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Hidden treasures in the Amazon region of Colombia, Ecuador and Peru: Diversity and uses (Poaceae: Bambusoideae)

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Abstract

Bamboos, both woody and herbaceous, occur in the humid lowland forest of the Amazon. The woody bamboos are not rich in diversity in this region, but herbaceous bamboos occupy the understory of these tropical forests, include endemic herbaceous genera and are more diverse at the species level that woody bamboos. During the years 2019 and 2020, the study of the diversity of native and exotic bamboos in the Amazon region of Colombia, Ecuador and Peru was done with the support of the Bambuzonia project, financed by the International Fund for Agricultural Development (IFAD) and the International Bamboo and Rattan Organization (INBAR). The bamboo diversity reported in this study area was 28 native and 13 exotic species, which are grouped into three tribes, Bambuseae, Arundinarieae and Olyreae. Its subtribes, genera and species are described for each tribe, and those with the greatest applicability and potential use are indicated. The taxonomic identification of the species was determined with a record of herbaria specimens and botanical exploration, and for the issue of applicability, a survey was designed for property owners or inhabitants of the area, with the aim of knowing local uses, names common, associated flora and fauna, information that was complemented with literature and herbarium data. Given the high rate of deforestation that this region is experiencing, its inhabitants begin to think of bamboo as an economical alternative, for daily use and with a quick return. This research project contributed to the knowledge of the diversity of the Bambusoideae subfamily in the Amazon region of Colombia, Ecuador and Peru, to set guidelines for its current and potential uses, and to sensitize the population involved (local authorities, farmers, ranchers, businesspersons, technological development centers, and universities) above this fast and versatile grass.

Keywords Bamboo; Biodiversity; Applicability; Sustainability

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1. Introduction

Diversity of the native and exotic Bambusoideae subfamily in the area of influence of the Bambuzonia project is represented by three tribes: Bambuseae, Arundinarieae and Olyreae. The Bambuseae tribes includes two clades: 1) the Neotropical clade made up by the Arthrostylidiinae, Chusqueinae and Guaduinae subtribes, and 2) the Paleotropical clade represented by the Bambusinae and Melocanninae subtribes; the Arundinarieae subtribe is only represented by the genus *Phyllostachys*; and the Olyreae tribe includes species from the Parianinae and Olyrinae subtribes.

This project, known as Bambuzonia, was carried out in Colombia, specifically in the departments of Caquetá and Meta; in Ecuador, in the provinces of Napo, Pastaza and Morona Santiago; and in Peru, in the departments of Junín, Pasco y San Martín, greatly contributing to the fight against the deforestation of the Amazon by providing alternatives to illegal crops and to reduce poverty by promoting knowledge on bamboo, its conservation, farming and transformation.

Altitudinally wise, bamboos in the area of influence of the Bambuzonia project are distributed from 230 m asl (Caquetá, Municipio Cartagena del Chairá) up to 1611 m asl (Napo, Cantón Chaco), range that is occupied by different types of ecosystems such as tropical rainforests, low montane rainforest, and disturbed or secondary forests, among others. Latitudinally wise, theses bamboo species are distributed from 1º45.8´ N (Caquetá, Colombia) to 11º39´ S (Satipo, Peru), and from 74º54.7´ W (Caquetá) to 78º0.9´ W (Morona-Santiago, Ecuador).

It is well known that the Amazon region is one of the world's richest regions in biodiversity, particularly in the diversity of Bambusoideae. However, the use, farming and transformation of these species are very limited. In the area of study of the project we observed from large patches of *Guadua* to small patches of woody and herbaceous bamboos under low scale farming mainly for landscape or domestic uses.

The contribution of the INBAR-FIDA project to this region was very enriching in every field of action, and the provincial and local governments of each country are expected to continue to integrally promote the economic, environmental, social and cultural development of bamboo in these Amazonian territories.

2. Materials and Methods

2.1. Area of study

The research took place on the area of action of the Bambuzonia project, which encompasses three countries: Colombia, Ecuador and Peru.

In Colombia the fieldwork was done between the 1-17 of October, 2020, in the departments of Caquetá and Meta. In Caquetá the samples were collected in the municipalities of Florencia, Albania, San José de Fragua y Cartagena del Chairá, in a latitudinal range from 1º16´ N to 1º46´ N and from 74º55´ W to 76º00´ W, and between 225 m asl to 750 m asl. In the department of Meta, field work only took place in the municipality of La Macarena, located to 2°11′ N and 73°47′ W, in an altitudinal range of 225 y 275 m asl.

In Ecuador the field work was done between the 8-20 of November, 2020, in the provinces of Napo (cantons of Tena, Archidona and Chaco), Pastaza (cantons of Pastaza, Santa Clara and Mera), and Morona-Santiago (cantons Morona, Tiwinza and San Pedro), from 0°21′ S to 2°59′ S, and from 77°21′ W to 78°09′ W, in an altitudinal range of 246 to 1611 m asl.

In Peru the first phase of the project took place on December 2-14, 2020, in the Departments of Junín (provinces of Satipo and Chachamayo) and in the Department of Pasco (province of Oxapampa), from 10°36´ S to 11°39´ S, and from 74°37´ W to 75°18´ W, in an altitudinal range of 580 m asl to 1887 m asl; the second phase was done on December 15-20, 2020, in the Department of San Martín, in the provinces of Moyobamba and Rioja, from 5°40´ S to 5°50´ S, and from 77°00´ to 77°26 W, and in an altitudinal range of 814 to 864 m asl.

The watersheds where the fieldwork took place were the ones corresponding to the Guayabero (La Macarena, Meta, COL), Bodoquero, Fragua and Luna (Caquetá, COL), Nuchiño (Napo, EC), Santiago (Tiwinza, EC), Negro, Venado and Chachamayo (Junín, PE), Bocaz (Pasco, PE), and Mayo and Indoche rivers (San Martín, PE).

2.2. Data Bases

Information was previously collected in the national herbariums of COL, TULV, SINCHI, HUAZ, ECUAMZ, QCNE, QCA AMAZ, MOL, QCNE, QCA, HUT, MHN, HOXA, and in the international herbariums of US, MO, NY, AAU, ISC, K, y F.

The botanical samples were collected during the field trips coordinated with the Bambuzonia team from each country, with the support and accompanied by the staff of the project in Colombia, Ecuador and Peru.

The herbarium species collected in Colombia were deposited in the HUAZ herbarium in the Universidad de la Amazonía in Florencia, Caquetá; the ones of Ecuador from the ECUAMZ herbarium of the Universidad Estatal Amazónica located in Puyo, Pastaza, and the ones of Peru were deposited in the MHN herbarium of the Universidad Nacional Mayor of San Marcos in Lima.

A survey was designed addressed to the landowners or dwellers of the area to get to know the local uses, common names, and the associated flora and fauna. This information was complemented with bibliographic data and with data from the herbariums.

3. Taxonomic Treatment

A total of 28 native species and 13 exotic species were inventoried during the identification of the bamboo's diversity in the Amazon zone, where the project FIDA-INBAR "*Innovación y promoción del bambú a través de procesos participativos de investigación-acción para la agricultura resiliente en Colombia, Ecuador y Perú*" (Innovation and promotion of bamboo through research-action participative process for resilient agriculture in Colombia, Ecuador and Peru") operated during 2019-2023.

The 41 species identified in this study are grouped into three tribes: Bambuseae, Arundinarieae and Olyreae. The subtribes, genus and species with higher applicability were described for each tribe.

3.1. Bambusae Tribe

Woody bamboo plants, rhizome pachymorph except in *Chusquea* sect. *Chusquea*, acropetal or bidirectional development of the branches. Foliage with external ligule over the leaf sheath. Laterally compressed spikelets, disarticulated under the glumes. Complex central nerve. 2n = (20) 40, (44), 46, 48, 70, 72. Includes approximately 65 genus and 790 species (Clark et al. 2015)

This tribe includes all the woody bamboos of the tropical countries. Its position as a monophyletic group is strongly supported, however, the molecular studies based on the sequences of the plastids and the nuclear genome consistently show two well defined clades that are geographically correlated: the Neotropical clade and the Paleotropical clade (Kellogg 2015).

Members of both clades were found in the area of study of the Bambuzonia project. The culms of the species of that tribe, native and exotic, reach their total height protected by the culm leaves and without producing lateral branches. Afterwards they begin the lignification process of the culm and the development of the branches that can be acropetal, which consists in the emission of branches form the base towards the apex or bidirectional, that is, the development of the branches of the mid part of the culm towards the base or towards the apex (Bamboo Phylogeny Group 2012; Kellogg 2015; Ruiz-Sánchez et al. 2021).

3.2. Neotropical Clade

The Neotropical woody bamboos (Figure 1) are a well-supported subclade within the Bambuseae tribe, with three subtribes: Arthrostylidiinae, Chusqueinae, and Guaduinae (Clark et al. 2015). They include approximately 468 species in 25 genera, and are geographically distributed from Mexico (28º), and the Caribbean Islands to Argentina and Chile (47º S), within an altitudinal range that goes from sea level to 4300 m asl (Judziewicz et al. 1999; BPG 2012; Clark et al. 2015; Ruiz-Sánchez et al. 2021).

3.2.1. Arthrostylidiinae Subtribe

Description: bamboos with a short or slightly elongated rhizome neck, internodes are generally hollow, all are subequal or on occasions very short internodes alternate with long internodes. The aerial branching is derived from a simple bud; branches with thorns absent. Culm leaf with sheaths usually bearing fimbriae or fimbriate auricles; oral setae are absent. Foliage leaf blade has a simple central vein that is pronounced on the abaxial side and have a different green colored band that extends along the entire margin. It usually presents an intercostal sclerenchyma band. Synflorescense usually without bracts, indetermined (pseudospikelets) or determined (spikelets), paniculated or racemose. The spikelet consists of 2-3 glumes, from one up to many fertile florets, and a rhachilla extension bearing a rudimentary floret; and a palea without winged keels. Usually 3 stamens, but there could be 2 or 6. The ovary is glabrous, with a short style; 2 stigmas, sometimes 3. Caryopsis basic, uncommonly baccate (Alvimia) or nucoid (Actinocladum, Merostachys) (Tyrrel et al. 2012; Clark et al. 2015;).

This is the most morphologically diverse subtribe among the woody Neotropical bamboos; it includes 16 genera and approximately 200 species (Ruiz-Sánchez et al. 2021), representing 64% of the genus and 40% of the species diversity of the Neotropics.

Species registered: in the area of study of the Bambuzonia project three species were reported belonging to three genera: *Aulonemia*, *Merostachys* and *Rhipidocladum* (Table 1).

Table 1. Species of the subtribe Arthrostylidiinae collected in the area of the study.

Genus	Colombia	Ecuador	Peru
Aulonemia david-smithii Judz. & Wass			X
Merostachys sp.			X
Rhipidocladum racemiflorum (Steud.) McClure	X	X	X

Aulonemia and Merostachys registered in Peru were found outside of what is denominated the Amazon region, they were collected in the Province of Oxapampa, above 1500 MASL. *Rhipidocladum racemiflorum* was mainly located in the low tropical forest and the foothills of the Andes, where it forms populations that are not too extensive, even though at times might cover larger areas. Local flora and fauna inhabit these vegetation formations, being an ecosystem that is favored by birds and butterflies.

Ecosystemic services: conservation of diversity, reduces temperature, protects the watersheds, and captures CO_2, protection of soil microorganisms and soil erosion (Londoño 2021c).

Local and/or ancestral uses: the culms of *Rhipidocladum racemiflorum* are used to make the structure of kites, and in the manufacturing of fireworks, using its light, firm culms to tie the gunpowder and make pyrotechnical Figures ("*Torches*" and "*voladores*") (Londoño 2021c). In Manabí, Ecuador, the thin-walled hollow internodes are used to store cigarettes, and to make baskets.

Potential uses: biodegradable straws. To make artful handicrafts, or as an ornamental plant (Londoño 2021c).

3.2.2. Chusqueinae Subtribe

Description: short necked rhizomes, sometimes presenting leptomorph rhizomes. Internodes of the aerial culms are generally solid, all are subequal. The aerial branching comes from a complement of multiple buds and have diverse shapes; branches with thorns absent. The culm leaf sheath usually lacking fimbriae or fimbriate auricles; oral setae are absent. The foliage leaf sheaths usually show cilia in the upper part, rarely presenting well developed fimbriae; oral setae are absent; auricles are absent. Foliage leaf blades have a pronounced and complex central vein. Synflorescense, usually without bracts, spikelets determined, paniculated or rarely racemose. The spikelets consist of 4 glumes, and one fertile floret, the

rhachilla extension is absent; without winged keels. Usually 3 stamens, sometimes 2. The ovary is glabrous, with a short style; 2 stigmas. Caryopsis basic (Clark et al. 2015; Kellogg 2015; McMurchie et al. 2022).

This subtribe only includes one genus, *Chusquea*, with 202 species that represent 40% of the bamboo diversity in the neotropics (Clark et al. 2015; McMurchie et al. 2022).

Species registered: *Chusquea serpens* L.G. Clark was reported in the Bambuzonia area of study of the project in the province of Morona-Santiago, at 1247 m asl (Table 2). Most of the species of this genus grow in the high montane forests and might grow in altitudes of up to 4300 m asl in formations known as paramos. However, this specie grows between (400-) 800-1650 m asl (McMurchie et al. 2022).

Table 2. Species of the Chusqueinae subtribe collected in the area of the study

Species	Colombia	Ecuador	Peru
Chusquea serpens L.G. Clark		X	
Chusquea uniflora Steud.		X	X

Chusquea serpens is a running bamboo, with a thin culm of up to 1 cm in diameter and up to 20 m in length, solid, with a wide foliar leaf blade (1.8-5 cm), that grows in medium elevations, and in the piedmont of the tropical rainforest. In Morona-Santiago, it grows in the low montane forest, in forests not much disturbed, forming isolated stands that climb like lianas on top of the arboreal vegetation. It grows associated with Araceae, *Costus*, Rubiaceae, Piperaceae, Heliconiaceae, palm trees, *Guadua*, among others (Londoño 2021b).
Ecosystemic services: contributes to the conservation of the specific fauna and flora of this ecosystem.

Local and/or ancestral uses: no local use is reported (Londoño 2021b).

Potential uses: since it is a thin, solid liana has a great potential for basketry and woven cane furniture (Londoño 2021c).

3.2.3. Guaduinae Subtribe

Description: rhizomes with short or elongated necks. Culm's internodes are hollow or solid, all are subequal. Aerial branching is generally derived from a single bud per node (*Apoclada* has 1-4 subequal buds per node); thorns absent or present. Culm leaves usually have

fimbriae or fimbriated auricles in the upper part of the culm leaf sheath; oral setae are generally present (absent in *Apoclada* and *Guadua*). Foliage leaf sheath has fimbriae or fimbriated auricles in the upper part, with oral setae present; blade on the abaxial side shows pronounced and complex central vein. Synflorescense, with or without bracts, undetermined (pseudospikelet) or determined (spikelet), paniculated. The spikelet (or spikelet proper of the pseudospikelet) consist of (0-) 1 to 4 (-7) glumes, and one to many fertile florets, with the rhachilla extension ending in a rudimentary floret; the palea keels without wings or prominently winged; 3 or 6 stamens. Ovary is glabrous to pilous, with a short style: 2 or 3 stigmas. Fruit a dry, basic caryopsis, exceptionally fleshy (some species of *Olmeca* and *Guadua sacorcarpa*) (Clark et al. 2015; Ruiz-Sánchez et al. 2021).

Guaduinae is the least diverse subtribe of the Neotropics, with 60 species in 6 genera, but is the one that includes the largest size species, with greater applicability, and the ones that occupy the largest area in the Amazon region (Silveira 2005; Ruiz-Sánchez et al., 2021)

Species registered: in the area of study of the Bambuzonia project seven species of *Guadua* were reported: *Guadua angustifolia* Kunth, *Guadua incana* Londoño, *Guadua lynnclarkiae* Londoño, *Guadua sarcocarpa* subsp. *purpuracea* Londoño & P.M. Peterson, *Guadua takahashiae* Londoño, *Guadua uncinata* Londoño & L.G. Clark, and *Guadua weberbaueri* Pilger (Table 3).

Table 3. Species of the Guaduinae subtribe collected in the area of the study

Species of *Guadua*	Colombia	Ecuador	Peru
Guadua angustifolia Kunth	X	X	
Guadua incana Londoño	X		
Guadua lynnclarkiae Londoño			X
Guadua sarcocarpa subsp. purpuracea Londoño & P.M. Peterson			X
Guadua takahashiae Londoño			X
Guadua uncinata Londoño & L.G. Clark	X		
Guadua weberbaueri Pilger		X	X

1. ***Guadua angustifolia* Kunth** in the area of the study it is characterized by having erect culms, with lengths of up to 35 m, diameters of 10-14 cm, and a wall thickness in the basal section that fluctuates between 0.9 and 2.5 cm.

Habit and culm description: *Guadua angustifolia* presents erect culms, slightly arched in the apex. The length of the culm: 18-25 m; average commercial length of the culm: 12 m; diameter: 10-14 cm; average DBH: 11 cm; average length of commercial internodes: 24.5 cm; wall thickness in the basal section: 1.2-2.6 cm, with an average thickness of: 1.8 cm; middle section wall thickness: 0.9-1.2 cm, with an average thickness of the middle section of 1 cm; wall thickness of the upper section: 0.9-1 cm, with an average thickness of the upper section of 0.97 cm. The thickness of the wall fluctuates between 2.5 cm in the basal portion up to 0.9 cm the apical one.

This specie grows inside of the tropical rainforest of the Amazon region, where it generally forms small patches, however, in some regions like Caquetá, where the settlement and deforestation activity is evident, dominant patches are starting to become apparent as a result of the anthropic deforestation, the same as what occurred in the Coffee Growing Region by the end of the XIX century and the beginning of the XX century (Londoño 2021a).

It is known with the common names of *Guadua*, *Guadúa*, *Guayaquil Cane*, *Guaduba*, *Uaúda*, *siørø* (Embera-Chamí), *Huamag* or *Wamag* (Kichwa), and has a range of distribution in the Amazon between 200 and 1200 m asl (Londoño 2021b).

Samples of *Guadua* were collected in the municipalities of Cartagena del Chairá and San José de Fragua that share many features with *Guadua angustifolia*, but the biometry of the culms reported some variations in relation to size*:* culm length 28-30 m (vs. 18-25 m in *G. angustifolia*), average commercial culm length 21 m (vs. 12 in *G. angustifolia*), diameter 10-18 cm (vs. 10-14 cm in *G. angustifolia*). Samples were also collected in Ecuador in the cantons El Chaco and Tiwinza, with some variations in size with respect to *G. angustifolia.*
Ecosystemic services: conservation of diversity; reduces temperature; improves the quality of soil; protects the watersheds; captures CO_2 , protection o from wind and embellishment of the landscape (Londoño, 2021 c).

Ecology & habitat: in the Amazon region this specie usually grows within the tropical rainforest in small patches. The *Guadua* stands host a great diversity of associated flora and fauna and have great microbial wealth in their soil. Because of their diffuse habit, and since they present long neck pachymorph rhizomes, species of Heliconiaceae, Araceae, ferns, Piperaceae, Rubiaceae, etc., grow in their interior. They are also ideal ecosystems for rodents, mammals, birds, reptiles, etc. The communities in the area of influence of the Bambuzonia project in Caquetá and Meta report the following fauna: a) mammals: the

brown capped capuchin (*Sapajus apella*), brown woolly monkey (*Lagothrix lagotricha*), saddleback tamarind (*Saguinus fuscicollis*), jaguar (*Panthera onca*), pale throated sloth (*Bradypus tridactylus*), two-toed sloth (*Choloepus didactylus*), giant anteater (*Myrmecophaga tridactyla*), red brocket deer (*Mazama americana*), honey bear (*Potos flavus*), bushpig (*Potamochoerus larvatus*), greater capybara (*Hydrochoerus hydrochaeris*), spotted paca (*Cuniculus paca*), nine-banded armadillo (*Dasypus novemcinctus*), black agouti and central American agouti (*Dasyprocta fuliginosa* and *Dasyprocta punctata*), crab-eating fox (*Cerdocyon thous*), oppossum (*Didelphis marsupialis*), red tailed squirrel (*Sciurus granatensis*), among others; b) birds: stinkbird or Canje pheasant (*Opisthocomus hoazin*), chachalaca motmot (*Ortalis motmot*), yellow-ridged toucan (*Ramphastos culminatus*), Salvin´s curassow (*Crax salvini*), Guainian cock-of-the-rock (*Rupicola rupicola*), grey-winged trumpeter (*Psophia crepitans*), white throated guttatus (*Tinamus guttatus*), fork-tailed flycatcher (*Tyrannus savana*), owls (*Otus* spp.), woodpeckers (*Piculus* spp., *Celeus* spp. *Melanerpes cruentatus*), lineated woodpecker (*Dryocopus lineatus*), night hawks (*Chordeiles* sp.), macaws (*Ara* spp.), undulated tinamu (*Crypturellus undulatus*), cattle egret (*Bubulcus ibis*), double striped-thick knee stone curlew (*Burhinus bistriatus*), smooth billed ani (*Crotophaga ani*), oil bird (*Steatornis caripensis*), pigeons (*Columba* spp.), russet-backed oropendula (*Psarocolius angustifrons*), tropical kingbird (*Tyrannus melancholicus*), thrush (*Turdus* spp.), red-capped manakin (*Ceratopipra mentalis*), hawks (*Buteo* spp.), eagles (*Spizaetus tyrannus*), among others; c) reptiles and others: southern American bush master (*Lachesis muta*), common lancehead (*Bothrops atrox*), coral (*Micrurus* sp.), false coral (*Lampropeltis triangulum*), mountain sipo (*Chironius montícola*), yellow rat snake (*Spillotes pullatus*), brown vine snake (*Oxybelis aeneus*), boa (*Boa constrictor*), iguanas (*Iguana iguana*), speckled caiman (*Caiman crocodilus*), chameleons lizards (*Anolis* sp.), golden tegu (*Tupinambis teguixin*), yellow footed tortoise (*Chelonoidis denticulata*), several species of arthropods (spiders, tarantulas and scorpions), among others. The presence of the South American Tapir (*Tapirus terrestris*), the South American rattlesnake (*Crotalus durissu*) and the scarlet ibis (*Eudocimus ruber*) were also reported in La Macarena (Londoño 2021a).

Local and/or ancestral use: *Guadua angustifolia* and *Guadua* aff. *angustifolia* are used locally to build or repair houses, to build bridges, in rural facilities (hen coops, corrals, fences for pastures, etc.), for agricultural tasks (brace and tutor crops, put a handle on tools), make fishing, music, hunting instruments, to make furniture, crafts, domestic utensils, as

conduits for water, to make parapets in ditches, to control erosion, to protect watersheds, to improve soil fertility, as firewood to feed firewood stoves, ovens, and sugar mills, as decorative elements, to place the tv antennas, to make pots and chicken feeders, to make recreational rafts to cruise the river (Londoño 2021a, 2021b).

In the municipality of Florencia, internodes are used to prepare a drink called "chicha": they cut a 2 m segment, they bore holes in the internodes, fill the segment with "chicha" and leave it to ferment for 4 days, then they take the segment to the minga (community work) to quench their thirst (person. comm., Norbey Dobigama, Chami-Purú Indigenous governor). He also reports that they use *Guadua* to heal the territory: the Chaman or traditional doctor takes 1.5 m long segments, they split them in the shape of a lance or spear, and then drives them into the ground of the reservation as they walk to through it to encourage good harvests and good crops. According to N. Dobigama, the use of *Guadua* is a long-standing tradition, from their great grandparents (Londoño 2021a).

Potencial use: *Guadua angustifolia* and *Guadua* aff. *angustifolia* can be used to make laminated boards, panels and particle boards; to manufacture composite materials using the guadua fibers mixed with other materials; to manufacture furniture and handicrafts with modern and innovative designs; in light and innovative construction, to make low cost housing, or private housing among others (Londoño 2021a, 2021b).

Phenology: *Guadua angustifolia* presents sporadic flowering. It flowers during the months of April to May, and from October to November, usually after dry periods (Londoño & Peterson 1991; Londoño 2021a, 2021b). The flowering of *Guadua* aff. *angustifolia* is unknown.

Agroclimatic conditions: average annual temperature between 20°C and 27°C, annual rainfall between 950 and 2500 mm with a bimodal distribution. It has a great ability to adapt to different types of soil (Londoño 2021a, 2021b).

2. ***Guadua lynnclarkiae*** **Londoño** is characterized by having erect culms, arched at the apex, with great development of lateral branches in the apical third, which extend over the canopy of the neighboring vegetation. Culms of lengths of up to 21 m, diameters of 8-11 cm, and wall thickness in the basal portion that fluctuates between 0.9 and 2.1 cm.
   Habit and culm description: erect culms at the base, apically arched, with primary branches extending over the tree canopy. Length of the culm: 10-15 (-21) m; average

commercial length of the culm: 8-10 m; diameter of the culm: 7-10 (-12) cm; diameter at breast height (DBH): 8-9 cm; length of commercial internodes 40-43 cm; thickness of the wall in the basal region: 1-2.3 cm, with an average thickness of : 1.5 cm; thickness of the wall in the middle section: 0.7-1 cm, with an average thickness of 0.85 cm; thickness of the wall in the upper section: 0.6-0.8 cm, with an average thickness of 0.7 cm. Thickness of the wall varies from 2.3 cm in the basal portion up to 0.6 cm in the apical one (Londoño 2021a).

Ecosystemic services: conservation of diversity; reduces temperature; improves the quality of soil; protects the watersheds, captures CO_2 (Londoño 2021c).

Ecology & habitat: *Guadua incana* is an endemic bamboo of Colombia, located in the eastern slope of the Cordillera Oriental (Eastern Mountain Range of Colombia), in the tropical rainforest of the departments of Caquetá, Putumayo and Meta in a 280 a 1200 m asl altitudinal range. It grows in the hillside forests of the Eastern Mountain Range, in the Amazon forest, and in Amazon plain ecosystems, surrounded by swampy areas. It is not very frequent. It is observed forming small non-dominant patches, along creeks and surrounding water outcrops. It grows associated to ferns, Araceae, Heliconiaceae, Melastomataceae, Lauraceae, palm trees, iraca palm (*Carludovica palmata*), trumpet tree (*Cecropia* sp.), balso tree, white wax tree, chilco (*Fuchsia magellanica)*, pomo (*Syzygium jambos*), guava tree, boca de indio (*Piptocoma discolor*), nacedero (*Trichanthera gigantea*), etc. The associated fauna reported was: a) mammals: nine-banded armadillo (*Dasypus novemcinctus*), red tailed squirrel (*Sciurus granatensis*), different types of monkeys, amazon or tropical weasel (*Mustela africana*), crab eating foxes (*Cerdocyon thous*), two-toed sloth (*Choloepus didactylus*), giant anteater (*Myrmecophaga tridactyla*), among others; b) birds: owls (*Otus* spp.), stinkbird or Canje pheasant (*Opisthocomus hoazin*), green-rumped parrotlet (*Forpus passerinus*), orange-chinned parakeet (*Brotogeris jugularis*), macaws, parrakeets (Psittacidae family), yellow rumped cacique (*Casicus cela*), among others; c) reptiles like the "X" snake common lancehead (*Bothrops atrox*), common caiman (*Caiman crocodilus*), lizards (*Tupinambis teguixin*) and yellow footed tortoise (*Chelonoidis denticulata*), and arachnids like tarantulas, spiders and scorpions, among others (Londoño 2021a).

Local and/or ancestral uses: fences and light rural infrastructure; doors, animal pens, posts to place tv antennas, to make home orchards, etc.

Potential use: produce fiber since its internodes are relatively long and thin walled. It can also be used for basket weaving or any type of weaving by extracting thin strips from young culms (mats, pack saddles [“*enjalmas*”]). The internodes can be edible are less bitter than the ones of *G. angustifolia*, and are food for wild animals like the Central American agoutis (*Dasyprocta punctata*) (Londoño 2021a). Recent studies identify bioactive compounds for natural health products in *G. incana* (Chitiva et al. 2023).

Phenology: its flowering cycle is sporadic. It was observed flowering between 2001 and 2004. It can flower continuously without dying during 2 to 3 years (Londoño & Zurita 2008).

Agroclimatic conditions: average annual temperature between 24°C and 26°C. Annual rainfall between 3000 and 4135 mm, December and January being the driest months, and May and June the wettest. The soils in the piedmont of the Eastern Mountain Range, eastern slope, presents a shallow effective depth and are considered to be of low fertility for farming; the oxisol and ultisol soils formed by sedimentary rocks of the tertiary from the Eastern Mountain Range are predominant, presenting low available concentrations of Ca, Mg, Na, and P (Londoño 2021a).

3. ***Guadua lynnclarkiae*** **Londoño** is characterized by having erect culms, slightly arched at the apex, with lengths of up to 35 m, diameters of (-8) 10-17 cm, and wall thickness in the basal portion that fluctuates between (0.8-) 1.5-4.5 cm.

   Description of the habit and of the culm: erect habit, slightly arched at the apex, diffuse; long necked pachymorph rhizome. Length of the culm: 12-35 m; average commercial length of the culm: 8-22 m; diameter: 8-17 cm; average DBH: 12.5 m, length of commercial internodes 40-55 cm; thickness of the wall in the basal region: 3-4.5 cm, with an average thickness of 2.6 cm; thickness of the wall in the middle section: 1-1.5 cm, with an average thickness of 1.2 cm; thickness of the wall in the upper section: 0.8-1.1 cm, with an average thickness of 0.9 cm. Thickness of the wall varies from 4.5 cm in the basal portion up to 0.9 cm in the apical portion (Londoño 2021a).

   Ecosystemic services: conservation of diversity; reduces temperature; improves the quality of soil and control of erosion; protects the watersheds, captures CO_2 (Londoño 2021c).

   Ecology & habitat: it grows mainly along the river banks; in the understory it is a home to Heliconiacea, Piperaceae, Araceae, Convolvulaceae, *Costus*, Cyperaceae, Melastomataceae,

Cyclantaceae, ferns, iraca palm trees, and grasses, and in the mid and higher strata we observe bushes and trees like the fig trees (*Ficus* sp.), lauraceae (*Aniba* sp.) and trumpet trees (*Cecropia* sp.). The fauna recorded in the *Guadua Lynnclarkiiae* populations is diverse: opossums, birds, reptiles, foxes, armadillos, lowland *paca* (*Agouti paca*), deer (*Mazama americana*), collared *pecarí* (*Tayassu tajacu*), black agouti (*Dasyprocta fuliginosa*), nine-banded armadillo (*Dasypus novemcinctus*), saddle back tamarind (*Saguinus fuscicollis*), and San Martín Titi monkey (*Plecturocebus oenanthe*). According to Capto et al. (2021), these animals feed of the tender foliage and the new shoots of *G. lynnclarkiae* (Londoño 2021c).

Local and/or ancestral uses: the traditional use of the culms of *G. lynnclarkiae* in Rioja, San Martín (Peru) from the Awajun community is to make mats to build housing. At present this *Guadua* is used to build enclosures, restore house walls, make furniture, and conserve hydric resources. It is also used in Moyobamba to build light infrastructure and to place the TV antenna. Its common name is Marona or Kegku in the Awajun language (Londoño 2013, 2021c).

Potential use: the large size of the culms as to length, diameter and wall thickness make *G. lynnclarkiae* an excellent material for industry and to manufacture laminates, panels, floors, etc. Because of the length of its internodes of almost 56 cm, this special also has great potential to produce fiber which is used to manufacture biodegradable composite materials (Londoño 2021c).

Phenology: it has a sporadic flowering cycle and according to the inhabitants of San Martín, this specie flowers once a year in the months of February and May and never dies (Londoño 2010).

Agroclimatic conditions: it is distributed in the northwest of Peru, in the Department of San Martín, between 800 and 900 m, in the banks of rivers and creeks. It does not tolerate floodable areas. There are very few populations left due to the severe destruction of the forest for agricultural purposes (Londoño 2013).

4. ***Guadua sarcocarpa* subsp. *purpuracea* Londoño & P.M**. Peterson is characterized by having erect culms at the base but arched in the middle and apical thirds, with lengths of up to 18 m, diameters of 6-9 cm, and wall thickness in the basal portion that fluctuates between 0.6 and 1.5 cm.

Habit and culm description: erect culms at the base and arched in the middle third and apical third. It develops long and/or short necked pachymorph rhizomes (up to 4 m). Length of the culm: 8-18 m; average commercial length of the culm: 8-9 m; diameter: 6-9 cm; average DBH: 8cm. Average length of commercial internodes 27-93 cm; thickness of the wall in the basal region: 0.6-1.5 cm, with an average thickness of 1 cm; thickness of the wall in the middle section: 0.4-0.5 cm, with an average thickness of 1.2 cm; thickness of the wall in the upper section: 0.3-0.4 cm, with an average thickness of 0.375 cm. Thickness of the wall varies from 1.5 cm in the most basal portion up to 0.3 cm in the upper portion (Londoño 2021c).

Ecosystemic services: conservation of biological diversity; captures $CO_{2;}$ protects the watersheds, reduces temperature; and control of erosion (Londoño 2021c).

Ecologia & habitat: the *Guadua sarcocarpa* subsp. *purpuracea* formations, popularly known in Peru as "*capirales*", is located in sloping land inside the jungle, or in secondary forests called "purma", or in areas cleared for agriculture or cattle breeding. These "*capirales*" are very special ecosystems because they occur in areas with high biological diversity. The Central Jungle of Peru, the Departments of Pasco and Junín are recognized worldwide as areas with high diversity and endemism. Within the "*capirales*" plants such as cecropia trees, Melastomataceae, ferns, Araceae, Piperaceae, Rubiaceae, and some of the trees they use for support are seen. According to the inhabitants interviewed, diverse fauna has been observed in the "*capirales*", represented among others by the honey bear (*Potos flavus*), lowland *paca* (*Agouti paca*), false paca- a hystricognath rodent (*Dinomys branickii*), squirrels, mice, monkeys, tigrillos, pale throated sloth (*Bradypus* sp.), birds such as toucans, cauca guans, cachalaca guans, wood peckers, tinamous, parrakeets, owls, wild turkeys, doves, and some reptiles, and arthropods such as snakes, lizards, chameleons, tarantulas, scorpions, tortoises, among others (Londoño 2021c).

Local and/or ancestral uses: the community of Pangoa, of the Nomachiguenga ethnia, has used the round culms of this specie to build their homes by placing them in a vertical position. Today, they use the mats made from the opened and flattened culms, or in the round culms as fences for cattle facilities; they also use the internodes to cook fish, to make and carry arrows; and to make thin, fine, strips used to manufacture the crowns used by the Ashaninka and Nomachinguenga indigenous community chieftains. For the Machiguengas and Nomanchiguengas indigenous communities its common name is "Capiro" while the

common name for “Piros” community is “Huata”. From “capiro” they make drinking glasses, torches (figures that are burned), enclosures and walls, clothing supports and clotheslines, as a conduit for the water hose, and they prepare a typical dish called “capirona”, that consists of cooking fish with aromatic herbs inside an internode of this bamboo (Londoño 2021c). The Piros and Machiguenga ethnias eat the fleshy fruit of *G. sarcocarpa* subsp. *Purpuracea* after boiling it (Londoño & Peterson 1991).

Potential use: this specie has a great potential to produce natural fibers from its culms because it has long internodes, of up to 93 cm. They also have great potential for the manufacturing of furniture and handicrafts because of their strong, thin-walled culms that could be used to develop innovative, simple designs with a cultural reference (Londoño 2021c).

Phenology: this specie reports flowering cycles approximately every 10 years, it flowers sporadically, observing a culm in bloom and the rest without producing inflorescence (Londoño 2013).

Agroclimatic conditions: it is distributed in the central jungle of Peru, in the departments of Junín and Pasco, but have also been reported in the departments of Cuzco, Province of Quispicanchis and in Madre de Dios, Province of Manu, Atalaya sector. This *Guadua* specie prefers tropical rainforests, above 700 m asl (Londoño 2021c).

5. ***Guadua takahashiae*** **Londoño** is characterized by having erect culms in the base and slightly arched in the apex, with lengths of up to 20 m, diameters of 8-15 cm, and a wall thickness in the basal section that fluctuates between 0.6 and 1.5 cm.

   Habit and culm description: erect and diffuse habit. Culm slightly arched at the apex; long necked pachymorph rhizome. Length of the culm: 15-20 m; average commercial length of the culm: 9-11 m. diameter: 8-15 cm; average DBH: 8-15 cm; average length of commercial internodes 29 cm; thickness of the wall in the basal section: 2-2.5 cm, with an average thickness of 2.2 cm; thickness of the wall in the middle section: 1.5-1.7 cm, with an average thickness of 1.6 cm; thickness of the wall in the upper section: 1 cm, with an average thickness of 17 cm. Thickness of the wall varies from 2.5 cm in the basal portion up to 1 cm in the apical one (Londoño 2021c).

Ecosystemic services: conservation of diversity; reduces temperature; improves the quality of soil; protects the watersheds, captures CO_2; (Londoño 2021c).

Ecology & habitat: the populations of *Guadua takahashiae* host a great diversity of local flora and fauna. In the Department of San Martín, the vegetation of the understory inside these *Guadua* ecosystem is scarce, however, associated plants such as ferns, heliconias, cacao trees, *Inga* sp., among others were observed. As to the diversity of associated fauna, mammals, reptiles and birds have been reported (Londoño 2021c).

Local and/or ancestral uses: in the Departments of San Martin and Amazonas, the round culms of *G. takahashiae* are used in construction, as beams for roofs, to make concrete slabs and to make walls; to place TV antennas; to make rows or home orchards; in the building of greenhouses and hen coops; to make enclosures or fences, in the decoration of restaurants, bars and stores; the flattened culm mats are used to build fences, adobe walls, enclosures, and the mats to build pens for small animal species in farms, and walls in houses (Londoño 2010, 2013, 2021c).

Potential use: the straight and almost tubular shape of the first 2/3 parts of the culm and the absence of branches with thorns on the culm make *Guadua takahashiae* an ideal bamboo for farming and sustainable exploitation, with a great potential for the construction industry (Londoño 2013). Its large size plus the knowledge of its physical mechanical properties can make this *Guadua* an ideal sustainable resource for the construction industry in Peru and to close the deficit of housing that exists. The fiber of *Guadua takahashiae* could be studied and it would be an additional material to manufacture biodegradable composite materials (Londoño 2021c).

Phenology: sporadic flowering during the months of April to May and from October to November (Londoño 2021c).

Agroclimatic conditions: in the department of San Martín, the average annual temperature fluctuates between 19.3°C and 32°C, with an average annual rainfall of 1150 mm, with a bimodal rainfall regime where the rainiest months are between February and May and between October and November, and the driest months are between June to August and between December and January (Londoño 2021c).

Guadua takahashiae occurs in the northwest of Peru, between 400 and 1200 m asl, where it is known as “Guayaquil”, “Green Bamboo”, or “Guayaquil Cane”, and it can be seen in the banks of rivers and creeks or in the slopes of the hillsides (Londoño, 2013).

6. ***Guadua uncinata*** **Londoño & L. G. Clark** is characterized by having erect culms in the base, which arch in the mid and upper thirds, with lengths of up to 8 m, diameters of 2-3 cm; the first two or three basal internodes are solid, and then the culm’s wall thickness fluctuates between 0.7 and 1 cm.

   Habit and culm description: erect culm at the base, but arches in the lower middle third, and climbs or leans on the neighboring vegetation using the uncinate thorns of its branches. Shows solid culms in the two or three first internodes, then with a cavity or lumen of less than 1 cm in internode 5 and a lumen of between 1.2 cm-1.5 cm starting on internode 7; length of the culm: 6-8 m; average commercial length of the culm: 2-3 m. diameter: 2-3 cm; average DBH: 3 cm; average length of commercial internodes 22-36 cm; thickness of the wall in the basal section: does not have because it is solid; thickness of the wall in the middle section: 0.7-1 cm, with an average thickness of 0.9 cm; thickness of the wall in the upper section: 0.6-0.7 cm, with an average thickness of 0.65 cm. Thickness of the wall varies from solid (base) to 0.5 cm (apex) (Londoño 2021a).

   Ecosystemic services: *Guadua uncinata* contributes to the conservation of swampy ecosystems or those having a high-water table, to the conservation of the fauna and flora specific to this type of ecosystem, and plays an important role in the connectivity between swampy ecosystems and *tierra firme* (dry ground) (Londoño 2021a).

   Ecology and habitat: it grows in floodplains known as the “bajos” or “chicuas”, associated to morichales (moriche palm tree ecosystems) or aguajales (permanently flooded areas), where the moriche palm tree (*Mauritia flexuosa*) is dominant. It also seen growing together with heliconias, Melastomataceae, ferns, Piperaceae, lianas and *Ficus* trees, trumpet trees, guamo trees *(Inga edulis*) and others. It forms congested and impenetrable stands since its culms don´t remain erect, leaning and intertwined with the neighboring vegetation. This specie grows in areas that flood periodically, between 280 and 1500 m asl, and is an indicator for peasants of fertile alluvial soils (Londoño & Clark 2002).

   The people living in the territories occupied by *G. uncinata* report the following associated fauna: a) mammals, armadillos, squirrels, titi monkey (*Saimiri sciureus*), otters (*Pteronura brasiliensis* and *Lontra longicaudis*), foxes, pale throated sloths, among others; b) birds:

great egret (*Ardea alba*) , egrets, owls, woodpeckers, pheasants, chachalacas *(chachalaca motmot*), yellow-crowned parrot (*Amazona ochrocephala*), orange-winged parrot (*Amazona amazónica*); c) reptiles like the snake common lancehead "X" (*Bothrops atrox*), *güío* or common boa (*Boa constrictor*), false coral snake (*Erythrolamprus bizona*), *cazadora* snake, frogs, lizards, and arachnids such as the tarantulas, scorpions, etc. (Londoño 2021a).

Local and/or ancestral uses: according to the natives of the Ingana Community of Putumayo, this bamboo has culms with somewhat long and thin internodes (35 cm), and they call it "cachupendo", differentiating it from *Guadua angustifolia* that has short internodes with bigger diameters which they call "*Guadua*". In Colombia there is no record of its use because the locals say it is not good timber. In Ecuador, according to the sample of McClure's herbarium No. 21364, *G. unicinata* is used locally for enclosures and for agricultural infrastructure (Londoño 2021a).

Potential use: its thin and solid culms might be used to manufacture furniture and handcrafts, and to make canes or poles for hikers. From the environmental standpoint, and because it is one of the few species of *Guadua* that tolerates high water table levels, it could be used for ecological restoration in swampy areas, or it could be used to make connectivity corridors in places that are discontinuous because of swamps, or they could be used to reforest watersheds that are unprotected in flooded areas or that have high soil humidity (Londoño 2021a).

Phenology: *Guadua uncinata* flowers sporadically the flowers remain green and do not die (Londoño & Clark 2002). From observations made between 1987 and 2020, this specie appears to have flowering cycles approximately from 5 to 10 years; once flowering starts, it can continue during 3-4 years. It flowered for the last time in 2015 and it was found in bloom in Caquetá in October 2020.

Agroclimatic conditions: average annual temperatures between 19°C (night time) and 28°C (day time). Average annual rainfall is 1216 mm, being the driest months July and August, and December and January, and the rainiest March and April, and October and November, a typical bimodal regime. Medium relative humidity is 83%. The soils in the hillsides of the Eastern Mountain Range, eastern slopes, present a shallow effective depth, and are considered to be of low fertility for farming. The Ultisol soils predominate, characterized by being mesic and warm thermal regimes, with an argillic horizon and a low base level

(Percentage of Base Saturation (PBS) < 35%). It occurs in an altitudinal range from 280 to 1500 m asl (Londoño 2021a).

7. **G*uadua weberbaueri* Pilger** is characterized by having erect culms in the base but arched and leaning in the mid and upper thirds, with lengths of up to 15 m, diameters of 3-7 cm, and basal section wall thickness that fluctuates between 0.9 y 1.2 cm.

   Habit and culm description: erect at the base, arched and seeks support in the middle and upper portion, forms dense colonies known as "pacales" or is found in the form of solitary and disperse stands within the jungle. Short or long necked pachymorph rhizome (up to 8 meters long). Length of the culm: 4-10 m; average commercial length of the culm: 3 m; diameter: 3-7 cm; average DBH: 4-5 cm; average length of commercial internodes 20-46 cm; thickness of the wall in the basal section: 0.9-1:2 cm, with an average thickness of 1.02 cm; thickness of the wall in the middle section: 0.6-0.7 cm, with an average thickness of 0.65 cm; thickness of the wall in the upper section: 0.3-0.4 cm, with an average thickness of 0.35 cm. Thickness of the wall varies from 1.2 cm in the basal portion up to 0.2 cm in the upper portion (Londoño 2021b).

   Ecosystemic services: conservation of biological diversity; captures CO_2; conservation of watersheds; reduces temperature; control of erosion, and improves the quality of soil (Londoño 2021b).

   Ecologia & habitat: The large areas covered by *Guadua weberbaueri* in the Amazon region host a great diversity of specific fauna and flora. As to the associated flora, we observe in its understory a great diversity of heliconias, Piperaceae, *Costus*, Cyperaceae, Melastomataceae and ferns; and in the tree strata, it is found together with trees from the Aceraceae and Moraceae families, among others. Some typical examples of the fauna hosted in the *pacales* are Bolivia´s bamboo rats, and monkeys of the *Saguinus fuscicollis* species. As to vertebrates and invertebrates, there are reports of ants, coleopters, birds, frogs, reptiles, rodents, monkeys, who use these *Pacales* for food, shelter or as a reproduction site. The *Guadua weberbaueri* in the Amazon region are increasingly disturbed by farmers who burn it to expand the agriculture or cattle breeding frontier (Londoño 2021b).

   Local and/or Ancestral uses: *G. weberbaueri* is used to build shelters or pens for small animal species, to manufacture baskets, to make handles for tools, and to build walls and everyday use utensils like containers, candlesticks, and others. The Amazon indigenous communities use them to make the arrowheads to hunt, *attack* and defend themselves. In the

Peruvian Amazon Forest, they use the culms to cook a dish called “pacamoto”, where inside the internode they cook fish, rice or meat. They drink the water inside the internodes to quench their thirst and it is believed to have medicinal properties (Londoño 2021b).

Potential use: given the length of the internodes (20-46 cm) they have great potential to produce natural fiber given the high quality of its fiber which was evaluated in a laboratory by L. Osorio and E. Trujillo (personal communication). The production of coal from its culms could also be investigated, although the walls of the culms are very thin. The settlers and farmers who eradicate it by burning do not want this specie. The shoots with prior treatments could be used as food for humans. It’s round culms, or the culms opened and pounded into mats (*esterilla*) can be used in the industry of furniture and handcrafts (Londoño 2021b). Its wide foliar leaves can be commercialized to pack food or decorate oriental cuisine dishes.

Phenology: this specie has sporadic flowering. It has flowering cycles every 25-30 years. When it flowers, the culm may or may not die. H. Panduro (personal communication) observed it in flower in 2019, and in 2020 in Moyobamba, San Martín, without showing the death of the entire population. The flower produces a fleshy fruit, which has an olive shape.

Agroclimatic conditions: this bamboo is more frequent and abundant in the Amazon region, having a great capacity to adapt to different types of habitats (Londoño 2021b). In Peru it grows in the formations called “matorral” or “purma”, and goes by the names of “maronilla”, “carricilllo” or “paca”. *Guadua weberbaueri* occupies the periodic and frequently floodable flat lands, flat and dissected flat terraces, and some areas having deficient drainage like the “aguajales” (swampy areas). It grows between 40-900 m asl (Silveira 2005). In Perú, in the department of San Martin (Moyobamba and Tocache) summers are short, very hot and partially cloudy, and winters are long, hot, humid, rainy and mostly cloudy. During the year, temperature varies between 18 °C-35 °C, and rarely drops below 16 °C or above 35 °C. Annual rainfall fluctuates between 1300 y 1800 mm.

Figure 1. Bamboos of the Bambuseae tribe: Neotropical clade. a. *Guadua angustifolia*; b. *G. incana*; c. *G. lynnclarkiae*; d. *G. sarcocarpa*; e. *G. takahashiae*; f. *G. uncinata*; g. *G. weberbaueri*; h. *Rhipidocladum racemiflorum*; i. *Chusque serpens*

3.3. Paleotropical Clade

This paleotropical clade (Figure 2) is made up by woody bamboos of the Bambuseae tribe native from Asia and tropical Africa, which in America are called exotic bamboos. In the area of the study in the Amazon region of Colombia, Ecuador and Peru, this clade is represented by the Bambusinae y Melocanninae subtribes (Kellog 2015; Clark et al. 2015).

3.3.1. Bambusinae Subtribe

This subtribe includes approximately 25 genera and 264 species (Kellogg et al. 2015). It is characterized by having inflorescence in the shape of spikelets or pseudospikelets, 6 stamens, 1 ovary or a reduced ovary, 3 stigmas and chromosomic number 2n = (48), 70, 72. It´s the subtribe presenting the most problems in relation to the limitation of the genera it includes (Kellogg 2015).

Bambusinae includes the largest size woody bamboos in the Old World, species that are found in the *Dendrocalamus*, *Bambusa* and *Gigantochloa* genera.

Species registered: in the Bambuzonia areas of study five species of the genus *Bambusa* were reported: *Bambusa eutuldoides* McClure, *Bambusa longispiculata* Gamble, *Bambusa multiplex* (Lour.) Raeusch. ex Schult f., *Bambusa oldhamii* Munro, *Bambusa vulgaris var. vulgaris* Schrad. ex J.C. Wendl., *Bambusa vulgaris var. vittata* Riviere & C. Riviere; two species of the genus *Dendrocalamus*: *Dendrocalamus asper* (Schult. f.) Backer and *D. brandissii* (Munro) Kurz; and one specie of the genus *Gigantochloa*: *Gigantochloa apus* (Schult. f.) Kurz, for a total of 8 exotic bamboo species of the Bambusinae subtribe.
The species that registered the greatest frequency in the area were *Bambusa vulgaris var. vittata*, *Bambusa multiplex* and *Dendrocalamus asper*.

1. ***Bambusa vulgaris var. vittata* Riviere & C. Riviere**

   This specie is native of China and is recognized as the most cultivated bamboo in the world for ornamental purposes (América, India, Europa, Asia, Africa and Australia).

   It forms somewhat congested stands, which are distinguished by the yellow color of the culms with unequal green stripes, which could measure up to 15 m in height and 12 cm in diameter, with internodes of between 20 to 25 cm, and pronounced nodes (Londoño 2004, 2021b, 2021c).

   It is believed that *B. vulgaris* var. *vittata* was introduced to America more than 200 years ago and it is practically naturalized. It is used as a barrier along the river and rivulet banks, and as protection bands and for erosion control in steep terrain. It is planted to mark land borders, to embellish the landscape, and to act as windbreakers. It hosts fauna such as rodents, reptiles, arachnids and different type of insects (Londoño 2021b, 2921c).

   Even though the culm of *B. vulgaris* is not straight, it is the most used bamboo in the world: its culms are used as masts in boats, rudders, lateral floats, as oars, to transport all type of

objects, as fences and as tutoring sticks. According to Dransfield & Widjaja (1995) it is rarely used as construction material because of its high susceptibility to insect attacks given its high starch contents. The slit culms are used as props and to build adobe walls. The culms provide raw materials for the bamboo furniture industry. Its biomass is used to manufacture pulp for paper. The shoots are too bitter to be edible and are rarely sold as vegetables. Sometimes the foliage of *B. vulgaris* is used as animal feed. Medical uses: the water in which the shoots are boiled is used as medicine to cure hepatitis, and to treat abscesses and malaria. Stems are used as a medicine for rheumatism. The bark is astringent and is used to induce menstruation. The leaves are boiled and used for heart problems and to alleviate fever in general or the one produced by malaria. Women use a broth decoction of boiled leaves as a "means to clean" or for dilation and curettage, and to help expel the placenta. The sap is used to treat fever and hematuria. The smoke produced when the culm is burned is used as a mosquito repellent (Dransfield & Widjaja 1995).

Potential uses: agglomerate panels, mixing its biomass with other type of fibers such as better-quality bamboos like the ones of *Guadua angustifolia* or with hard timber. The culm leaves can be used to manufacture biodegradable dishes and utensils (Londoño 2021b, 2021c).

2. ***Bambusa multiplex* (Lour.) Raeusch. Ex Schult. f. in J.J. Roemer & J.A. Schultes**

Bambusa multiplex are only known as cultivated crops. It probably originated in Indochina and in the south of China but is now grown extensively in the tropics and subtropics including the southeast of Asia, the pacific islands, Australia, Africa, Madagascar and America. It has been genetically manipulated and there are several varieties and forms, for example: *B. multiplex* var. *multiplex, B. multiplex* f. *alphonso-karri* (Satow) Nakai; *B. multiplex* var. *riviereorum* (R. Maire) Chia & Fung; and *B. multiplex* f. ´Fernleaf´ and *B. multiplex* f. ´Golden Goddess´ (Dransfield & Widjaja 1995).

B. multiplex forms caespitose stands, with short necked pachymorph rhizomes. The culm is thin, erect in the base, and arched at the tip. They can reach up to 7m in height, with a diameter of 2.5 cm. It is hollow, with a thick wall. The internodes are 30-50 cm in length, glabrescent, soft, covered by a white wax when young (Londoño, 2004).

Bambusa multiplex is excellent for fences and it is a very common ornamental plant in gardens. The culms are frequently used as umbrella handles and fishing rods, and in Indonesia and Thailand, the culms are used for handcrafts (Dransfield & Widjaja 1995;

Londoño 2004). In Southeast Asia, *B. multiplex* is cultivated up to 1500 m in diverse types of soils. It grows well in sandy soils and survives frost (Dransfield & Widjaja 1995).

Potential uses: To produce biodegradable straws and create delicate handcrafts (Londoño, 2021a).

3. ***Dendrocalamus asper* (Schultes f.) Backer ex Heyne**

Its origin is not very clear, but it is believed to come from the southeast of Asia. It was introduced to tropical countries of Asia, America and Australia (Dransfield & Widjaja 1995).

It is a woody bamboo, forming caespitose stands, with short necked pachymorph rhizomes. The culms are erect, arched at the tip. They can reach up to 30m in height, with a diameter of 20 cm, and wall thickness between 1 y 3.5 cm. It is hollow and are characterized because they develop in the node region of the basal internodes many adventitious roots. (Londoño 2004).

Dendrocalamus asper culms are used as construction material for houses and bridges. The internodes of the apical portion are used to store water, or as containers to cook rice and vegetables. The young shoots of *D. asper* are the most edible and better tasting among all the Asian tropical bamboos (Dransfield & Widjaja 1995).

In the Asian tropical region this specie grows from sea level up to 1500 m. Its optimal development is achieved at an altitude of between 400-500m in areas where the average annual rainfall is 2400 mm. It grows in any type of soil; however, it behaves better in well drained soils (Dransfield & Widjaja 1995).

Potential uses: in agribusiness to produce laminated and veneered panels. Biomass to generate biofuel through pellets. It also has good fiber production for composite products, shoots are used as food, to produce flour and other food derivates (Londoño 2021b).

3.3.2 Melocanninae Subtribe

This subtribe includes 9 genera and approximately 84 species (Kellogg et al. 2015).

It is characterized by inflorescence in the form of pseudospikelets organized as a cluster in the nodal region. The spikelets usually have 2 glumes, 6 stamens, 1 elongated and hollow style, 3 stigmas and a glabrescent ovary, it has a chromosomic number of 2n = 72 (Kellogg et al. 2015).

Species registered: only one specie was reported in Ecuador, in the Bambuzonia project study area: *Melocanna baccifera (Roxburgh) Kurz.*

4. ***Melocanna baccifera (Roxburgh) Kurz***

It's naturally distributed in the northeast of India, in Bangladesh, Pakistan, Nepal and Myanmar. It has been cultivated occasionally and has been introduced worldwide in many botanical and private gardens (Dransfield & Widjaja 1995).

A woody bamboo, with a long necked pachymorph rhizome, it forms caespitose stands when young and diffuse when adult. The culms are erect and straight, but with a pendulous apex. Culms having a height of 10-15 (-20) m, and a diameter of 1.5-7 cm. They are hollow, cylindrical, glabrescent, with a length of 20-35 cm, a thick wall in the basal internodes, but thin in the mid and upper third (Londoño 2004).

Melocanna baccifera is used as construction material, to make baskets, mats, furniture, handcrafts and domestic utensils. It is recognized by its excellent fiber to manufacture pulp for paper. Its long internodes with slightly marked internodes make this bamboo an excellent material for furniture, handcrafts and for the extraction of fiber (Dransfield & Widjaja 1995). It shows gregarious flowering, and when it flowers it produces fleshy fruits that look like figs, and the entire population dies.

It grows well in sandy-clay-loamy soils of an alluvial origin, and in pure sand residual soils. It withstands long dry periods, and the rhizomes are extremely resistant to fires (Dransfield & Widjaja 1995).

Potential uses: to manufacture furniture and for handcrafts. For agriculture and cattle infrastructure, to build ceilings and divisions.

Figure 2. Bamboos of the Bambuseae tribe: Paleotropical clade. Bamboos of the subtribe Bambusinae: a. *Bambusa multiplex*; b. *B. vulgaris* var. *vittata*; c. *B. longispiculata*; d. *Dendrocalamus asper*; e. *B. oldhamii*; f. *D. brandissii*; g. *Gigantochloa apus*. Bamboo of the subtribe Melocananninae: h. *Melocanna baccifera*

3.4. Arundinarieae Tribe

Woody bamboo plants, rhizomes leptomorph or pachymorph. The culms are usually hollow. Basipetal development of branches. Foliage with an external ligula present over the foliar sheath. Complex central nervature. Spikelets laterally compressed. 2n=48. It includes 26 genera, 533 species and 12 clades (Kellogg 2015).

This tribe includes all the woody bamboos of temperate countries or of countries with seasons; it is a monophyletic group according to molecular studies. The culms of the Arundinarieae species, the same as in the Bambuseae tribe, reach their total height without branching, only protected by the culm leaves, and initiate the culm lignification and branching process later. In Arundinarieae the production of branches with foliage always take place from the top down, what is known as a basipetal development of the branches (Bamboo Phylogeny Group 2012; Kellogg 2015).

Species registered: in the area of study of the Bambuzonia project, in Ecuador and Peru, only one species of this tribe was reported belonging to *Phyllostachys,* Clade V according to Kellogg (2015).

1. ***Phyllostachys aurea* (André) Rivière & C.Rivière**

This species originates in the subtropics of China and Japan, and has been introduced to most countries of the world (Figure 3). It is a species with extensive capacity of climatic and soil adaptation; it is more resistant to low temperatures that *Bambusa vulgaris var. vittata* and grows in deep, fertile, well drained soils (Dransfield & Widjaja 1995).

In America it has been cultivated in almost every country, in an altitudinal range of between 400-2200 m asl. It develops better above 1000 m asl. It has been recorded that the lower the altitude the culms are less tall and have a smaller diameter. It goes by the names of "*guaduilla*" (Colombia & Ecuador) and "*bambusillo*" in Peru. (Londoño 2021b, 2021c). This species that has leptomorph rhizomes must be controlled so that it doesn't become an undesirable plant, however it is ideal to control erosion in areas having steep slopes.

Phyllostachys aurea forms diffuse stands, with leptomorph rhizomes. The culm is erect, hollow, has a length of 2-12 m and a diameter of 2- 4 (-6) cm. When young it has a green color covered by a whitish wax. The length of commercial internodes fluctuates between 15-25 cm with a wall thickness of between 0.5 cm (internodes of the basal section) and 0.2 cm (internodes of the apical section) (Londoño 2021b, 2021c).

According to Dransfield and Widjaja (1995) its strong and flexible culms are used to make fishing rods, ski poles, canes, javelins, and to build lightweight structures. They are also used to manufacture handcrafts, furniture, umbrellas, fans, and other souvenirs. Its fiber is used to make handmade paper. The new shoots are used as food and have a very good quality. It is

used as an ornamental plant, however its leptomorph rhizome shows a very rapid growth in all directions.

Potential use: to produce edible shoots, for the basketry industry, to manufacture furniture and handcrafts with modern and innovative designs (Londoño 2021b, 2021c).

Figure 3. Bamboo of the Arundinarieae tribe: a., b., c. *Phyllostachys aurea*

Olyreae Tribe

Herbaceous bamboo plants, caespitose. Culm leaves do not develop. The foliage leaf sheath lacks an external ligula and usually does not present auricles or fimbriae. Inflorescence is usually axillar and terminal, some are born on culms without leaves and separated from the vegetative culm. Monoecious plants, usually with evident pistillate spikelets and small staminate spikelets. The spikelet is dorsally-ventrally compressed, with a floret and without a rachilla extension (Figure 4). It includes 23 genera and 131 species (Oliveira et al. 2014; Kellogg 2015).

This tribe includes herbaceous bamboos both of tropical and subtropical countries. In America it is distributed from Mexico and the Caribbean Islands to Argentina and Paraguay. The Olyreae species are mainly found in the understory of the jungle or in the border of the jungle, they are less common in open and humid ecosystems (Judziewicz et al. 1999; Oliveira et al. 2014).

The phylogenetic group of bamboo (BPG 2012) indicated that there is no morphological synapomorphies for this tribe, even though the fact of being Monoecious is a synapomorphy within the context of the Bambusoideae subfamily.

This tribe requires more molecular studies, however, the studies up to date recognize 3 subtribes: Buergersiochloinae, Parianinae and Olyrinae (Oliveira et al. 2014).

A total of 14 species belonging to the Olyreae tribe were registered in the area of study of the Bambuzonia project in Colombia, Ecuador and Peru, with the following distribution: 4 genera and 9 species belonging to the Olyrinae subtribe and 1 genus and 5 species belonging to the Parianinae subtribe (Table 4).

Table 4. Genera and number of species per genus of the Olyreae tribe collected in the area of the study

Genera (No. spp.)	Colombia	Ecuador	Peru
Cryptochloa (1 sp.)	X	X	
Lithachne (1 sp.)			X
Olyra (6 spp.)	X		X
Raddiella (1 spp.)	X		
Pariana (5 spp.)	X	X	X

3.5.1. Olyrinae Subtribe

Herbaceous bamboo plants, caespitose, connected by rhizomes or stolons. They are usually perennial, occasionally scandent (*Olyra latifolia*), and don´t develop fimbriae in the upper portion of the foliar leaf sheath. Monoecious bamboos with dimorphic spikelets, unisexual, feminine spikelet with a hardened lemma and palea, and a masculine spikelet with 3 stamens (Judziewicz et al. 1999; Kellogg, 2015).

Species registered: nine species of this subtribe were reported in the Bambuzonia project area of study in Colombia, Ecuador and Peru: *Cryptochloa unispiculata* Soderstr., *Lithachne pauciflora* (Sw.) P. Beauv., *Raddiella esenbeckii* (Steudel) C.Calderón & Soderstrom, *Olyra ecaudata* Doell, *Olyra fasciculata* Trin., *Olyra latifolia* L. and the identity of three more species (*Olyra* spp.) is still pending.

1. *Olyra ecaudata* Doell

Herbaceous bamboo. It is distributed in Central and South America. In the Bambuzonia project it was reported in the central jungle of Peru, between 800 and 1100 m asl. It has opaque green culms of up to 2 m in height, diameter of 3 mm, a small lumen, long internodes of up to 80 cm in length. The foliar leaf blade with a cordate base, 25-35 cm in length x 4-8 cm in width, on the abaxial surface it is rough to the touch; the foliar leaf sheath has a pronounced and dark ring on the base. Inflorescence in an open panicle, with a purple color in the base of the branching.

Environmental services: contributes to curb erosion in the ravines, to conserve the local entomofauna and the microbial wealth of the soil (Londoño 2021c).

Potential use: no traditional use was recorded. However, it has a great potential as an ornamental plant, because of the color of its inflorescence and the cordate shape of the foliar leaf blade. The culms of *Olyra ecaudata* can be used to make delicate handcrafts or straws (Londoño 2021c).

2. *Olyra fascicualata* Trinius

Herbaceous bamboo that grows in the central part of Peru, in Bolivia, Brazil, Paraguay and the North of Argentina. It grows in open spaces, slopes, and ravines on the side of the roads, between 500 and 1000 m asl. It is characterized because it has in its feminine spikelets a soft tissue with abundant oil, probably to attract ants for seed dispersal (Londoño 2021c).

Olyra fascicualata is characterized because it has culms with a height of 2-3 m, a diameter of 0.5-1 cm, internodes with a length of 25-65 cm, with a very conspicuous dark ring in the base of the foliar leaf sheath. Inflorescence in an open panicle having a purple color where you can see the contrast of the masculine flowers, completely purple, with the color of the feminine flowers that have a green color at the base and purple in the mid and upper parts (Londoño 2021c).

Ecosystemic services: contributes to curb erosion in the ravines, to conserve the local entomofauna and the microbial wealth of the soil (Londoño 2021c).

Potential use: no traditional use was recorded in the area of activity of the Bambuzonia project. However, it has a great potential as an ornamental plant, because of the color of its inflorescence and the width of its foliar leaf blade. The culms of up to 1 cm in diameter can be used to make biodegradable straws (Londoño 2021c).

3. *Olyra latifolia* L.

This herbaceous bamboo has the most widespread distribution in the world (Judziewicz et al 1999). In the neotropics it is distributed from the northeast of Mexico and the Caribbean islands to the north of Argentina, Paraguay and the south of Brazil. It has also been reported in tropical Africa and Madagascar (Judziewicz et al. 1999). It is abundant in the Amazonian tropical rainforest, where it is observed growing in the clearings of the jungle, in the understory, or over the ravines on the sides of the roads (Londoño 2022). It is also

characterized because it is the largest herbaceous bamboo of the world. It common name is "*sacha-trigo*" or "*pingulla-shucush*" (Londoño 2021c).

Olyra latifolia is erect or scandent. Its culms are hollow, spotted with purple, covered by irritant pilous when young, herbaceous to slightly woody, their height goes from 1-4 m and up to 1 cm in diameter, with a wall thickness of 2 mm. The length of the basal internodes is 10-20 cm. The length of the internodes in the middle portion is 30-40 cm. It is grouped forming small to robust stands. It is characterized because it has very wide foliar leaf blade, from that its specific nickname "latifolia", which can measure up to 8 cm in width and 26 cm in length.

Ecosystemic services: contributes to the conservation of the entomofauna of the tropical rainforest and the microbial wealth of the soil (Londoño 2021c).

Local and/or ancestral uses: its thin, split culms are used as a knife by several Amazonian tribes to cut the umbilical cord of newborns. There are records of its use as a fungicide by the Cuna indigenous communities of Panama and Colombia (Londoño 2021c).

Potential use: to manufacture biodegradable straws, and to act as a support for indoor plants such as orchids. As an ornamental plant. (Londoño 2021c).

3.5.2 Parianinae Subtribe

Herbaceous bamboo plants, caespitose, connected through rhizomes or stolons. With fimbriated auricles in the upper part of the foliage leaf sheath. Single terminal inflorescence, without branching. The terminal pistillate spikelets are surrounded by multiple staminate spikelets, with a hardened and flat pedicel. The filaments of the stamens are fused (Kellogg 2015).

This subtribe includes the *Ermitis* Doell and *Pariana* Aubl genera.

Species registered: only species of the genus *Pariana*: *Pariana campestris* Aubl., *Pariana* aff. *aurita* Swallen and three more species without a defined identity were reported in the Bambuzonia Project area of study.

1. ***Pariana campestris* Aubl.**

   Herbaceous bamboo, abundant in the area of activities of the Bambuzonia project. It is mainly distributed in the Colombian, Ecuadorian, Venezuelan, Guyana, Peru and Brazil Amazon regions, in the understory of the jungle. It is commonly known as "*papelillo*",

"*tebocabo*" (Aucas) or "*Tury-yee*" (Yukunas) (Judziewicz et al. 1999). This species frequently grows in areas that flood periodically forming dense colonies under the shadow of the tree vegetation of the jungle, but is dominant in the jungle clearings where it forms small patches. It is also located over ravines and in the creek banks. *Pariana campestris* rarely grows in low montane jungles under 1500 m asl (Judziewicz et al. 1999).

Pariana campestris shows rhizomes in stolons. Erect, thin, hollow culms with pronounced nodes in the nodal region. It measures from 0.5-1.5 m in height, with diameters between 0.2-0.5 cm; a lineal-lanceolate foliar lamina, with fimbriae in the upper part of the foliar sheath. It produces inflorescence at the end of the foliar complement, very bright and colorful, of a yellow color that are characterized for hosting multiple flower fascicules, exhibiting yellow anthers, loaded with grains of pollen to attract the pollinizing insects (Londoño 2021a, 2021b).

Ecosystemic services: contributes to the conservation of the biological wealth of the Amazon forest, to the conservation of the Amazon entomofauna and the conservation of the insects that pollinate it. It also contributes to the conservation and quality of the amazon soils (Londoño 2021a, 2021b).

Local and/or ancestral uses: the Wuaorani communities of Colombia and Ecuador use this species as a cure for snake bites, and they use the ashes of the plant to heal wounds (Londoño 2021a). They also inhale its smoke to cure several body pains. The Embera-Chamí community of the Chamí-Purú indigenous reservation inform that their healers use the dry branches of *Pariana* in the yage (*Banisteriopsis caapi*) ceremonies because it produces a very special sound when they use it to fan their patients.

Potential use: they have great potential as an ornamental plant because of its medium size and the intense color of its leaves. The branches could be used for floral arrangements or as dry foliage since the leaves do not detach from the branches easily (Londoño 2021a, 2021b).

1. ***Pariana* aff. *aurita* Swallen**

The *Pariana aurita* specie is endemic from Peru, however, this specie that is very similar was collected in the municipality of Florencia, District of El Caraño, township of Sardinas (Colombia) at 314 m asl in the jungle´s understory. It grows in the understory of the tropical rainforest, in bush ecosystems where it forms small patches. It is also located over humid

ravines and on creek Banks, in an altitudinal range of between 200 and 500 m asl (Londoño 2021a).

Pariana aff. *aurita* is characterized by its stoloniferous rhizomes, erect, thin, hollow culms, with pronounced nodes in the nodal region that has a height of 0.5-0.7 m, with diameters between 0.3-0.5 cm; the foliar leaf blade is ovate-lanceolate, with a maximum size of 3 cm of width and 16 cm in length, it has a green color on the upper side and whitish on the underside, an auriculate and fimbriated foliar leaf sheath in the upper part. It produces inflorescence terminal to the foliar complement of a pale yellow color.

Ecosystemic services: contributes to the conservation of the biological wealth of the Amazon forest, to the conservation of the entomofauna of the area and the conservation of the insects that pollinate it. It also contributes to the conservation and quality of the amazon soils (Londoño 2021a).

Local and/or ancestral uses: according to Huitoto communities, they use this specie to produce sounds in the "*yage*" ceremony, but they use it after the foliage leaf dries.

Potential use: it has potential as an ornamental plant because of its medium size and its two-colored foliar leaf blade; it can be grown for the healers who use yage (Londoño 2021a).

Figure 4. Bamboos of the Olyreae tribe. Bamboos of the subtribe Olyrinae: a. *Cryptochloa unispiculata*; b. *Raddiella esenbeckii*; c. *Olyra fasciculata*; d. *O. ecaudata*; e. *Lithachne pauciflora*. Bamboo of the subtribe Parianinae: f., g. *Pariana campestris*; h. P*ariana* aff. *aurita*

Conclusion

The area of action of the Bambuzonia project is diverse in Bambusoideae and has optimal climatic and soil conditions for the growth of bamboos. During the study 61 specimens were collected and studied. A total of 28 native bamboo species belonging to 10 genera, and 13 exotic bamboos belonging to 5 genera were identified. The native genera including the largest number of species are *Guadua* with seven species (25%), *Olyra* with six species (21%) and *Pariana* with five species (18%).

In Colombia 12 native species and 3 exotic species were identified; for Ecuador 10 native species and 12 exotic species, and for Peru 15 native species and 6 exotic species were identified. Peru is the country reporting the largest diversity of native species (15 spp.), with

9 species of woody bamboos and 6 spp. of herbaceous bamboos. It must be noted that the Central Jungle of Peru, Department of Pasco, sector of Bajo Bocaz was the site were the greatest diversity of bamboo genera and species was recorded among all the places visited in the area of influence of the Bambuzonia project.

Ecuador reported the most diversity and largest area cultivated with exotic bamboos, diversity that is probably due to the introduction of Asian species in the Experimental Station of Pichilingue, Province of Los Ríos in 1945 by Dr. Floyd McClure, species that have been distributed to other provinces of the country. *Dendrocalamus asper* is the exotic species that has the greatest impact at the national level, with more than 2000 hectares already established.

For the indigenous communities that inhabit this Amazon region, bamboo has been a plant with a very valuable traditional connotation in the medicinal, ceremonial and utilitarian areas. The expectation is that with the taxonomic identification of the species that inhabit the area of influence of the Bambuzonia project (FIDA-INBAR) contributes to their conservation and to a better appropriation of this botanical wealth by the inhabitants of the area.

Conflict of Interest

The authors declare there is no conflict of interest

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