrations in the atmosphere may lead to a reduction of the páramo surface area (elevation: 3,000 to 3,500 m) from 0.3 to 0.07 % and the humid sub-páramo (elevation: 2,500 to 3,000 m) from 0.37 to 0.29 % (Anderson *et al*., 2012; Castaño-Uribe, 2002; Garavito, Gómez, & Palacio, 2018; Gutiérrez, 2002).

Within the strategies to mitigate past and future environmental impacts and for motivating conservation and management plans, many of the ecosystems, including the lakes within, were declared Natural National Parks (e.g., Chisacá and Chingaza páramo lakes) (Parques Nacionales Naturales de Colombia [PNN], 2016). For the Fúquene, Suesca, and Pedropalo lakes and the nearby forest and forest reserves, environmental management

strategies have been implemented to maintain their biodiversity and protect their water. Nevertheless, the special protection of these areas allows for scientific studies and guarantees sustainable tourism (Espitia, 2010; Moreno, 2018).

The heteropterans subject matter of this study, also known as "aquatic bugs," belong to suborders Nepomorpha and Gerromorpha, the latter being semiaquatic inhabitants living in the air-water interface (Moreira, 2015). About their trophic role, some aquatic heteropterans, such as the "water boatmen," are predators of other invertebrates and small vertebrates (Hirai & Hidaka, 2002), while others at some period of their lives might be detritivores or herbivores. In turn, they are prey for other aquatic arthropods and vertebrates such as fishes, birds, and little mammals (Chemes, Giraudo, & Gil, 2010).

Some species of genera *Buenoa* and *Notonecta* are important for biological control. They prefer eating larvae and adult mosquitos of public health importance such as *Clues* and *Aedes* (García, Vivar, Quezada, & Huamán, 1996; Neri, Quiroz, Rodríguez, Tejada, & Badii, 1997; Quiroz, Herrera, & Badii, 1996; Quiroz, Rodríguez, Solís, & Badii, 2005). Adults and eggs of some corixids, notonectids, and naucorids are used as food for human consumption (Araujo & Beserra, 2007) and members of genera *Notonecta*, *Pelocoris* and *Limnocoris* inflict painful stings if manipulated carelessly (Menke, 1979).

Gerridae and Veliidae are potential indicators of the quality of water, preferring waters with high dissolved oxygen concentrations and suitable surface tension (Padilla-Gil, 2012). The corixids are included as water quality bioindicators (Rizo-Patrón, Santo Domingo, & Trama, 2011). Aquatic and semiaquatic heteropterans are also considered as indicators of paleopotamic flood systems (Skern, Zweimüller, & Schiemer, 2010). Freshwater heteropterans from the Neotropical realm were reviewed by Moreira (2015) and Moreira, Rodrigues, Sites, Cordeiro, and Magalhães (2018), the latter with illustrated keys for suborder, family, and genus levels.

Nepomorpha and Gerromorpha of aquatic ecosystems in Colombia

The Gerromorpha are the most studied heteropterans in the Andean region. In the last decade, taxonomic studies focused on Gerridae and the genus *Rhagovelia* in Pacific Piedmont, Western Slope of the Western Cordillera (Padilla-Gil, 2016a; Padilla-Gil, 2019a; Padilla-Gil & García-López, 2016; Padilla-Gil & García-López, 2016). Other studies were conducted in Andean-Amazonian Piedmont, eastern Slope of the Eastern Cordillera, again on Gerromorpha and genus *Rhagovelia* (Padilla-Gil, 2014b; Padilla-Gil, 2016b; Padilla-Gil, 2019b) and yet another study on *Rhagovelia* was conducted in the Central Cordillera, Tolima department (Parra-Trujillo, Padilla-Gil, & Reinoso-Flórez, 2014). However, most of the aquatic ecosystems inhabited by gerromorphans are lotic, particularly small streams, whereas there are no reports of gerromorphans from high Andean lakes in Colombia.

Nepomorpha from high Andean lakes in Colombia are not well known either, and only general taxonomic profiles have been published on this suborder so far (Nieser & Padilla-Gil, 1992; Padilla-Gil, 1993; Padilla-Gil, 2002; Padilla-Gil & Nieser, 1992; Padilla-Gil & Nieser, 1994; Tinerella & Polhemus, 2006). Thus, it is fair to state that the diversity and distribution of aquatic and semiaquatic heteropterans from high Andean and Andean lakes and their taxonomic similarity are still poorly known.

The objective of the present article is to describe the aquatic and semiaquatic heteropteran species inhabiting Andean and High Andean lakes and compare their compositional similarity. Given the lack of previous studies on aquatic heteropterans in Colombian páramo and sub-páramo lakes, and considering the strategic importance of their habitats and associated water-based ecosystem services, this study aims to fill a knowledge gap about the diversity and ecology of this important taxonomic group.

Materials and methods

Study area

Geographic location, altitude, and forest type (Barrera-Torres & de Barrera, 1997) of all the study lakes are shown in Table 1 and Figure 1. Detailed information on lakes of major importance is described below.

Table 1. Location of the study lakes in Cundinamarca, Colombia: coordinates, elevation, and forest type.

Location	Elevation (m.a.s.l.)	Forest type	Coordinates	
El Ocaso	1,800	bhPMtc	4°43'00" N	74°25'01" W
Cachipay	1,585	bhPMtc	4°43'53" N	74°26'11" W
Chisacá	3,700	bmhM	4°18'30" N	743°12'54" W
Buitrago	3,400	bmhM	4°46' N	73°50' W
Suesca	2,800	bhM	5°06'20" N	73°48'09" W
Fúquene	2,543	bhM	5°28'12" N	73°44'14" W
Pedropalo	2,000	bhPMtc	4°40'53" N	74°23'16" W
Fusagasugá	1,728	bhPMtc	4°20'11" N	74°21'49" W

bhPMtc: warm transition humid premontane forest, bmhM: very humid montane forest, bhM: humid montane forest.

Source: Own elaboration based on Barrera-Torres and de Barrera (1997).

Study lakes and importance

Buitrago (Páramo de Chingaza) and Chisacá (Páramo de Sumapaz) lakes are located on the Western Slope of the Eastern Cordillera in Cundinamarca; both are Natural National Parks and are part of the Chingaza-Sumapaz-Guerrero Páramo Complex. Their ecosystem services relate to the provisioning of water, biodiversity conservation, food production, and the integration of indigenous communities and farmers that inhabit the conservation corridors of this territory. Chingaza is a strategic ecosystem for the more than 7 million inhabitants of Bogotá city, providing 80 % of Bogotá's water supply; 70 % of this complex is an area under special protection. Due to the hydrogeological potential these páramos have, a special strategy such as the establishment of the "Chingaza-Sumapaz-Guerrero conservation corridor" was created (Garavito, Gómez, & Palacio, 2018; Sguerra *et al*., 2011).

The Fúquene Lake, of glacial origin, is located on the Western Slope of the Eastern Cordillera. It belongs to the Fúquene Basin, from which the Ubaté, Lenguazaque, and Suta rivers drain. Its water area covers 30 km², at an elevation of 2,543 m. This basin borders the Lenguazaque, Ubaté Alto, Guachetá, Suta, Cucunubá, and Ubaté Bajo basins (Cabrera, 1957). As for biotic resources, the lake contains six fish species belonging to an equal number of genera and families. The lake constitutes a strategic ecosystem due to its connectivity with the Rabanal Páramo and El Robledal Forest Reserve (CAR, 2006).

The Suesca Lake is located at an elevation of 2,800 m in the Western Slope of the Eastern Cordillera between the Suesca and Cucunubá municipalities. The lake is on the Nemocón anticline and is crossed by the Suesca geologic fault, with a water surface area of 145.7 ha (Barrera *et al*., 2004).

The Pedropalo Lake Forest Reserve is located within the Tena municipality, Cundinamarca, in the Western Slope of the Eastern Cordillera. Its importance lies in its hydric regulation, ecosystem services, and tourism. Eighty-three percent of its vegetation is tropical, characterized by a mix of lauraceous, sub-Andean, and Andean forest (Hernández, Rosales, & Cortés, 2011).

The Fusagasugá Lake is in a heavily vegetated landscape that ranges between 900–2,000 m.a.s.l., with a temperature range of 18–24 °C, and 1,000 to 2,000 mm of rainfall during the year. Its fish fauna consists of three species. The lake lies in the drainage basin of the Cuja River, which passes through La Puerta and Chinauta municipalities. It is possible to find geological formations such as Terrazas Altas that dates to the Quaternary Period (Municipio de Fusagasugá, 2004).

Heteropteran sampling

Aquatic heteropterans were collected from all eight lakes (Table 1) on two sampling occasions (dry and wet season) between 1989 and 1991. A square hand net was used, and two collectors worked simultaneously for an hour. Specimens were preserved in 70 % ethanol until taxonomic analysis. All specimens were incorporated into the collection at the Instituto de Ciencias of the Universidad Nacional de Colombia (ICN), Bogotá.

Physicochemical variables

Water temperature: thermometer; dissolved oxygen: Winkler method; pH: test paper; water transparency: Secchi disc. The parameters were determined in situ.

Taxonomic identification

Specimens were identified using a dissection scope with the support of specialist Dr. Nico Nieser and based on the references previously quoted in the section "Nepomorpha and Gerromorpha of aquatic ecosystems in Colombia."

Data analysis

Species occurrence was compared with the altitudinal range at which they were found to establish geographic trends. To compare taxonomic similarity among the eight lakes, cluster analysis was performed using Euclidean distance as the similarity matrix and the UPGMA algorithm for plotting dendrograms using the program Past 3.17.

Results and discussion

A total of 20 species of aquatic and semiaquatic heteropterans were found in the eight studied lakes (Table 2); Nepomorpha was the most numerous taxon, with 12 species, four genera, and two families. In contrast, Gerromorpha had eight species, seven genera, and five families.

The genus with the greatest number of species was *Neosigara*, with five species, followed by genus *Buenoa* with four species (Figure 2).

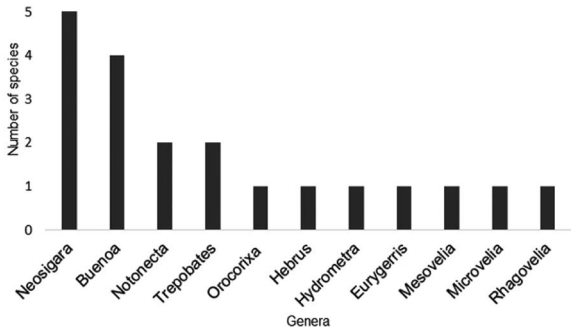

Figure 2. Species richness of the genera of aquatic and **semiaquatic heteropterans from Cundinamarca lakes.**

Source: Own elaboration.

Nepomorpha was the most abundant group at a higher elevation (Figure 3), particularly in the páramo lakes (elevation: 3,400–3,700 m), where species of genus *Neosigara* (*N. aristera, N. akantinomeros, N. sterea*, and *Orocorixa makrocheira*) prevailed. In contrast, Gerromorpha was the most diverse and abundant group in lakes at lower elevations, below 2,000 m.a.s.l. (Figure 3).

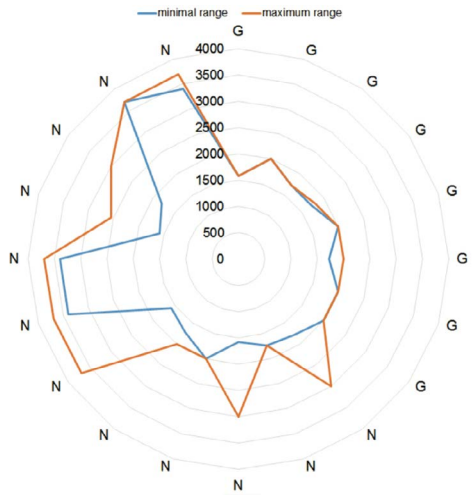

Figure 3. Altitudinal ranges of Nepomorpha (N) and Gerromorpha (G) species of high Andean and Andean lakes in Cundinamarca, according to Table 2.

Source: Own elaboration.

The Pedropalo Lake was the location with the highest species richness of aquatic and semiaquatic heteropterans (12 species), followed by the Chisacá and Fusagasugá lakes, with five species each.

The Buitrago and Chisacá lakes were the most similar in terms of their heteropteran composition (Figure 4), both being páramo lakes located at an elevation of 3,400–3,700 m with very humid montane forest vegetation. Their taxonomic similarity is based on the presence of four species of *Neosigara* and *Orocorixa* that were previously mentioned. The occurrence of these four species appears to be an exclusive feature of these high Andean aquatic ecosystems to the north of the Eastern Cordillera in Colombia. At other latitudes of the Andes mountain range, towards the south, the geographic distribution of the genera disappears. Another species shared by these páramo ecosystems is the *Notonecta melaena* that is widely distributed at the Colombian Andes. The biotic similarity is mirrored by similar environmental and habitat conditions. These two oligotrophic lakes have high oxygen saturation 97–125 %, highly transparent waters with temperatures between 9–13 °C, and a pH of 5–6.

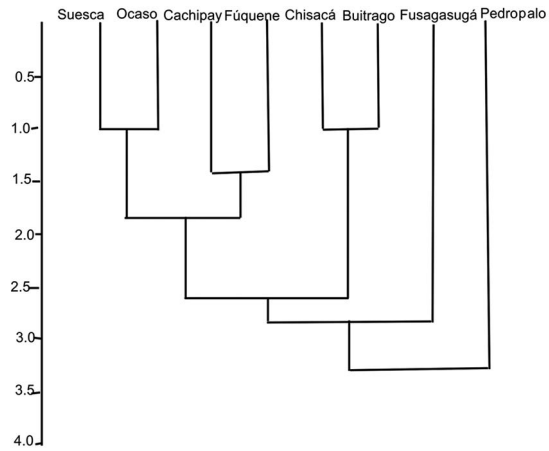

Figure 4. Dendrogram of taxonomic similarity of aquatic and semiaquatic heteropterans of eight high Andean and Andean lakes in Cundinamarca (Euclidean distance, UPGMA linkage).

Source: Own elaboration.

Table 2. Species of Nepomorpha (N) and Gerromorpha (G) of the lakes in Cundinamarca, Colombia.

Species	Infraorder	Lakes
Buenoa cucunubensis Padilla-Gil & Nieser	N	Fuq, Oca, Pp, Sue
Buenoa gracilis Truxal	N	Fus
Buenoa pallipes (Fabricius)	N	Cac, Fuq, Oca, Pp, Sue
Buenoa platycnemis (Fieber)	N	Pp
Species	**Infraorder**	**Lakes**
Eurygerris atrekes Drake	G	Pp
Hebrus elimatus Drake & Cobben	G	Pp
Hydrometra argentina Berg	G	Pp
Mesovelia mulsanti White	G	Fus, Pp
Microvelia pulchella Westwood	G	Pp
Neosigara akanthinomeros Padill-Gil & Nieser	N	Bui, Chi
Neosigara aristera Nieser & Padilla-Gil	N	Bui, Chi
Neosigara columbiensis Lundblad	N	Cac, Fuq, Pp
Neosigara murilloi Hungerford	N	Oca, Pp, Sue
Neosigara sterea Nieser & Padilla-Gil	N	Chi
Notonecta indica Linnaeus	N	Pp, Bui, Cac, Chi, Fuq
Notonecta melaena Kirkaldy	N	Oca, Pp, Sue
Orocorixa makrocheira Nieser & Padilla-Gil	N	Bui, Chi
Rhagovelia andina Padilla-Gil	G	Cac
Trepobates taylori (Kirkaldy)	G	Fus
Trepobates trepidus Drake & Harris	G	Fus, Oca

Bui: Buitrago, Cac: Cachipay, Chi: Chisacá, Fuq: Fúquene, Fus: Fusagasugá, Oca: Ocaso, Pp: Pedro Palo, Sue: Suesca.

Source: Own elaboration.

The other lakes with very similar biotas correspond to the ones located in Andean forests between 1,585–3,000 m.a.s.l. Lakes of intermediate elevation, such as Suesca, El Ocaso, Fúquene, and Cachipay, show a wide distribution of species from genera *Neosigara*, *Notonecta*, and *Buenoa*. Despite being located at a similar altitude, the lakes occur on different slopes: The Western Slope (El Ocaso and Cachipay) and the Eastern Slope (Fúquene and Suesca) of the Eastern Cordillera. All these lakes are characterized by oxygen saturation of 105–117 %, slightly turbid waters, water temperatures between 9–22 °C, a pH between 5–7, and an abundance of littoral and floating vegetation.

Lastly, the Fusagasugá and Pedropalo lakes, located at an elevation of 1,728 m and 2,000 m, respectively, had the most dissimilar biota of aquatic and semiaquatic heteropterans, characterized by a greater richness of gerromorphans. The Fusagasugá Lake is characterized by a 79 % of dissolved oxygen saturation, slightly cloudy waters, a water temperature of 28 °C, a pH of 6, an area with scarce aquatic vegetation, and high anthropic intervention.

In the Pedropalo Lake, low altitude-species, mainly gerromorphans and some species from high altitudes, such as genera *Notonecta* and *Neosigara*, converge. The habitat is characterized by 110 % dissolved oxygen saturation, slightly cloudy waters, a water temperature of 19 °C, and a pH of 5. This lake shows a high degree of eutrophication. Nevertheless, it is in suitable ecological condition due to its dynamics and the contiguous forest that is a mix of lauraceous and oak (Hernández, Rosales, & Cortés, 2011), as evidenced by adequate oxygen saturation, and contributes to maintaining the hydric equilibrium.

The Pedropalo Lake constitutes an encounter of diverse biotas, applying equally to its vegetation as well as its assemblage of aquatic and semiaquatic heteropterans. This corroborates the idea of it being an ecotone (Hernández, Rosales, & Cortés, 2011).

Several species of semiaquatic bugs inhabit lotic ecosystems in Colombia's high Andes such as genera *Altavelia* (elevation: 1,500–3,600 m), *Eurygerris fuscinervis* (lotic and lentic ecosystems, elevation: 800–3,000 m), *Microvelia piedrancha* (elevation: 2,275 m), and *Paravelia daza* (elevation: 2,700–3200 m) in the south-west Andean mountain range (Padilla-Gil & Arcos, 2010; Padilla-Gil & Moreira, 2011; Padilla-Gil & Moreira, 2013; Polhemus, Molano, Morales, Moreira, & Floriano, 2019). However, lake heteropterans are little known, although genus *Buenoa* from the tropical lakes of the Pacific coast (elevation: 10 m) was studied by Padilla-Gil (2014a); in contrast, the composition of the *Buenoa* species are different between the Pacific and Andean lakes.

The invertebrates of Ecuadorian high Andean lakes, including aquatic invertebrates of páramo lakes, were studied by Bench & Bilton (2001), concluding that their composition was very similar to that of lakes of lower altitudes. However, the Ecuadorian páramo lakes of this study only had heteropterans from the Corixidae family, whereas no mention was made of any other aquatic or semiaquatic heteropteran family.

The composition of these species from the high Andes mountain range is unique, founding several endemic ones. This feature highlights the importance of this biota, establishing a close relationship between these species and water quality. As an example, the corixid community was associated with the water quality of European lakes: oligotrophic or eutrophic (Jansson, 1977; Savage, 1982; Savage, 1994). On the other hand, trophic relations (Corixoidea), predator-prey interactions, and control of mosquito larvae of medical importance (Notonectidae) are of current interest (Dalal, Cuthbert, Dick, & Gupta, 2020; Hädicke, Rédei, & Kment, 2017).

CONCLUSION

In conclusion, the aquatic and semiaquatic heteropterans from high Andean forest lakes in Cundinamarca is restricted to species of the infraorder Nepomorpha, belonging to genera *Neosigara, Orocorixa, Notonecta*, sharing a similar composition. Lakes of the Andean forest at lower altitudes (up to 3,000 m.a.s.l.) also feature another genus like *Buenoa* as well as several different species of *Neosigara*. In contrast, species belonging to the Gerromorpha predominate in lakes at lower altitudes (up to 2,000

m.a.s.l.). A few Nepomorpha species (e.g., *N. melaena* and *B. pallipes*) have wide distribution ranges that extend down to lower elevations. The Pedropalo Lake had the highest species richness of aquatic Heteroptera, containing representatives of Nepomorpha as well as Gerromorpha, and appears to be an ecotone where high-altitude and low-altitude assemblages of aquatic and semiaquatic heteropterans converge.

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