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Trichoptera (Insecta) from the collection of the Instituto de Biodiversidad Neotropical (IBN-CONICET-UNT), Tucumán, Argentina

Trichoptera (Insecta) de la colección del Instituto de Biodiversidad Neotropical (IBN-CONICET-UNT), Tucumán, Argentina

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ABSTRACT

Biological Collections are extremely important for understanding environmental changes that occur in natural systems. The Instituto de Biodiversidad Neotropical (IBN) has a collection of insects associated with the Yungas Mountain rivers that is over 30 years old, scientifically supported by studies on the systematics and taxonomy of several orders. The objective of this work is to give visibility to the IBN collection and accessibility to the complete dataset of caddisflies through open-access portals. As a result, the collection represents around 50% of the Trichoptera species described for the study area. The majority of the records (38%) come from material collected between 500 and 1000 m a.s.l. and date from 1999 to 2006. The records cover 14 out of 30 protected areas, with Calilegua National Park having the highest number of species (19 species). Three large undersampled areas are identified to concentrate future sampling efforts.

Keywords — Biological Collections; Caddisflies; Indicators; Vacancy Areas; Yungas.

RESUMEN

Las Colecciones Biológicas son sumamente importantes para comprender los cambios ambientales que ocurren en los sistemas naturales. El Instituto de Biodiversidad

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Neotropical (IBN) posee una colección de insectos asociados a los ríos de Montaña de Yungas de más de 30 años, sustentada científicamente en estudios sobre sistemática y taxonomía de varios órdenes. El objetivo de este trabajo es darle visibilidad a la colección del IBN y accesibilidad al conjunto de datos completos de tricópteros a través de portales de libre acceso. Como resultado, en la colección está representado alrededor del 50% de las especies descritas para el área de estudio. La mayoría de los registros (38%) provienen de material colectado entre los 500 y 1000 m s.n.m. y datan de 1999 a 2006. Los registros cubren 14 de 30 áreas protegidas, siendo el Parque Nacional Calilegua el área con mayor número de especies (19 especies). Tres grandes áreas submuestreadas son identificadas para concentrar futuros esfuerzos de muestreos.

Palabras clave — Áreas vacantes; Colección biológica; Indicadores; Yungas.

INTRODUCTION

Biological collections contain invaluable specimens that serve as critical resources for comprehending the historical, current, and forthcoming effects of environmental changes on natural systems (Kemp, 2015; Lendemer et al., 2019). Over time, these collections are increasingly essential for conservation biology and addressing societal concerns. Thus, their maintenance and expansion are necessary to meet the growing demands for these valuable resources (Drew, 2011). Regrettably, the continued existence of biological collections in Argentina is at risk due to several factors, such as lack of awareness of their value and contributions, as well as inadequate coordination and connectivity among collections (Teta, 2021). Sharing a dataset of collections is essential to provide overviews or inventories of the materials included. However, providing databases with additional analyses and interpretations of the data is also important to facilitate hypothesis and guide future studies more effectively. This would provide a more comprehensive source of information and ensure that these invaluable resources are preserved and utilized for years to come.

The Instituto de Biodiversidad Neotropical (IBN, CONICET – UNT) has dedicated over 30 years to studying the systematics and taxonomy of several orders of insects, including Ephemeroptera, Trichoptera, Odonata, and Coleoptera, which are predominantly found in the mountainous rivers of Northwestern Argentina (Domínguez and Fernández, 2009). These insects, along with other significant taxa like Plecoptera, Megaloptera, Hemiptera, Acarina, Gastropoda (both terrestrial and aquatic), and reptiles, are housed at the IBN collection.

Recently, IBN has initiated a project to digitize their collection, enabling sharing with the scientific community. This project began with the Baetidae (Ephemeroptera) and Elmidae (Coleoptera) datasets, which are now available on the Global Biodiversity Information Facility (GBIF) portal (Albanesi, Cristobal, Manzo and Nieto, 2020).

Trichoptera is a highly diverse order of freshwater insects, including around 16200 known species worldwide. These insects are cosmopolitan, with a global presence across all continents except Antarctica. In Argentina alone, there are over 330

species, spanning 80 genera and 18 families (Holzenthal and Calor, 2017; Morse, 2023). The caddisfly larvae secrete silk, which allows them to construct cases, retreats, nets, and other structures, facilitating the exploitation of various resources and different environments. This adaptability explains the high diversity of the group and the wide range of trophic adaptations they display, enabling them to exploit diverse aquatic microhabitats (Mackay and Wiggins, 1979; Flint et al., 1999, Stewart and Wang, 2010, Okano and Kikuchi, 2012).

Caddisflies are excellent indicators of aquatic ecosystem quality and are particularly useful in reflecting the intensity of different stressors. As a result, they have been extensively studied and incorporated into various environmental quality indices, such as EPT (Klemm, Lewis, Fulk and Lazorchak, 1990), ElPT (von Ellenrieder, 2007), and IBY-4 (Dos Santos, Molineri, Reynaga and Basualdo, 2011), the latter of which is specific to streams and rivers of Yungas Forest. While Trichoptera larvae are well-known to aquatic ecologists and taxonomists, Trichoptera adults are less familiar. These small, drab-colored insects usually fly after sunset and are attracted to artificial lights, often appearing in large numbers (Holzenthal and Calor, 2017). Despite their inconspicuous appearance, both adults and larvae play crucial roles in energy flow and nutrient dynamics within aquatic environments (Holzenthal and Calor, 2017).

Since 2005, extensive research has been conducted on the Trichoptera of Las Yungas in Argentina and South Bolivia. This research has resulted in several taxonomic, ecological, and biogeographical contributions being published (Rueda Martín, 2005, 2008, 2011; Isa Miranda and Rueda Martín, 2014; Dos Santos, Rueda Martín and Reynaga, 2015; Pero et al., 2018; Rueda Martín and Sganga, 2021). Our objective is to increase accessibility to a comprehensive dataset on caddisflies (Trichoptera) found in rivers within the Argentine Yungas forest, with a focus on protected areas, at the species level.

MATERIALS AND METHODS

Study area

The majority of the records of this work corresponds to the biogeographic province known as Yungas Forest or Bosque Tucumano-Boliviano (Cabrera and Willink, 1973; Morrone, 2001). The Yungas Forest is a subtropical mountain forest that extends along non-continuous mountain ranges from southern Bolivia to Catamarca province in northwestern Argentina. It forms part of a larger formation (mountain rainforest) that spans a North-South belt recognized from the Andes of Venezuela to the northwestern mountains in Argentina. The forest is ecologically important due to its altitudinal variation, which ranges from 400 to 3000 m a.s.l.

The Yungas Forest has a warm and humid climate with an annual temperature range of 14 °C to 26 °C and rainfall that varies from 1000 to 2500 mm (Hueck, 1978), with a dry season during winter and spring. It is noteworthy that the Yungas Forest in northwestern Argentina and the Paranaense forest in northeast Argentina together harbor 50% of the country's total species richness (Brown et al., 2001).

The specimens were collected from northwestern Argentina, specifically from the provinces of Salta, Jujuy, and Tucumán, which constitute the primary database of Trichoptera in the IBN collection.

Description of the samples

Sampling description.— During the day, adult specimens were collected from exposed rocks and vegetation in the river using aerial nets, while nocturnal adults were captured using a mercury vapor light trap with an electric generator from late afternoon to early night. To enable molecular studies, mainly for immature association and phylogeny, all specimens were collected and preserved in 96% ethyl alcohol.

Posterior abdominal segments of male adults were dissected and cleared in 10% NaOH at around 25 °C for a duration of 8 to 12 hours. Subsequently, each abdomen was neutralized with lactic acid, the soft parts were removed, and the cuticle was washed with water. The diaphanized abdomens were then preserved in 96% alcohol along with the remaining parts of each individual. Glycerin was used as the mounting media to secure the different views of the genital segments and to recover the abdomen (Rueda Martín et al., 2021). The genital segments were examined under an Olympus BX 51 optical microscope equipped with a camera lucida (40X).

The immature specimens were collected from rivers in northwestern Argentina, because of their wide diversity of ecological requirements, different methods were used, such as Surber nets, D nets, and forceps with visual inspection of substrates. Larvae and pupae were fixed and preserved in 75-96 % ethyl alcohol. All associations were made using the metamorphotype method (Vorhies, 1909; Milne, 1938). All collected material has been identified, labeled and georeferenced. Identification and data are reliable, especially because all material was compared to type material from National Museum of Natural History (NMNH), Smithsonian Institution, Washington, DC, USA.

Data collection.— The dataset discussed here is part of the Entomological Collection database of the Instituto de Biodiversidad Neotropical (IBN) located in the province of Tucumán, Argentina. Detailed information regarding the programs used for analysis and dataset structure can be found in Albanesi et al. (2020).

The data were analyzed in a GIS (QGIS Development Team, 2020). The georeferenced points were overlapped on the protected areas of national and provincial jurisdiction (Administration of National Parks, Federal System of Protected Areas) and the reference maps were constructed from QGIS. In addition, digital elevation model GDEM-Aster V2 (global digital elevation model, version 2, Satellite Aster) was used to delineate altitude ranges that are related to the different altitude floors of the Yungas.

To ensure accuracy, the dataset was exported in DarwinCore v.1.4, post-validation was performed using the DARWINTEST software, and metadata was integrated with the dataset in DarwinCore Archive format. Finally, the dataset was made available to the Global Biodiversity Information Facility (GBIF) using their Integrated

Publishing Toolkit (IPT), and is available at https://www.gbif.org/dataset/7ef3c846-013e-48c9-8407-7e8bfab270b4

RESULTS

The Trichoptera database at IBN comprises 1465 records from Argentina and Bolivia, including approximately 18700 identified specimens belonging to 14 families, 43 genera, and 94 species. The two most represented families are Hydropsychidae (432 records, 30%) and Leptoceridae (203 records, 13%). The three most commonly recorded genera are *Smicridea* McLachlan (364 records, 25%), *Marilia* Mueller (141 records, 10%), and *Atopsyche* Banks (125 records, 9%), accounting for 43% of the total records. The collection has a high representation of the fauna in the area, with over 50% of the species recorded for the study area (Table I). The collection also includes two holotypes: *Helicopsyche obscura* Rueda Martin and Miranda (2015) and *Cyrnellus boliviense* Rueda Martín et al. (2021).

In northwestern Argentina, the database contains 997 records, with 37, 31 and 27 species recorded in the provinces of Tucumán, Salta, and Jujuy, respectively (Figure 1). The most abundant species in Tucumán are *Atopsyche spinosa* Navás, *Marilia cinerea* Navás, and *Polycentropus joergenseni* Ulmer. In Salta, the most frequent records are *M. cinerea*, *Oecetis knutsoni* Flint, and *Marilia elongata* Martynov, while in Jujuy, *O. knutsoni* and *Protoptila dubitans* Mosely are more frequent.

Figure 1. Number of Trichoptera species known versus number of species represented in the collection of Instituto de Biodiversidad Neotropical (CONICET – UNT), for the three focal provinces in northwest of Argentina.

Figura 1. Número de especies de Trichopteros conocidos versus número de especies representadas en la colección del Instituto de Biodiversidad Neotropical (CONICET – UNT), para tres provincias del Noroeste de Argentina.

Table I. List of species represented in the Instituto de Biodiversidad Neotropical (CONICET – UNT) collection, by province.

Tabla I. Lista de especies por provincias de la colección del Instituto de Biodiversidad Neotropical (CONICET – UNT).

Especies	Jujuy	Salta	Tucumán
Calamoceratidae			
Banyallarga argentinica Flint, 1983	X	X	X
Banyallarga loxana (Navas, 1934)	X	X	
Banyallarga yungensis Flint, 1983	X	X	X
Phylloicus lituratus Banks, 1920		X	
Glossosomatidae			
Mortoniella pocita (Flint, 1983)	X		X
Mortoniella punensis (Flint, 1983)			X
Mortoniella wygodzinskii (Schmid, 1958)		X	X
Protoptila dubitans Mosely, 1939	X	X	X
Protoptila julieta Robertson & Holzenthal, 2008	X	X	X
Helicopsychidae			
Helicopsyche muelleri Banks, 1920		X	
Helicopsyche obscura Rueda Martin & Miranda, 2015			X
Helicopsyche turbida Navas, 1923		X	X
Hydrobiosidae			
Atopsyche callosa (Navas, 1924)		X	X
Atopsyche kamesa Ross & King, 1952		X	
Atopsyche maxi Rueda Martin, 2006 (“2005”)	X	X	X
Atopsyche spinosa Schmid, 1959	X	X	X
Atopsyche yunguensis Rueda Martin, 2006		X	
Cailloma lucidula (Ulmer, 1909)			X
Hydropsychidae			
Leptonema boliviense boliviense Mosely, 1933	X	X	X
Smicridea (Rhyacophylax) atrobasis Flint, 1983	X	X	X
Smicridea (Rhyacophylax) bifida Rueda Martin & Sganga, 2011		X	
Smicridea (Rhyacophylax) dithyra Flint, 1974			X
Smicridea (Rhyacophylax) elisae Rueda Martin & Sganga, 2011		X	
Smicridea (Rhyacophylax) mesembrina (Navas, 1918)	X		X
Smicridea (Rhyacophylax) murina McLachlan, 1871	X		X
Smicridea (Rhyacophylax) pampeana Flint, 1980	X		X
Smicridea (Rhyacophylax) peruana (Martynov, 1912)	X	X	X
Smicridea (Rhyacophylax) thermophila Rueda Martin & Sganga, 2011	X		
Smicridea (Rhyacophylax) valeni Rueda Martin & Sganga, 2011			X
Hydroptilidae			
Hydroptila argentinica Flint, 1983	X	X	X
Hydroptila bidens Flint, 1983		X	
Hydroptila catamarcensis Flint, 1983			X
Hydroptila pulestoni Flint, 1980			X
Leucotrichia alisensis Martiin, 2011			X
Leucotrichia lerma Angrisano & Burgos, 2002			X
Metrichia argentinica Schmid, 1958			X
Metrichia neotropicalis Schmid, 1958			X
Neotrichia elongata Flint, 1983	X		
Neotrichia falcifera Flint, 1974	X		
Neotrichia gotera Flint, 1983	X	X	
Oxyethira parce (Edwards & Arnold, 1961)		X	X
Leptoceridae			
Grumichella flaveola (Ulmer, 1911)	X	X	
Oecetis excisa Ulmer, 1907	X	X	X
Oecetis knutsoni Flint, 1981	X	X	X
Odontoceridae			
Marilia cinerea Navas, 1931	X	X	X
Marilia elongata Martynov, 1912		X	X
Marilia flexuosa Ulmer, 1905	X	X	X
Philopotamidae			
Chimarra argentinica Ulmer, 1909	X	X	X
Chimarra plaumanni Flint, 1983	X		
Polycentropodidae			
Cyrnellus collaris Flint, 1971			X
Polycentropus joergenseni Ulmer, 1909	X	X	X
Total species by province	27	31	37

The majority of records in the Trichoptera database show a concentration between 500 and 1000 m a.s.l. (38%) (Table II). However, there is a noticeable decrease in richness above 2000 m a.s.l., where the environmental conditions differ and change from forest to grassland. It is important to note that sampling effort, measured by the number of sites, is unevenly distributed across these different altitudinal strata (Table II). Records dates back from 1959 to 2020, with the highest influx occurring in 1999 and between 2004 to 2006 (Figure 2).

Table II. Species richness, percentage (of all species) and sampling effort (number of sites) according to altitude range from the Instituto de Biodiversidad Neotropical database (CONICET – UNT).

Tabla II. Riqueza de especies, porcentaje (de todas las especies) y esfuerzo de muestreo (números de sitios) en cada rango altitudinal, de la base de datos del Instituto de Biodiversidad Neotropical (CONICET – UNT).

Altitudinal range	n species	Percentage	n sites
0 - 500	24	20	20
500 - 1000	31	26	49
1000 -1500	32	27	52
1500 - 2000	24	20	29
2000 - 2500	8	7	10
> 2500	1	1	2

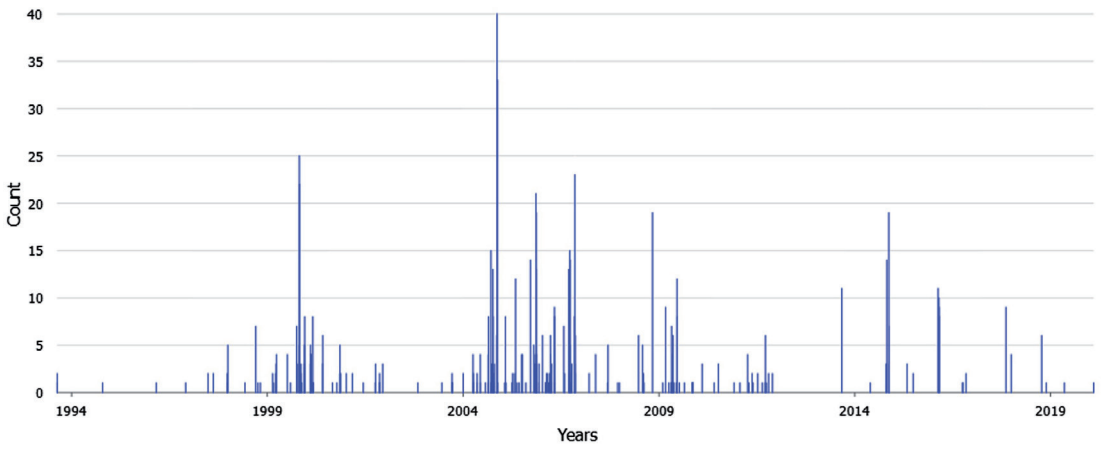

Figure 2. Frequency of records of caddisflies in relation to the years of the collection of the Instituto de Biodiversidad Neotropical (CONICET – UNT), Tucumán, Argentina.

Figura 2. Frecuencia de registros de tricópteros en relación a los años del Instituto de Biodiversidad Neotropical (CONICET – UNT), Tucumán, Argentina.

The dataset includes records from 14 of the 30 protected areas in the Yungas region. The National Park Calilegua has the highest number of species (19 spp.), followed by the National Park Baritú (16 spp.) and the National Reserve El Nogalar from Los Toldos (14 spp.) (Figure 3A). The map of sample point concentration shows areas of high density, such as the Lules River basin in Tucumán (A), the surrounding area of Los Toldos in Salta province (B), and the surrounding areas of the National Park Calilegua (C). Additionally, there are some areas with little or no

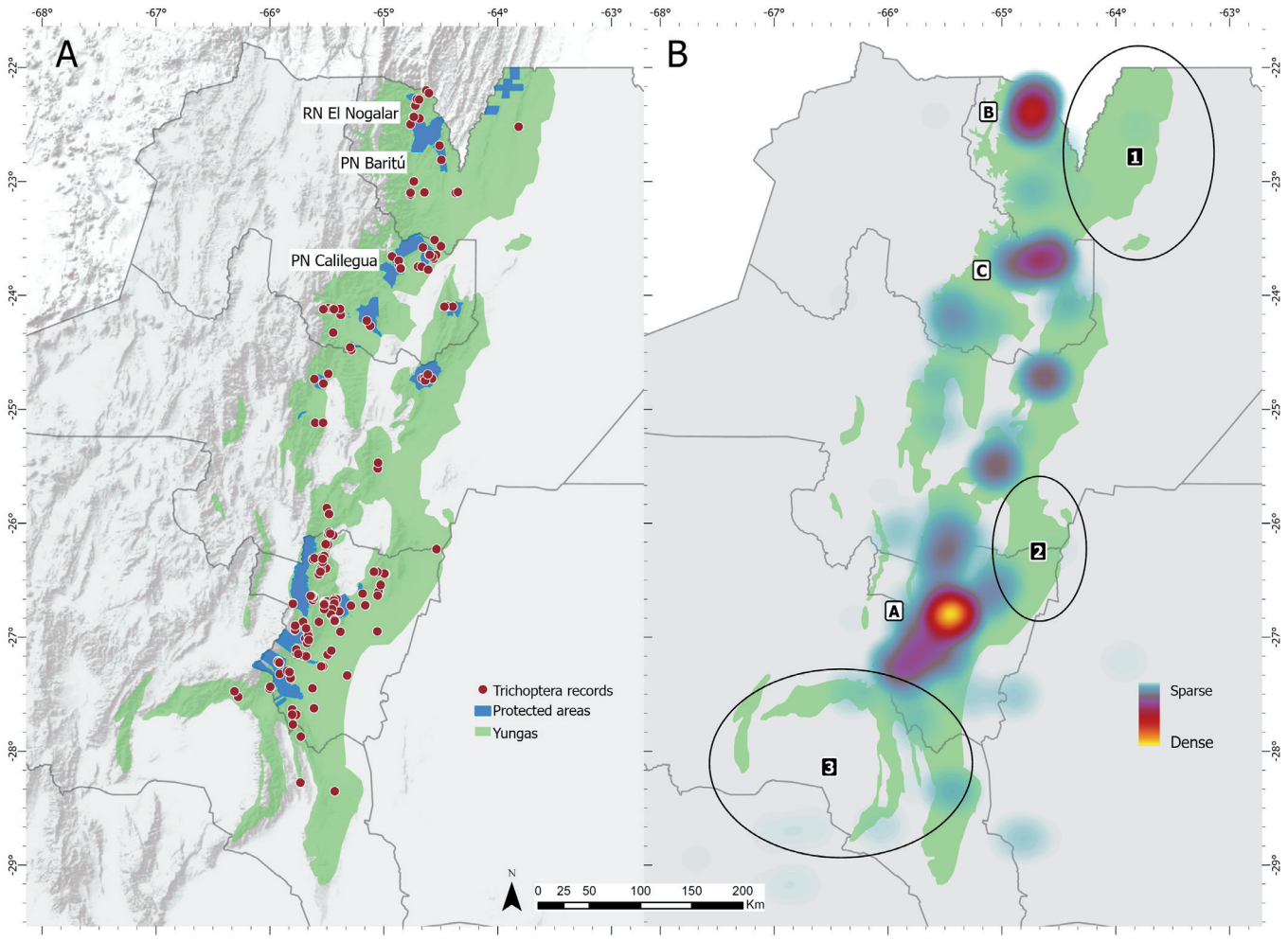

Figure 3. A) Distribution of Trichoptera records, and B) heat map (concentration of sampling points) and information gap areas within the Yungas ecoregion from the collection of the Instituto de Biodiversidad Neotropical (CONICET – UNT), Tucumán, Argentina.

Figura 3. A) Distribución de los registros de Trichoptera, y B) mapa de calor (concentración de puntos de muestreo) y áreas de vacíos de información en la ecorregión de Yungas de la colección del Instituto de Biodiversidad Neotropical (CONICET – UNT), Tucumán, Argentina.

information, these areas include San Martín in northeastern Salta (1), the northeastern region of Tucumán province and the southeastern region of Salta province (2), and the empty area of southern Yungas in Catamarca province (3) (Figure 3B).

DISCUSSION

This study provides records at species level of identification and georeferenced locations that are freely accessible through the GBIF. Additionally, the study identifies areas in the Yungas that require further research and suggests the need for collaboration with other institution (e.g., Instituto – Fundación Miguel Lillo, Tucumán; Instituto de Bio y Geociencias del NOA, Salta; National Universities of Catamarca and Jujuy) to exchange and identify materials from these regions.

The high number of records for the Hydropsychidae can be attributed to their preference for flowing water habitats worldwide. Their larvae are a common and abundant component of the bottom fauna (Holzenthal and Calor, 2017). The family is divided into five subfamilies, with Smicrideinae having the highest diversity of species and genera. In the New World, Smicrideinae are represented only by *Smicridea*. The genus, with its two subgenera, *Smicridea* and *Rhyacophylax*, constitutes the most species-rich and abundant hydropsychids in the Neotropics, with over 200 described species (Holzenthal and Calor, 2017; Pero et al., 2021). The importance in our database of the Leptoceridae, also known as long-horned caddisflies, is not surprising because this group has a cosmopolitan distribution, with many of its species and genera found in warmer regions. They are adaptable to a wide variety of habitats, including large and small rivers, cascades, and even semi-terrestrial situations, both in lowlands and highlands (Holzenthal and Calor, 2017).

The remaining families such as Calamoceratidae (*Banyallarga* and *Phylloicus*), Hydrobiosidae (*Atopsyche*), Hydroptilidae (*Hydroptila*, *Leucotrichia*, *Metrichia*, *Neotrichia*, *Oxyethira*), Glossosomatidae (*Mortoniella* and *Protoptila*), Odontoceridae (*Marilia*) and Polycentropodidae (*Polycentropus*) present a lower diversity and frequency in the studied area and therefore are less represented in our database. All of them are related to mountains rivers, small springs and cascades that provides the resources they need: food, oxygen and materials for construction of larval and pupal cases.

In the Neotropics, a total of 3545 species of Trichoptera belonging to 158 genera and 26 families have been documented, with 336 species, 80 genera, and 18 families reported in Argentina. Within the Yungas region of Argentina, 64 species, 28 genera, and 13 families have been reported (Holzenthal and Calor, 2017; Morse, 2023). The IBN collection is highly representative of the documented fauna in the region, housing over 50% of the species recorded for Yungas region.

The majority of the records from 500 to 1000 m a.s.l. are situated along main roads in an anthropic landscape with multiple threats to biodiversity such as habitat loss (due to urban and agricultural conversion), pollution (from fertilizers and pesticides), pathogens, introduced species, and climate change (Domínguez and Fernández, 1998; Romero et al., 2011; Sánchez-Bayo and Wyckhuys, 2019). These anthropic alterations of environments have affected the caddisfly species, which are being lost at a faster rate compared to other freshwater insect orders (Sánchez-Bayo and Wyckhuys, 2019).

The Trichoptera collection at IBN is highly valuable for its comprehensive representation of Yungas region fauna, with a high percentage of described species for each province (74% in Tucumán, 60% in Salta, and 79% in Jujuy) and its database can be very useful to plan next steps in caddisfly researches. Identifying information gaps in the surveyed area, such as in the highly threatened ecoregion of Chaco Serrano in sector 2, can aid in identifying potential high diversity areas. Similarly, sector 3, where the Yungas reaches its southern limits, and sector 1, where inaccessible private land and industrial activity hinder data collection, also represent areas with potential biodiversity gaps.

It is crucial to recognize the fundamental role that basic systematics plays in decision-making concerning conservation areas (Christie et al., 2020). To ensure the

availability of fundamental diversity data for other types of studies, it is necessary to continue efforts in collecting, identifying, and updating datasets. Sharing datasets of published records, including geographic information and accurate identifications at the highest taxonomic level, is an effective way to make information easily accessible in a concise and organized format. This approach enables the development of more streamlined processes for obtaining data for future studies in areas such as distribution, preservation, ecology, biogeography, protected areas, and climate change. By ensuring a high level of accuracy and quality, we can enhance the efficacy of these studies and inform conservation efforts more effectively (McNeely, 2002).

In spite of the fact that our study area has been sampled along 30 years, the representation is around 70% only. There still are species that remain unrecorded, for example, *Merionoptila wygodzinskyi* Schmid 1959, only known from type material deposited at NMNH, that is an endemic species from Tucumán province. Another interesting species for the science is *Ithitrichia ferni* Rueda Martín 2006, which is endemic from Northwestern Argentina, with other three species of the genus that are Holartic. Species in Xiphocentronidae also are underrepresented in the collection, perhaps because the adult of this species have diurnal activity and larvae are semiterrestrials.

It is important to continue efforts to fill in these gaps in knowledge, especially for species that are rare, endemic, or threatened. This requires not only collecting and identifying specimens, but also utilizing new technologies and approaches such as DNA barcoding and citizen science initiatives to gather more data. Collaborations with other institutions and experts in the field can also help to expand knowledge of Trichoptera fauna in the study area and beyond.

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