THE FIRST BOTANICAL EXPLORATION TO THE UPPER CUIARÍ (CUYARÍ) AND ISANA RIVERS, UPPER RÍO NEGRO BASIN, GUAINÍA DEPARTMENT, COLOMBIA

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Abstract. This account reports a journey of ca. 500 km from the city of Inírida to the Colombian basins of the Cuiarí and Isana Rivers (Guianía department) in April–May 2014, the first botanical expedition to this region. This area exemplifies one of the last innermost and botanically unexplored regions of the northwestern corner of the Amazon basin (the upper Río Negro basin), aside from the fieldwork started some 234 years ago with the exploration of the middle and lower portion of the Isana basin in Brazil (where it is called Içana) by the Portuguese naturalist Alexandre Rodrigues Ferreira. On our expedition we collected 1301 botanical numbers, which resulted in eight new species (two already published), two new families, and 24 species new to the Flora of Colombia. Another noteworthy feature is the high diversity of the forests in the upper Isana River, represented by between 108 and 162 spp. with a diameters ≥ 2.5 cm in different 40 x 40 m plots (1600 m²). The Isana River is a white-water basin (with high levels of sediments), with large areas covered by the vegetation typical of black-water rivers (Amazon Caatinga forests, lower forests, savannas and sclerophyllous shrubby vegetation over white-sand soils). This feature results from the influence of several black-water rivers, the headwaters of which drain from Precambrian Guiana shield outcrops. This account of the first botanical exploration in the Colombian portion of the Cuiarí and Isana Rivers is yet another example of the need for continued floristic studies in regions where there are large geographic gaps in the knowledge of Amazonian flora. Advances in documentation of this flora can be achieved through institutional and private partnerships, improved training, and continued fieldwork in collaboration with local inhabitants. A discussion of demarcation issues regarding the frontier between Brazil and Colombia in this northwestern corner of the Amazon basin, its physical and biological environments, and its ancestral and current inhabitants is presented.

Keywords: Amazonia, botanical exploration, upper Río Negro basin, Cuiarí and Isana Rivers, Colombia

Resumen. La presente crónica describe el recorrido de aproximadamente 500 km desde la ciudad de Inírida hasta los sectores colombianos de las cuencas de los ríos Cuiarí e Isana (departamento del Guianía) en abril–mayo de 2014, actividad que representa la primera exploración botánica a esta region. Esta es una de las últimas regiones del Noroeste de la Cuenca Amazónica (alto Río Negro) que no se había explorado botánicamente, a pesar de la gran cantidad de trabajos de campo realizados en el alto Río Negro, las cuales comenzaron hace 234 años, con la exploración de las cuencas media y baja del río Isana en Brasil (donde es llamado Içana) por el naturalista portugués Alexandre Rodrigues Ferreira. Durante el viaje se colectaron 1301 números botánicos, de estos, se identificaron ocho especies nuevas para ciencia (dos ya publicadas), igualmente dos familias y veintecuatro nuevos registros para la Flora de Colombia. Otro aspecto biológicamente importante es la alta diversidad de los bosques del alto río Isana, donde se midieron entre 108 y 162 spp. (DAP ≥ 2.5 cm) en parcelas de 40 x 40 m (1600 m²). La cuenca del rìo Isana es de aguas claras, con extensas áreas de vegetación propias de los sistemas de aguas negras (i.e. bosques de Caatinga Amazónica, extensas sabanas y arbustales esclerófilos sobre suelos de arena blanca). Esta situación es debido a los numerosos caños y ríos que desembocan en los sectores medios y bajos de la cuenca, provenientes de los afloramientos precámbricos del escudo guayanés. El presente registro de la primera exploración botánica en la parte colombiana de los ríos Cuiarí e Isana demuestra la necesidad de continuar con los estudios florísticos en sectores poco estudiados. Sin embargo, avances en documentar la flora y vegetación serán logrados a través de las alianzas institucionales y privadas, a través de entrenamientos en trabajos de campo y en el incremento de nuevas expediciones con la colaboración de los habitantes locales. Se incluye información acerca de la historia de la delimitación de la frontera entre Brasil y Colombia, aspectos físicos y biológicos de la cuenca del río Isana, sus habitantes antiguos y actuales, y reseñas de la exploración botánica del noroeste de la cuenca Amazónica.

Yaakuti iipenaa. (Abstract in Kuripako). Jlieje yaakutida likadaa wajnee, likaitepe jnete lidana najnikarun inakuapana wadeepedali 500 km iyapika likuñueta Inirida jnete liukawa Iniali jnete kuwialisre Colombiakawani (departamento del Guainía), katsa idejnikjeti ikuñuetakada nanakuaapana jnaja yajnikape ikapa awakada nesre. Katsa nene piketenkawa Noroeste Cuenca Amazonía (Padzawidza jiwidaan) karukawa nakanantakawa awakada inakuapana; nentsatja manupeka jnaja idejnikape pia nesre, 234 años nakuñuetakadzamina, nakapa pia jlieje lipamudzuaka jnete linumanaa jlieje Iniali Brazil kawani (najne nesreni Iniali) lima jlieje kaakunadali ipedzukada awakada Portugués Alexandre Rodrigues Ferreira. Najnikadanaku nesre naniwa 1301 jaikulima, nanakjite naaketa ochona jaiko waliperi karuperitsa nakapaali (Dzamada nanakjite upina nadana nanaku), jnetetsakja, dzamapuku jaikulima nadzawaka jnete veinticuatro waliperi jaiko karuperi pia paaketa Colombia liko. Pada kaakunadali linakjite jlieje nadejnikale, naaketakapuaka manupe nadzawaka jnaja awakadalima Isana jiwidansre, nawaa 108 jnete 162 nadzawaka jnaja jaiko (namakaneka ≥5 cm) jnete pakuraratanda awakada limakaiteka 40 x 40 m (1600 m²). Jlieje Isana uni jalekjai, isrokada manupe awakadalima pakapampe nerikuda jnaja uni itakjaipe (i.e. bosques de Caatinga Amazónica, extensas sabanas y arbustales esclerófilos sobre suelos de arena blanca). Kadzuni, lima jlieje lisroka manupe iñaupukjape inukape linakjite jlieje jidzapa najnenda escudo guayanés jnete naaketakawa iniali yapidza. Jlieje wadananda pandza linakuapana jlieje idejnikjeti wadzekatali inali jnete kuwiali Colombia kawani, likananta fa wasrokatsa wakanantakapjaka awakada inaku karukawatua naaka nesre. Metsa, wataitakaru wadzekatakani nasrotsa nadejnika napidzawaka jnaja gobierno idzarupe jnete jnaja yakajleperitsa liudza, nakanantaka matsiawa jnete namanupeta jnaja idejnikjeti awakadaliku naapidza jnaja naiki limínanai. Lirikuda tsakja jlieje nenwatsa wakaite kuame piaka jneraka jnenana jnaja Colombia jnete Brazil, kjalekawaka lidzena jnete awakadalima inakuapana, jnaja liminanai upiperi jnete pandzaperi, jnete kuame najnikarun jnewa nakapa kadzuliaja Noroeste Cuenca Amazónica liko.

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The lowland rainforests of the Amazon basin harbor the highest tree diversity in the world, not found in any other terrestrial ecosystem (Gentry, 1992; ter Steege et al., 2013, 2016; Dexter et al., 2017; Antonelli et al., 2018; Dick and Pennington, 2019). According to current research on its vegetation (mainly referring to rainforest), it is botanically poorly known (Hopkins, 2007; Schulman et al., 2007; Cardoso et al., 2017). Cardoso et al. (2017) assert that "the Amazon is renowned for holding an unprecedented, yet poorly known or unexplored plant diversity," a statement we would dispute. These authors also point out that many regions inside the basin remain unrepresented by even a single collection, perhaps implying that many species distributions are still inadequately known, not well understood, or both (ter Steege et al., 2011, 2016, 2019). We argue that several of the innermost areas of the basin (e.g., the Río Negro basin, Manaus, and, the Guayana Shield *sensu lato*) have been relatively well explored and studied; information about the explorations are summarized in Aymard et al. (2016a,b) and ter Steege et al. (2016).

Currently, it is well-understood that the turnover or replacement of terrestrial taxa across rivers are driven by biogeographic patterns in the Amazon basin and its major tributaries (Ribas et al., 2012; Pirani et al., 2019). This pattern was first pointed out by Wallace (1852), and it has since been documented for other terrestrial organisms at multiple geographic scales (Naka and Brumfield, 2018). However, in this immense basin, western Amazonia (the area between the Andes and the Amazon River) is so far the place with the highest plant diversity (Valencia et al., 2004; Tuomisto et al., 2016; Draper et al., 2019), perhaps due to its remarkable geographic history during the Cenozoic (e.g., formation of the Amazon River and the uplift of the northern Andes), events that profoundly influenced climate, speciation, and biotic interchange, generating the highest diversity of habitats (Hoorn et al., 2010, 2017; Antonelli et al., 2018). Nonetheless, the accurate connection of these events with biotic diversification often is doubtful (Baker et al., 2014).

Although Amazonian forests have been shown to be diverse, some tree species are consistently more abundant than would be expected from chance alone, a feature initially pointed out by Black et al. (1950), Ducke and Black (1953), and Pires et al. (1953), and later corroborated by ter Steege et al. (2013) and Zizka et al. (2018). An estimated 11,676 tree species, belonging to 1225 genera and 140 families, make up Amazonian forests (ter Steege et al., 2016). However, a recently revised assessment places the number of Amazonian tree species at 10,071 (ter Steege et al. 2019), with over half the stems belonging to just 227 species. These disproportionately common trees have been dubbed the "hyperdominants" (ter Steege et al., 2013). Rare species also contribute to this diversity (Wills et al., 2006), but their spatial distribution remains unsatisfactorily understood (Zizka et al., 2018).

The Colombian portion of the Cuyarí (or Cuiarí) and upper Isana Rivers represents a prime example of the situation described above—a region located in the upper Río Negro (Guianía) that had been a complete botanical blank. In addition, that area (e.g., Papunaua River) had an important role in the Amazon rubber boom of 1860–1930, as a result of constant human movement between the upper Río Negro and the middle Orinoco River (Rivera, 1924). The cruel treatment to which rubber tappers were subjected for six to eight months of the year was called the "Putumayo scandals" (García-Jordán, 2001). These frightful events symbolized a dark chapter of human history characterized by exceptional exploitation of and cruelty toward Amerindian populations (for a review, see Coomes and Barham, 1994; Kraus, 2018).

The present account reports the first botanical exploration of the Colombian portion of the Cuyarí o Cuiarí and upper Isana Rivers (Fig. 1). Interest in studying these basins has been motivated by a project that would protect more than 4,000,000 ha of diverse vegetation, thus improving the quality of life of communities that live in the watersheds of several rivers (i.e., Cuyarí, Guianía, and Isana) that are part of the upper Río Negro basin. With its strategic location and well-conserved habitats, this region, which had been isolated from researchers and thus completely unknown biologically, is a potentially important site for biological exploration.

Materials and Methods

We conducted a review of data from ca. 33,000 collection sites stored in digital biodiversity databases, and consulted bibliography sources available by April–May 2014. These tools allowed us to assemble data on the occurrence of species from various sources, such as herbaria and museums, as well as data from the literature. An updated database of botanical collections from the Isana (in Colombia) or Içana (in Brazil) River basins and surrounding areas in Brazil and Colombia was compiled from records in Tropicos (www.Tropicos.org), the speciesLink Network (http://www.splink.org.br), *Lista de espécies da Flora do Brasil* (http://inct.florabrasil.net/category/lista-de-especies-da-flora-do-brasil/), Jabot (http://www.jbrj.gov.br/jabot), and Global Biodiversity Information Facility (https://www.gbif.org/). We also reviewed the collections of herbaria at A, COAH, COL, GH, and NY (acronyms according to Thiers, 2012), and the most recent bibliographical analysis of Colombian Amazonian plants (Infante-Betancour and Rangel-Ch., 2018a,b). In order to indicate the route from the city of Inírida to the Colombian portion of the Cuiarí and the upper Isana Rivers, we marked all the points mentioned in our journey in a digital image of this region, which is available in the following link: https://drive.google.com/file/d/1VrvnOfMOY9R5bIk3TQEsVP1hQedecq-b/view

Footnotes continued

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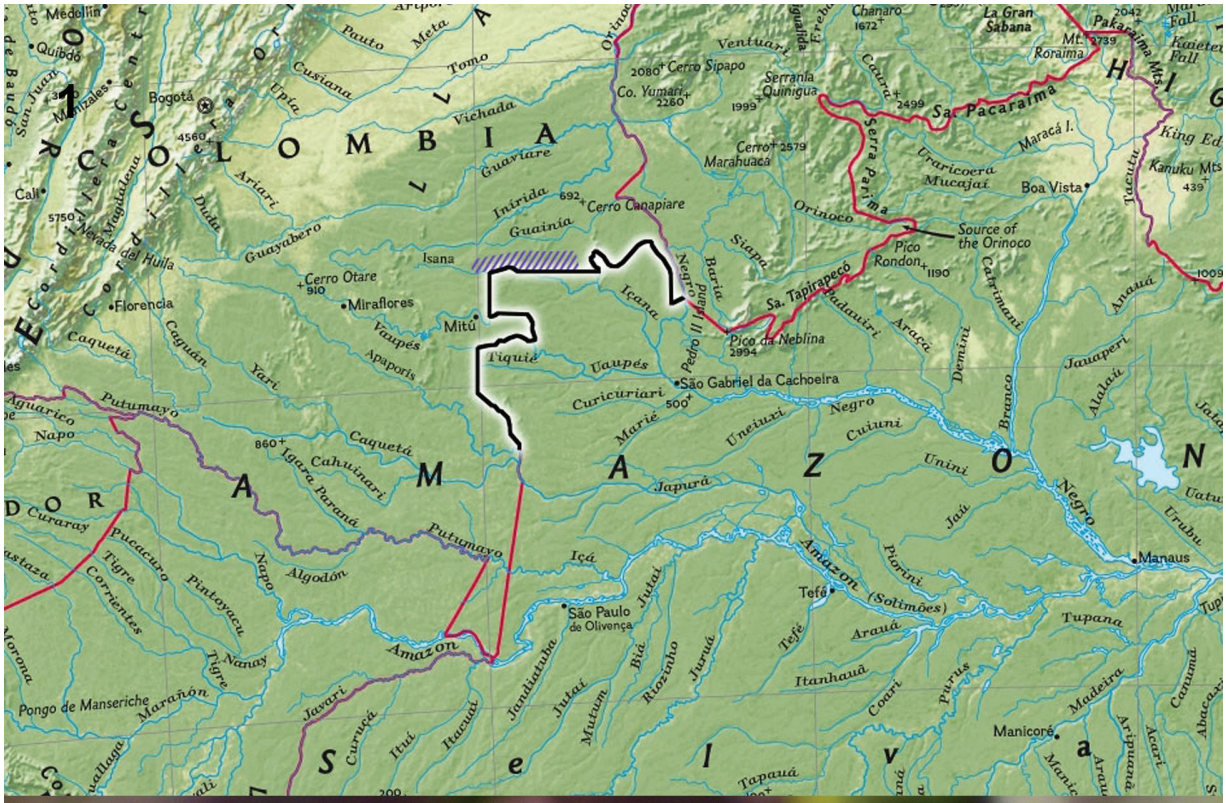


FIGURES 1–2. **1**. Map of Brazil and Colombia showing the border (double bold) according to the agreement known as the Treaty of Bogotá, or the treaty of Vázquez Cobo-Martins, signed in Bogotá in 1907. The area marked with diagonal lines represents the region of the first botanical exploration in the Colombian basins of the Cuiarí and Isana Rivers. Compiled by C. Méndez. **2**. Flower of *Asteranthos brasiliensis* Desf. (Lecythidaceae). Photograph courtesy of Hans ter Steege.

Results

The Río Negro Context: the Cuiarí and Isana River basins

The Cuiarí and Isana Rivers are found in the upper Río Negro basin, the largest black-water river in the world (Marengo et al., 2012). The latter has its headwaters in the sources of the Guianía River (Colombia), located in the northwestern corner of the Amazon basin, and it communicates with the Orinoco River basin through the Casiquiare Channel (Stokes et al., 2018). The basin of the Río Negro (the name that this river takes at the confluence of the Guianía River and the Casiquiare Channel) and its main tributaries (e.g., Río Branco and the Curicuriarí, Isana, Vaupés, and Xié Rivers) occupy a surface area of ca. 750,652 km^2 and have a combined length of ca. 1600 km. The Río Negro originates at the headwaters of the Guianía River and flows south in northwestern Brazil, turning eastward above the town of São Gabriel da Cachoeira. There the Río Negro is joined by the Içana River and then by the Vaupés, the latter flowing eastward from the confluence of the Itilla and Unilla Rivers, located south of Guayabero River, Colombia. The Río Negro continues flowing toward Manaus, where it meets the Solimões to form the main body of the Amazon River (Santos et al., 1984; Lleras, 1997; Epps and Stenzel, 2013). The name "Río Negro" (in Spanish; "Rio Negro" in Portuguese) means "black river," in reference to the dark waters of this river, due to their high tannin content, that create a stark contrast where they merge with the muddier waters (or "white waters") of the Solimões (Sioli, 1968; Leenheer and Santos, 1980). The sandy, acidic soils and low levels of nutrients in clear- and black-water river systems render them far less productive than the white-water systems found elsewhere in Amazonia (Ríos-Villamizar et al., 2014). However, the region sustains a complex system of vegetation, rivers, inhabitants, languages, and unique cultural practices (Márquez and Pérez, 1983; Kraus et al., 2018).

In general, this sector is characterized by elevations of 50–300 m, and has large surfaces of "terra firme" forests, flooded forests (Igapó and Varzéa), and sclerophyllous forests on oligotrophic soils known as "Caatinga Amazónica" or forested Campinarana, as well as shrublands (Banas, or low Campinas) and extensive and continuous white-sand savannas (Prance, 1989, 1996, 2001; Huber, 1995a,b; Lleras, 1997), the latter two of particular interest to those concerned with the conservation of the region's unique ecosystems and their natural resources.

As mentioned above, the Isana and Cuyari Rivers drain into the Río Negro basin; geographically, their basins are nested between the Xié (to the north) and the Vaupés (to the south) river basins. Politically, the upper portion of the Isana River is located in Colombia, the middle and lower portions in Brazil. The entire basin has a surface area of ca. 17,000 km^2 (of which ca. 60% is located in Brazil and 40% in Colombia), and the river is ca. 500 km long, extending across the Brazil-Colombia border up to its confluence with the right bank of the Río Negro, near São Gabriel da Cachoeira (Amazonas state, Brazil). The Cuiarí River has its headwaters on the east side of the "Serranía de Caranacoa" in Colombia. It has a surface area of ca. 4,000 km^2 (ca. 30% in Brazil and 70% in Colombia), and a length of ca. 200 km. The Cuiarí flows from Colombia to Brazil along the right side of the "Serranía de Naquén," until its confluence with the left bank of the Içana River, near Vista Alegre (Amazonas state, Brazil).

The Brazilian, Colombian, and Venezuelan Boundaries

The arrangement of the political borders of Brazil, Colombia, and Venezuela has always involved complex negotiations, because since the time of the arrival of explorers from the Iberian peninsula to the Amazon basin the frontiers between colonial territories of Portuguese and Spanish empires were not "sufficiently clear" (USDS, 1985). The Treaty of Madrid, signed in 1750, was a mechanism that expanded the territories of the Portuguese empire to reach almost the current area of Brazil (Ferreira-Reis, 1993): the extend this territory later was rectified in part by "La Comisión de límites del Orinoco" and other explorations that took place between 1754 and 1761 (Lucena Giraldo and de Pedro, 1992). The upper Rio Negro territory was thoroughly disputed, mainly by competing for hegemony over navigation between the Amazon and Orinoco basins through the Casiquiare Channel (Brito, 2014). This region was well known since the 17th century from maps elaborated by Jesuit missionaries (i.e., S. F. Gilij, M. de Tapia, and M. Román), and the Portuguese slavery networks (Donis-Ríos, 1989; Cabrera-Becerra, 2010). At the time they became independent, the Brazilian empire and new Republics (Colombia and Venezuela) inherited this situation (USDS, 1985), and frontier negotiations were complex because of two conflicting juridical principles. The Portuguese crown applied the principle of *uti possidetis facto*, which considers the position of their land through the factual exercise of sovereignty, whereas the Spanish crown utilized *uti possidetis jure*, by which they defended their rights to territory awarded to Spain and their colonies as long ago as the first European explorations in the New World (Ramírez, 2006). In 1826, more attempts were made to solve the border problems, which included the fact that Colombia's border with Brazil was also affected by the status of its disputes with Venezuela in the Río Negro district (García, 1942). In addition, Portugal claimed at this time that the precise location of New Granada Viceroyalty boundaries were uncertain (USDS, 1985). The latter was not true at all, because many maps published from 1798 to 1865 showed that the northwestern corner of the Amazon basin (the Rio Negro basin), and the middle Orinoco River belonged to the Viceroyalty of Nueva Granada, and the Captaincy General of Venezuela (see: http://babel.banrepcultural.org/cdm/singleitem/collection/p17054coll13/id/656/rec/32). An agreement was reached in 1907, known as the "Treaty of Bogotá" (or "El Tratado Vázquez Cobo-Martins"). However, this treaty considered only the northern section between the frontiers of Brazil and Colombia with Venezuela (USDS, 1985; López-Garcés, 2014). Therefore, through this instrument Colombia accepted as frontier a line ca. 300 km between the mouth of Apaporis River and "Uarirambá," a place where both banks

of the upper Isana River start to belong to Brazil. From this landmark, the line goes 184 km straits to the East to the headwater of Memachí River. From the latter point the line up and down 50 km to North and South to get the "Cerro El Mono" located in South of "Serranía de Naquén." Finally, the line goes ca. 120 km to East, and turn ca. 120 km to South to reach "Piedra de Cocuy" on the Rio Negro (Fig. 1). After this moment to the present time, the lower and middle Içana and the lower Cuiari River basins became part of Brazil territory. The Brazilians were able to take advantage of the situation perhaps because they were more familiar with key locations and the courses of many rivers proposed as dividing landmarks.

The Inhabitants

It is now well known that the region comprising the upper Río Negro and the Orinoco River was traveled and inhabited for several millenia by ancestral groups such as the Makú-Puinave, the Arawak, and the Tucano as well (Franky-Calvo, 2006; Zucchi, 2006). These migrations came from the Central Amazon region approximately 4500–4000 B.P. (Meggers, 1979, 1994), as a result of devastating droughts (van der Hammen, 2006; Olivares et al., 2015). Therefore, the present-day indigenous peoples of northwestern Amazonia form part of a complex, hierarchical, pluriethnic, and multilingual social system shared among Brazil, Colombia, and Venezuela, involving over 24 ethnic groups (Stenzel, 2017).

Traditionally, the inhabitants of the upper Isana and Cuiarí Rivers, the Guianía, and some parts of the upper Inírida are the Kuripacos; the Baniwa groups occupy the lower and middle Içana, Cuiarí, and Ayarí (or Aiari) Rivers as well (Journet, 1980–1981). Two nations that belong to the Arawak language family have also lived for centuries in this area (Cabrera-Becerra, 2010). The headwaters of the Isana River are considered sacred by these cultures, who believe that the center of the world ("umbilicus"), where all human races began, is found in the pristine region known as "raudal" Uaipui or Wapui, located in the Ayarí (Aiari) River, a tributary of the middle Içana River in Brazil (Romero, 1993). Because large peneplains and residual plains separate the rivers, these indigenous groups built a unique network of trails to connect the rivers, making travel by foot possible. These trails are known as Kuwe or Kuwai (the name of a powerful cultural hero among the Arawak of the northwestern Amazon), and as "varaderos," "varadeiros," or "trochas" (portages) by the "Yalanai nai" (non-indigenous people). This trail network was used to reach sacred places, and for political, religious, and migratory purposes. They also were part of a long-term strategy for resisting incursions into their ancestral territories and for surviving exploitation and deprivation resulting from the rubber boom (Vidal and Zucchi, 1996; Vidal, 2000).

One topic that is impossible to avoid when discussing the basin of the Isana or Içana River is the evangelization of the native population by Sophie Muller, an American Protestant missionary affiliated with the New Tribes Mission. This evangelical crusade started in 1948, when she came from the Guianía River, funded numerous churches, and promoted values and practices under the influence of several other Protestant missionaries (Wright, 1999; Capredon, 2018). In less than five years, she converted most of the Baniwa people who lived in the middle and lower Isana or Içana River basin to Protestantism (Pollock, 1993; Boyer, 2008). This evangelic proselytism generated dramatic cultural changes (e.g., she convinced the Baniwa people to no longer use tobacco, or drink "caxiri," a fermented drink made with cassaba). In addition, she stamped out their ancestral shamanism practices known as "pajelança," and the initiation and exchange ceremonies called "podáali" as well (Wright, 1999). For centuries, shamans in the overall Amazon basin have made use of hallucinogenic snuffs (e.g., *Virola* ssp., Myristicaceae; *Anadenanthera peregrina* (L.) Speg., Fabaceae), psychoactive plants (e.g., *Banisteriopsis caapi* (Spruce ex Griseb.) C.V. Morton, Malpighiaceae; *Psychotria viridis* Ruiz & Pav., Rubiaceae), rock pieces (e.g., quartz stones), animal parts (e.g., feathers, jaguar canines and other animal teeth, and snakes' heads) to enter the spirit world, and achieve a trance and transform themselves into diverse kinds of animals and spirit beings (Wright and Hill, 1992; Wright, 1998, 2013). Currently, we estimate that about 80% of the native population is willing to continue with the values and practices imposed by Protestant missionaries and they no longer are interested at all in shamanism practices. However, they still are motivated to preserve several aspects of their ancestral cultures such as the use of Curare, *Strychnos* spp., an arrow poison, as well as the use of other plants for food and medicine.

Exploration

The Río Negro basin was relatively well explored and studied by the earliest inhabitants of the region, who were able to classify vegetation types and its most important species before Europeans arrived (Abraão et al., 2008). The first Iberian journeys down the Amazon River, from the Andes to the Atlantic Ocean, were undertaken by Francisco de Orellana (1541–1542) and Pedro de Ursúa (1560–1561), the latter accompanied by, among others, the infamous Lope de Aguirre. Chronicles of these travels (written by Fray G. de Carvajal in the case of Orellana's saga, and by F. Vázquez, P. de Almesto, and others in the case of Ursúa's, in many versions in the literature, e.g., Mampel González and Escandell Tur, 1981; Pastor and Callau, 2011) spoke of large areas of forest along the Amazon River; numerous, well-populated native villages; and a large river with black water that came from "El Poniente," the Río Negro (Carvajal, 1848; Simón, 1861). Subsequently, many outstanding researchers collected plants and studied the vegetation of this amazing river. Charles de la Condamine, who navigated the river in 1743, wrote the first biological report (La Condamine, 1745); his expedition is considered the beginning of the great era of Amazonian travel by European scientists (ter Steege et al., 2016). He remarked on numerous plant products such as curare, the arrow poison, *Strychnos* spp. (Loganiaceae); the quinine tree, *Cinchona officinalis* L. (Rubiaceae); and the rubber tree, *Hevea* spp. (Euphorbiaceae) (La Condamine, 1745).

Alexandre Rodrigues Ferreira made the first known large collection of Amazonian plants during his voyage of 1783–1792 (Wurdack, 1971). He explored the Amazon River and its main tributaries, including the Río Negro, where his itinerary notably included the Içana River (Rodrigues-Ferreira, 2008). His group collected and drew numerous plants and animals during this trip. *Asteranthos brasiliensis* Desf. (Lecytidaceae), with showy yellow, fused petals, and an actinomorphic androecia, is perhaps one of the most extraordinary plants they documented (Mori et al. 2017; see Fig. 2).

As we report here, botanical explorations in the Colombian portion of the Cuiarí and Isana Rivers had been limited before our journey. The only reference that we found was a note about the presence of *Brownea grandiceps* Jacq. in the upper Içana and Papunaua Rivers (Ducke, 1939, 1949). This record, nonetheless, is vague, since no specimen was cited: vouchers are crucial in authenticating the taxonomy of an organism, as a tool for identifying its procedence and distribution, and for additional taxonomic, genetic, ecological, and/or environmental research (Culley, 2013). In fact, Ducke based this information on "reliable informants" ("segundo informantes fidedignos"; see Ducke, 1939: 66, 1949: 95–96), and he never was in the Içana River basin (see Egler, 1963, and our database). Ducke did collect this species in São Gabriel da Cachoeira (*Ducke 23735*, US) in 1932, then a village (currently a city) located downstream of the confluence of the Içana River with the Rio Negro.

The present-day Amazonian Colombian territory was firstly botanical explored by C. F. P. von Martius, in "Montis Arara-Coara" (Araracuara), Caquetá River (Japurà or Yapurà in Brazil) in January–February 1820 (Martius, 1847). Remarkable of this trip were the collections of *Schoenocephalium arthrophyllum* Seub. (currently, *Monotrema arthrophyllum* (Seub.) Maguire) and *S. martianum* Seub. (Rapateaceae), the latter so far an endemic species of the Amazonian Colombian region (Berry, 2016). Almost a century later, the most legendary individual in the Amazon basin, the botanist and entomologist W. A. Ducke (Archer, 1962; dos Santos, 2016) collected near "La Pedrera," Caquetá River, in 1912 (Ducke, 1915; Dugand, 1948). The upper Río Negro River was explored by the famous naturalists F. H. A. von Humboldt and A. J. A. Bonpland (in 1800), A. R. Wallace (in 1851), and R. Spruce (in 1849–1854), at a time when biologists were preoccupied with a fascination for nature, and before modern scientific investigations of ecology and evolutionary biology (Ricklefs, 2012). Also, the explorers H. A. Rice and P. P. Bauer in 1912–1913 traveled in this region (Rice, 1914), and the middle and lower Içana were surveyed by T. Koch-Grünberg (with O. Schmidt) in 1903 (Kraus, 2004), and by C. Nimuendajú in 1927 (Nimuendajú, 1950).

After the Treaty of Bogotá between Colombia and Brazil was signed in 1907, the Brazilian government started a program of exploration inside the Río Negro basin in 1928–1929, under the charge of Marshall Boaberges Lopes de Sousa. The botanist on this expedition, F. von Luetzelburg (Lopes de Sousa, 1959), made significant annotations about the Içana's types of vegetation, observing the "Caatingas Amazon forests" in the lower part of the basin and terra firme forests mixed with Piaçava palm communities (*Leopoldinia piassaba* Mart.) in the middle (Lopes de Sousa, 1955). Later, R. de Lemos Fróes traveled for nine years (1941–1952) from the Içana River's mouth to the Cerro Tunuhí(y); about this time other explorers also were in this basin, among them B. A. Krukoff in 1942 and J. T. Baldwin, Jr., in 1944. Exploration of this river continued with the work of R. E. Schultes with J. Murça Pires, G. A. Black, and F. López in 1947, 1948, and 1952. On the 1947 trip, they reached the Serra de Tunuhí (Tunuí or Tunuhy; 1.4704187 N -68.1522703 W), a place that Schultes recorded as the Içana's headwaters (Davis, 1996), although they were still ca. 300 km away.

Alvaro Fernández-Pérez, a Colombian botanist, arrived in February 1953 at the Papunaua River (a tributary of the upper Inirida River), a river connected to the upper Isana by a 25 km long ancestral trail over a land isthmus (Bauer, 1919). This area was referred to in the famous novel *La Vorágine* as a place used as an indigenous refuge from the rubber barons (Rivera, 1924). Another noteworthy figure is M. U. Mee, the famous British botanical artist, who traveled to this river in 1965 and collected *Neoregelia margaretae* L.B. Sm. (Bromeliaceae), a species previously thought to be endemic to Brazil but recently found near the Vaupés River in Colombia (J. Aguirre-Santoro, pers. comm. 2019). However, the most significant botanical explorer of the Brazilian portion of the Içana River was the tireless Ricardo de Lemos Fróes (Brazil, Maranhão, 1891–1960). He participated in expeditions to the Amazon basin conducted by B. A. Krukoff between 1923 and 1950 (Landrum, 1986). However, he felt a special connection to the Içana River, making significant botanical collections in this area from 1941 to 1952. As a result, he collected several new species (e.g., *Anaxagorea angustifolia* Timm., Annonaceae; *Dichapetalum froesii* Pires, Dichapetalaceae; *Swartzia froesii* Cowan, *Clitoria tunuhiensis* Fantz, and *Dicymbe froesii* Ducke, Fabaceae). The two latter taxa, hitherto known only by his original collections from "Serra de Tunuhy" in November 1945 and May 1947, respectively. Since these earlier explorations, numerous botanists, anthropologists, and ecologists (the majority from Brazil) have visited the Brazilian portion of the Içana River to study the flora, vegetation, ethnography, and inhabitants (Aikhenvald, 1999; Ramírez, 2001; Abraão et al. 2008, 2009; Stropp et al., 2011; Epps and Stenzel, 2013; Iubel, 2015; Moraes-F. et al. 2019).

The Journey

The trip started on 10 April 2014, in Villavicencio city (Meta department), where we took a plane to Puerto Inírida (currently Inírida), the capital of the Colombian department of Guainía. As the airplane circled before landing in Inírida, we could see the amazing forest, swampy areas with palms, the low vegetation of scrubby vegetation, white-sand savannas, and the riverine forest along the Atabapo, Inírida, and Guaviare Rivers. Puerto Inírida was founded in 1963 in a place called Obando. Today it is a very active small city

and can be reached by air from Bogotá and Villavicencio and by small-to-medium boats (called "bongos") from the upper Guaviare River, or from the confluence of the Atabapo, Guaviare, and Orinoco Rivers in Venezuela.

For the next five days we stayed in Inírida and made final arrangements for supplies, food, and personnel. On 15 April, we hired two "bongos" to take us to Huesito, a point located on the lower Inírida River, where we transferred our gear to two agricultural tractors with wagons; we then drove 170 km from Huesito to Puerto Caribe (Fig. 3) to reach the Guianía River through "Caño" Guamirza. The landscape in this area consists of an array of sclerophyllous forests ("Caatinga Amazónica") and swampy, white-sand shrubby communities, mixed with extensive and continuous areas of savanna dominated by "flor de Inírida" (*Guacamaya superba* Maguire; Rapateaceae) and numerous species of Cyperaceae, Eriocaulaceae , Rapateaceae, and Xyridaceae as well. In the showy inflorescences of "flor de Inírida" (Fig. 4), flowers open briefly to expose the tips of the petals; they are visited by hummingbirds seeking the nectar produced near the base of the petals. The inflorescences of this species are collected locally in Venezuela and Colombia, either fresh or dry (Berry, 2004), to make floral arrangements. These trips were made at night because of the high temperatures during the day: we departed from Huesito at 7 pm and it took all night because the speed was limited to ca. 20 km per hour and because one of the tractors had trouble with its tires. At midnight we arrived at Pato (after traveling 70 km), located on the middle Guasacavi River. It is a beautiful black-water river, whose confluence with Caño Temi and the Atacavi River forms the Atabapo River. The 12-hour trip was difficult because of the constant bouncing of the wagons, which made sleep impossible. However, we finally arrived at 6 am at Caño Guamirza (Fig. 5), a small black-water stream that has its headwaters in Colombia and then crosses into Venezuela, where it joins the Guianía River near Tonina. We took two bongos and navigated the Guamirza for ca. six hours until we reached Tonina. The vegetation of this small river consists of periodically flooded forests on black water called "Igapó" dominated by *Licania lanceolata* Prance (Chrisobalanaceae), *Aldina latifolia* Spruce ex Benth., *Macrosamanea pubiramea* (Steud.) Bar. & Grimes, and *Macrolobium angustifolium* (Benth.) R.S. Cowan (Fabaceae). Also, the river-banks and forest understories are mixed with a herbaceous matrix of dense colonies of *Thurnia polycephala* Schnee (Thurniaceae), *Spathanthus bicolor* Ducke (Rapateaceae), *Steyermarkochloa angustifolia* (Spreng.) Judz.(Poaceae), and *Lagenocarpus* spp. (Cyperaceae). In Tonina we drew up guidelines to set up our first plot in a place named Puerto Caribe on April 17, in a tall terra firme forest on a hill with clay soils. This community was dominated by *Monopteryx uaucu* Spruce ex Benth. (Fabaceae), a species locally known as "Awiñaa" (Kuripako).

The next day, we took a 12-hour trip up the Guiania River to San José del Guianía, which included navigating the rapids of Guarivén, Venado, Oso, and Sapo (Fig. 6). We stayed in San José del Guianía for two days, making preparations for the trip to the upper Guianía River (Fig. 7) and to explore the black-water river called "Caño" Naquén (Fig. 8). On 21 April, we reached Caño Naquén and made a one-day trip to the entrance of the "varador" (portage) of Naquén, an ancestral trail ca. 28 km long that links Caño Naquén with the Cuiarí River. We slept there, and at sunrise the next day the team and six Kuripacos (who carried an astonishing load of hundreds of kilograms of equipment and food) started walking on the trail. It took the team 12 hours to arrive, completely exhausted, at our destination, near the abandoned town of Miraflores, overlooking the Cuiarí River (Fig. 9). Along the way, we were able to classify more than 14 different types of vegetation; particularly noteworthy was a forest dominated by *Parkia panurensis* Benth. *ex* H.C. Hopkins (Fabaceae). We stayed in Miraflores for four days, waiting for the helpers to arrive with the rest of the equipment, gasoline, and food. While there, we set up a second plot on 25 April in a medium terra firme forest dominated by *Micrandra spruceana* (Baill.) R.E. Schult. (Euphorbiaceae) on a hill with sandy soils. In this forest, we documented a tree of *Peridiscus lucidus* Benth. (Peridiscaceae), the first report of Periscaceae in the vascular flora of Colombia (Aymard and Arellano, 2018). During the fieldwork on this plot, a large, the dangerous ant "Veinticuatro" or "Yanábe" (in Colombia and Venezuela; in English "bullet ant"; *Paraponera clavata* Fabricius, Formicidae) stung Adela Lozano's finger. This caused concern because "Veinticuatro" refers to the 24 hours of pain that follow the sting. Nonetheless, Orlando Cordubi, our local consultant, found nearby a species of a liana of the genus *Peritassa* (Celastraceae), made a string with the bark, and tied it around Adela's finger. Luckily the pain went down and she was able to continue working in the field. On 26 April we left Miraflores and continued up the Cuiarí River. The "bongos" use small engines called "rabetas" or "pequepeques," which are designed in Brazil and use a technology that reduces fuel consumption up to 30% as compared with conventional outboard engines. We reached the town of Sejal, where we stayed for three days. Then we passed through the towns of Barranquilla, Cucurital, and Amanadona, reaching the rapids and waterfall of Yuruparí on 30 April (Fig. 10). This part of the Cuiarí River is not navigable, so we walked a short "varador" of ca. 8 km to get above the falls (Fig. 11). Another group of Kuripacos was waiting for us there and helped us to get to the town of Campo Alegre. We stayed there for a week doing fieldwork; in "Caño" Guaviarito we collected a second arborescent species of *Ampelozizyphus* (*A. kuripacorum* Aymard & Castro-L. Rhamnaceae; see Fig. 12). Until the early 21st century, the genus was characterized by a lianoid habit (Aymard and Castro-Lima, 2015). Later, we explored the base of the "Serranía de Caranacoa" (Fig. 13) and found *Rhabdodendron amazonicum* (Spruce ex Benth) Huber (Rhabdodendronaceae; Fig. 14); this collection represented the first record of this family in the vascular flora of Colombia and the upper Río Negro basin (Aymard et al., 2016). This new locality extends considerably the northwesterly distribution of this taxon inside the Amazon

FIGURES 3–4. **3**. Road from Huesito to Puerto Caribe, on our way to the Guianía river via Caño Guamirza. Photograph by Adela Lozano. ©Ciprogress Greenlife. **4**. Inflorescence of *Guacamaya superba* Maguire (Rapateaceae). Photograph ©Ciprogress Greenlife.

FIGURES 5–6. **5**. Caño Guamirza, a small black-water stream that has its headwaters in Colombia and then flows into Venezuela, where it flows into the Guianía River, near Tonina. Photograph by Adela Lozano. © Ciprogress Greenlife. **6**. Oso rapids in the Guianía River. Photograph by Adela Lozano. © Ciprogress Greenlife.

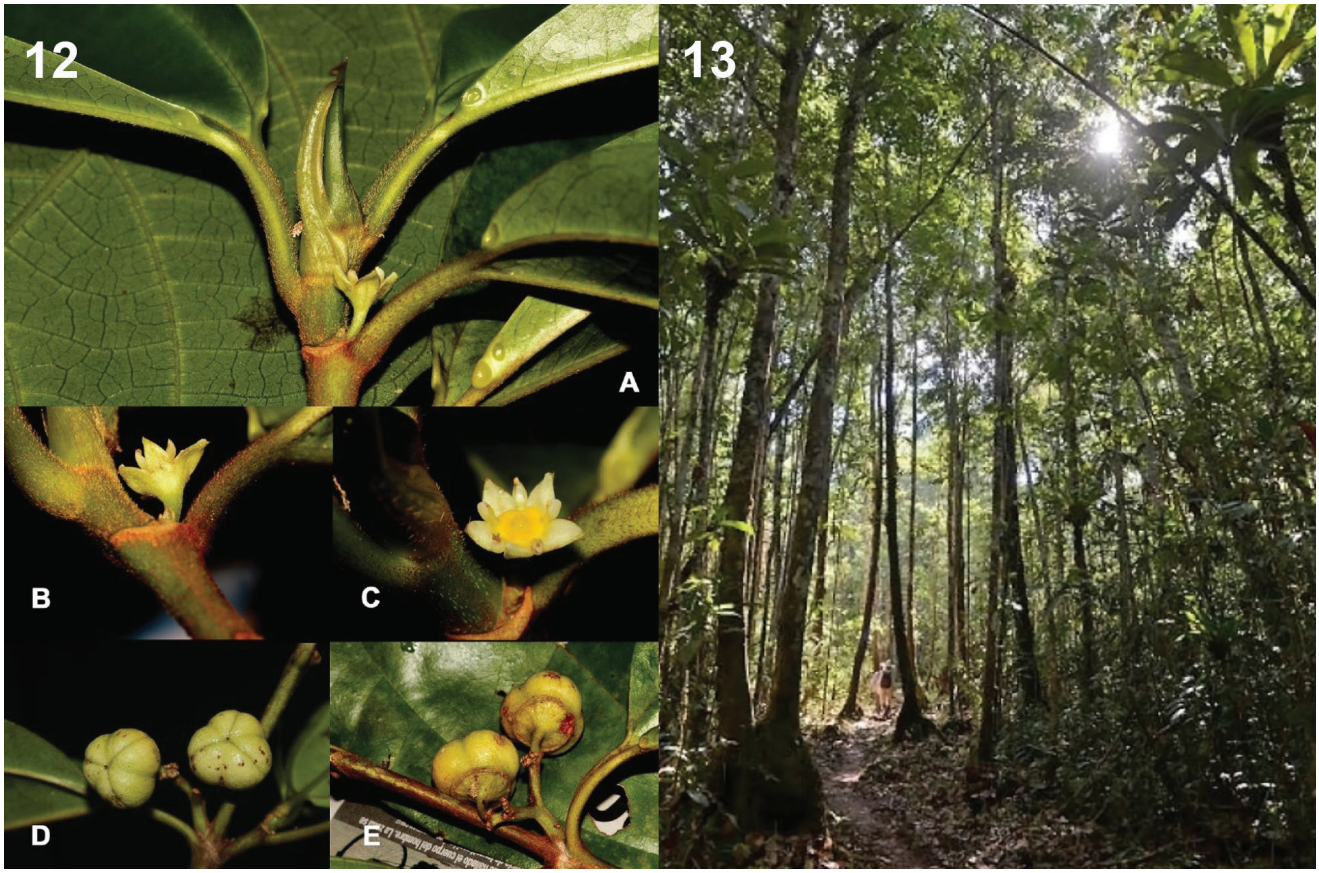
FIGURES 7–8. **7**. Guianía River, near the town of San José del Guianía. Photograph by Adela Lozano. ©Ciprogress Greenlife. **8**. Confluence of the Caño Naquén with the Guianía River. Photograph by María C. Montilla. ©Ciprogress Greenlife.

FIGURE 9. Upper Cuiarí River. Photograph by Jorge L. Contreras. © Ciprogress Greenlife.

FIGURES 10–11. **10**. Yuruparí rapids in the Cuiarí River. Photograph by Freddy Gómez. ©Ciprogress Greenlife. **11**. End portion of the "Varador (portage) de Raudal Yuruparí" at the Cuiarí River. Photograph by Freddy Gómez. ©Ciprogress Greenlife.

basin. The habitat of *R. amazonicum* is a tall Amazonian caatinga forest with a closed canopy, which lets little light filter to the understory. At this site, the primary dominant species were *Hevea rigidifolia* (Spruce ex Benth.) M. Arg. (Euphorbiaceae), *Mezilaurus caatingae* van der Werff (Lauraceae), *Caraipa longipedicellata* Steyerm. (Calophyllaceae), and *Micropholis maguirei* Aubrév. (Sapotaceae).

At Campo Alegre on 8 May, the team was divided in two groups, one going directly to Camanaos-Punta de Tigre, towns on the upper Isana River (Fig. 15). The other group continued up the Cuiarí River and passed through the towns of Berrocal de Cuiarí and Sabanita-Caño Yarí to reach the entrance of the "varador" of Puerto Canada (Fig. 16). They walked this trail for ca. 12 hours to arrive at Venado, located on the Colombian left bank of the Isana River. Across the river from Venado are the Brazilian towns of Uarirambá and Bethel; one km along both banks of the Isana River belongs to Brazil. The trip continued one more day up the Isana River until we reached Camanaos–Punta de Tigre. There we stayed a week, studying the surrounding forests and setting up three plots. We found that the terra firme forests of the upper Isana are richer in species: in a single plot 40 × 40 m (1600 m^2) we measured and identified 152 species. We continued exploring the upper Isana River and collected several new records for the Flora of Colombia. However, the most remarkable finding was a new species of the genus *Rapatea* (*R. isanae* Aymard & Arellano-P. - Rapateaceae), which is only the second species with white petals in a genus that otherwise has only yellow petals (Fig. 17; Aymard and Arellano-P., 2016). On 18 May, one group flew to Mitú, and the noteworthy aspect of this part of the trip was that A. Calero Cayopare's team returned to Inírida following the same route used to reach Punta de Tigre 33 days earlier.



Figures 12–13. **12**. *Ampelozizyphus kuripacorum* Aymard & Castro-Lima (Rhamnaceae). **A**, apex of a vegetative shoot, showing domatia on the lower surface of several leaves and a flower; notice the indument on leaf sheaths and petioles; **B**, side view of flower; **C**, flower viewed from above; **D–E**, two views of the fruits. Photographs by Francisco Castro-Lima. © Ciprogress Greenlife. **13**. Portion of Varador (portage) Campo Alegre to Serranía Caranacoa at the Cuiarí River. Photograph by Freddy Gómez. ©Ciprogress Greenlife.

Final Remarks

Here, we describe and illustrate a journey of ca. 500 km from Inírida to the Colombian basins of the Cuiarí and Isana Rivers, the first botanical exploration of this particular portion of the Colombian Amazon, in the innermost corner of the northwestern Amazon basin (the upper Río Negro basin). This was one of the last regions of the planet botanically unexplored, in the particular case of the Rio Negro, aside from the collections in the lower basin, some 234 years ago, by Alexandre Rodrigues Ferreira and his group. Since then, thousands of new plant collections have

FIGURES 14–15. **14**. *Rhabdodendron amazonicum* (Spruce ex Benth.) Huber (Rhabdodendraceae). Close-up of the immature fruits. Photograph by Francisco Castro-Lima. ©Ciprogress Greenlife. **15**. View of the upper Isana River near the town of Punta de Tigre. Photograph by Freddy Gómez. ©Ciprogress Greenlife.

FIGURES 16–17. **16**. Entrance of the Varador (portage) of Puerto Canadá at the Cuiarí River. Photograph by Jorge L. Contreras. ©Ciprogress Greenlife. **17**. *Rapatea isanae* Aymard & Arellano-P. (Rapateaceae). Close-up of the inflorescences showing the petals. Photograph by Gerardo A. Aymard C. ©Ciprogress Greenlife.

been gathered, and currently we have a good understanding of the structure and floristic composition of the upper Río Negro (Dezzeo et al., 2000; Clark et al., 2000; Córdoba and Etter, 2001; Boubli, 2002; Aymard et al., 2009; Medina and Cuevas, 2011; Stropp et al., 2011; Pombo de Souza, 2012; Cárdenas-López et al., 2014).

In our case, we collected 1301 botanical numbers and identified 726 species, which yielded 8 new species (2 already published), 2 families, and 24 species new to the Flora of Colombia. Perhaps one of the most important features of this project was that it showed the value of fieldwork conducted through alliances between private initiatives and the Kuripaco nation.

Another noteworthy feature of this region is that it has a unique drainage system created by several black-water rivers flowing east into the upper Río Negro in Brazil. These rivers are separated by large peneplains and residual plains (sometimes interrupted by "Serranías" and numerous granitic outcrops), occupied by a unique array of plant communities. The Isana is a white-water river that has particular features in its physical and biological environments: it has its headwaters on hills with clay soils, dominated by tall terra firme forests located between the Papunaua and Querarí Rivers. After the waters of the Caño Suruí (Koliriarí) enter the river, the Isana flows for ca. 120 km, defining the border between Colombia and Brazil and then entering Brazilian territory near the town of Uarirambá-Bethel. In Camanaos, the tall terra firme forests of the headwaters region change to a medium forest mixed with palm communities; in the vicinity of the Wapuí waterfall and the Santaré and Venado rapids, the vegetation becomes a mosaic of Amazon Caatinga forests, Piaçava palm communities (*Leopoldinia piassaba* Mart., Arecaceae), and lower forests, savannas, and shrubby vegetation, over large areas of white-sand (podzols soils). These abrupt changes are due to the influence of the several black-water rivers, whose headwaters drain from Precambrian Guiana shield outcrops.

The terra firme forests located in the upper Isana region are plant communities with high species diversity. We measured between 108 and 162 spp., in three plots of 40 × 40 m (1600 m^2), with diameters ≥ 5 cm. In comparison, western Amazonia is so far the place with the highest plant diversity (Valencia et al., 2004; Draper et al., 2019). Valencia et al. (2004) reported between 473 and 644 ssp. (with diameters ≥1 cm) in 1 ha (10,000 m^2) in a plot located in Cuyabeno, Ecuador; Gentry (1988) measured more than 300 spp. in Iquitos in 1-ha plots (Perú).

The upper Río Negro region is reportedly not a region rich in plant species (Dezzeo et al., 2000; Boubli, 2002; Aymard et al., 2009). However, the higher diversity we found in this area could be attributed to the combination of white-water river (waters with sediments) vegetation (a feature of the upper Isana River) with larger areas covered by the vegetation typical of the black-water rivers.

This report of the first botanical exploration of the Colombian portion of the Cuiarí and Isana Rivers is yet another example demonstrating the need for continued floristic studies in regions where there are large geographic gaps in the knowledge of Amazonian flora, so that there can be adequate planning for conservation and sustainable use of regional biota. Advances in the documentation of the upper Río Negro flora will be achieved only through institutional and private partnerships, improvements in training, and continued fieldwork—mounting new expeditions with many researchers working in collaboration with the local people.

Finally, the Río Negro basin has outstanding global conservation significance due to its extraordinary biodiversity and the potential for long-term conservation, due to its large size and still-pristine nature, and the probability of its maintaining wet rainforest conditions while anticipated climate change–induced drought intensifies in the Western Amazon. Nonetheless, mining for precious and other minerals, selective logging, fires, and new road developments will continue to threaten its yet-to-be-determined conservation status.

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