

## Original Paper

# Flora of Anacardiaceae in the Upper Paraná Atlantic Forest

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### Abstract

The Atlantic Forest has one of the richest floras in the world and floristic surveys are essential to understand its biodiversity and promote its conservation. This study aims to contribute to the floristic understanding of Anacardiaceae in the Iguacu National Park (Brazil) and the Iguazú National Park (Argentina). Monthly samplings were performed from 03/2019 to 02/2020 and sporadic samplings from 11/2020 to 01/2021 in the main trails from both parks, as well as herbarium review and surveys on virtual platforms. Two native species: *Lithraea molleoides* and *Schinus terebinthifolia*, and two exotic cultivated species: *Mangifera indica* and *Spondias purpurea* were found in the Iguacu National Park and only one native species, *Schinus terebinthifolia*, in the Iguazú National Park. Identification key, descriptions, photographs with diagnostic characters of the taxa, taxonomic comments, geographical distribution, phenology, common names, uses and observations are provided.

**Key words:** Iguacu National Park, Iguazú National Park, *Lithraea*, *Schinus*.

### Resumen

El Bosque Atlántico tiene una de las floras más ricas del mundo, siendo los relevamientos florísticos imprescindibles para el conocimiento de su biodiversidad y conservación. Este trabajo tiene como objetivo contribuir al conocimiento florístico de Anacardiaceae del Parque Nacional do Iguacu (Brasil) y del Parque Nacional de Iguazú (Argentina). Se realizaron colectas mensuales desde 03/2019 a 02/2020 y esporádicas de 11/2020 a 01/2021, en los principales senderos de ambos parques, visitas a herbarios y consultas en las plataformas virtuales. Se encontraron dos especies nativas: *Lithraea molleoides* y *Schinus terebinthifolia*, y dos especies exóticas cultivadas: *Mangifera indica* y *Spondias purpurea* en el Parque Nacional do Iguacu y solamente una especie nativa, *Schinus terebinthifolia*, en el Parque Nacional Iguazú. Se presenta una clave de identificación de las especies, descripciones, fotografías con caracteres diagnósticos, comentarios taxonómicos, distribución geográfica, fenología, nombres comunes, usos y observaciones.

**Palabras clave:** Parque Nacional do Iguacu, Parque Nacional Iguazú, *Lithraea*, *Schinus*.

### Introduction

Anacardiaceae species stand out due to the economic significance of their edible fruits such as mango *Mangifera indica* L., cashew nut *Anacardium occidentale* L., rose pepper *Schinus* L. and mombins *Spondias* L., their beverages, good quality timber, medicinal properties, ornamentals,

and the industrial employment of their resins and tannins (Font Quer 1964; Judd *et al.* 2009; Muñoz 2000; Pell 2009; Pell *et al.* 2011; Simpson 2006; Stevens 2023; Souza & Lorenzi 2019; Silva-Luz *et al.* 2021; Mitchell *et al.* 2022). Many species are used in reforestation and ecological restoration planning due to their pioneer character, as well

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as species with a high invasive potential such as rose pepper *Schinus terebinthifolia* Raddi which produces easily dispersed drupes, specially by birds (Lowe *et al.* 2004; Silva-Luz 2011).

Anacardiaceae are typically woody aromatic plants with resiniferous, lactiferous or tannin ducts, frequently allergenic, harmless or thorny, with simple or pinnate leaves, cymose inflorescences, actinomorphic flowers, pentamerous, isostemonous or obdiplostemonous, dialypetalous, with annular intrastaminal nectariferous disc and fruits generally drupe, single-seeded, never dehiscent (Simpson 2006; Pell 2009; Pell *et al.* 2011; Souza & Lorenzi 2019; Silva-Luz *et al.* 2021). Terrazas (1994) was the first to hypothesize the monophyly of the family, using genetic sequences of the *rbcL* chloroplast, along with wood morphology and anatomy. Consequently, inter and intra-specific relations in the family were confirmed through combined molecular and/or morphological analyses by specialists (Pell 2004; Wannan 2006; Silva-Luz *et al.* 2019; Bordignon & Vogel 2020). It includes 81 genera and 800 species, distributed mainly in tropical and subtropical regions, but also extends to temperate regions, in diverse dry and humid habitats, mostly low lands (Pell 2009; Pell *et al.* 2011; Silva-Luz 2011; Silva-Luz *et al.* 2021; Mitchell *et al.* 2022). The highest diversity within the family is located in the tropics and its center of origin is Southeast Asia, with Paleotropical regions being richer than Neotropical ones, with ca. 200 species and 32 genera (Mitchell *et al.* 2022). Anacardiaceae shows a wide geographic range, as well as ecological and morphological diversity, which reflects mainly in the quantity of genera, due to their fruit morphology and the dispersion syndromes of the seeds (Weeks *et al.* 2014; Mitchell *et al.* 2022). Seven genera and 33 species are found in Argentina (Flora Argentina 2021) and 15 genera and 64 species in Brazil, of which 10 genera and 23 species are listed in the Brazilian Atlantic Forest (Stehmann *et al.* 2009; Silva-Luz *et al.* 2021).

Atlantic Forest is a global biodiversity *hotspot* (Mittermeier *et al.* 2011), its Southeast fraction constitutes the Alto Paraná Atlantic Forest (BAAP), distributed mostly in the second and third plateaus in the state of Parana up to the western slope of the Serra do Mar in Brazil, to the eastern Paraguay and northwest of Argentina (Di Bitetti *et al.* 2003; Labiak 2014). Currently, only 5% of its original area remains still preserved, due to the advance of the agricultural and livestock frontier, with a varying conservation status and fragmentation degree within each of these

countries, in virtue of historical, productive and demographic peculiarities (Di Bitetti *et al.* 2003; Giraudo *et al.* 2005). The Parque Nacional do Iguaçu (ParNa Iguaçu) and Parque Nacional Iguazú (ParNa Iguazú) are comprehended within this eco-region, located in Brazil and Argentina, respectively, and despite of its fragmentation these are the largest remains with full protection. Regarding its floristic composition, Souza *et al.* (2019) identified a total of 54 families, 135 genera and 218 species in the ParNa Iguaçu, while Srur *et al.* (2009) identified 94 families, 239 genera and 411 species in the ParNa Iguazú. Anacardiaceae was one of the families recorded in both studies, but no floristic studies were accomplished for the family in BAAP.

The present study aimed to provide a floristic survey of Anacardiaceae within the Parque Nacional do Iguaçu (Brazil) and the Parque Nacional Iguazú (Argentina). Dichotomous keys for taxa with diagnostic vegetative and reproductive characters, taxonomic comments, common names, uses, geographic distribution, habitat, phenology, scientific illustrations and/or photographs and comments, are proposed.

## Material and Methods

This work was performed in the Parque Nacional do Iguaçu (ParNa Iguaçu), Paraná state, Brazil and the Parque Nacional Iguazú (ParNa Iguazú), Misiones province, Argentina; both parks are located in the ecoregion of the Atlantic Forest of the Alto Paraná. Nevertheless, both parks share a subtropical humid mesothermal climate, being comprehended in the Cfa Köeppen's classification, with a transitional climate between tropical and temperate, with hot rainy summers and high annual precipitation average (1,500 to 2,000 mm), without a defined dry season and low probability of frosts (Alvares *et al.* 2013; IAPAR 2018). Subtropical rainforest constitutes the predominant vegetation in both parks, with different communities according to the local environmental conditions, type of soil and dominant arboreal species (Cabrera 1971; Di Bitetti *et al.* 2003). Some typical communities include the “canela-preta” *Nectandra megapotamica* (Spreng.) Mez and “marfim” *Balfourodendron riedelianum* (Engl.) Engl. forests in deep lateritic soils, the palm *Euterpe edulis* Mart. and “peroba rosa” *Aspidosperma polyneuron* Müll. Arg. forests, the bamboo forests and *canela* forests of various *Nectandra* Rol. ex Rottb. and *Ocotea* Aubl. species (Cabrera 1971; Giraudo *et al.* 2005; Srur *et al.* 2009).

The ParNa Iguaçu is located mainly in the municipalities of Céu Azul, Matelândia, São Miguel do Iguaçu, Serranópolis do Iguaçu and Foz do Iguaçu, in the state of Paraná, Brazil; with an area of 185.262 hectares; from 25°05' to 25°41' South latitude and 53°40' to 54°38' West longitude (Souza *et al.* 2017, 2019). It is located in the Third Plateau of Paraná, predominantly constituted of Oxisols at altitudes varying from 750 m in the north to 100 m in the south, limited by the hydrographic basin of the Iguaçu River (Souza *et al.* 2017, 2019). ParNa Iguaçu is constituted of 85% semi-deciduous seasonal forest or *Floresta Estacional Semidecidual* (FES) in the southern and central fragments, where the stationary climate determines the physiological rest (drought due to the cool winter); resulting in the semi-deciduous foliage of 20–50% of the trees. Further north there is 15% of Araucaria Forest, Montano Mixed Ombrophilous Forest or *Floresta Ombrófila Mista* (FOM), which are forests with higher altitude, cooler temperatures and high precipitation, resulting in more rigorous winters and characterized by the dominance of the *Araucaria angustifolia* (Bertol.) Kuntze in the upper stratum of the canopy (IBGE 2012; Souza *et al.* 2017).

The ParNa Iguazú Park includes the Reserva Nacional Iguazú and the Parque Nacional Iguazú, with an area of 67,000 hectares at 25°58' South latitude and 54°13' West longitude, located in the district of Iguazú, province of Misiones, Argentina (Srur *et al.* 2009). Soils are predominantly deep Ultisols with high concentration of iron, aluminum and silicon, high contents of reactive nitrogen and low contents of phosphorus (Srur *et al.* 2009). The topography shows smooth tableland-like undulations with altitudes varying from 125 m to the north, on the west limit and beginning of the Inferior Iguazú River; to 380 m to the southwest over the Yacuí creek (Srur *et al.* 2009). The vegetation is exclusively constituted of Semi-Deciduous Seasonal Forest (FES) (Cabrera 1971; Giraudo *et al.* 2005; Srur *et al.* 2009).

To complete the survey in both protected areas, the area was divided in five parts (Fig. 1): ParNa Iguaçu with four areas comprehending Céu Azul in the north, Capanema in the south and Foz do Iguaçu in the west; and ParNa Iguazú with an area in the southwest.

Area 1, Céu Azul, included the trails: Fazenda Rio Butu, Nascentes do Jumelo, Araucárias, Cachoeira rio Azul, Manoel Gomes and Jacutinga (Fig. 1A-F), characterized predominantly by FOM with transition to FES, with altitudes from 400 to

700 m. Area 2 of Matelândia/Serranópolis (Fig 1G) has predominantly a FES forest formation and altitudes from 150 to 450 m. Area 3, Capanema, included the trails: riverbanks of Iguaçu River in the Brazilian side, Cachoeira rio Silva-Jardim and Ilha do Sol (Fig. 1H-J), characterized predominantly by FES and altitudes from 150 to 250 m. In the area 4 of Foz do Iguaçu the trails were: Poço Preto, Represa São João, Antiga Usina, Escola Parque, Macuco Safari, Bananeiras, Cataratas and Hidrante (Fig. 1K-R), with vegetation predominantly FES and altitudes from 100 to 270 m. In the area 5, of Puerto Iguazú, the following trails were included: Sendero Verde, Paseo Inferior & Superior, Garganta del Diablo, Macuco, trail to Hidrómetro, along the National Route 12 and Provincial Route 101 (Fig. 1), with vegetation predominantly FES and altitudes from 125 to 380 m.

The floristic survey was performed following the Walking Method (Filgueiras *et al.* 1994) with monthly samplings from March 2019 to March 2020 and sporadic sampling from November 2020 to January 2021. The specimens were gathered and incorporated in the Herbarium Evaldo Buttura (EVB, acronyms following Thiers, continuously updated), from the UNILA (Foz do Iguaçu), for specimens from the ParNa Iguaçu. The specimens collected in the ParNa Iguazú were processed at the Centro de Investigaciones Ecológicas Subtropicales (CIES) before being stored at the Instituto de Botánica del Nordeste (CTES) and Instituto de Botánica Darwinion (SI). The material was photo documented and herborized according the method described by Gadelha-Neto *et al.* (2013).

In addition to sampled materials, specimens from the herbaria CTES, EVB, MBM, SI, UNOP and UPCB were reviewed. All data available from sampling expeditions were used, as well as virtual specimens from Jabot (2021), ReFlora (2021) and SpeciesLink (2021); for confirmed species on virtual platforms from HCF, IBGE, RB and UFMT herbaria. The *Documenta Florae Australis* (Flora Argentina 2021) database, which includes an updated inventory on the vascular flora from Argentina and South America, was also used.

Specialized literature was used in order to identify the species, such as monographs from specialists, taxonomic reviews and keys (Barkley 1944, 1962; Cabrera 1938; Mitchell & Daly 2015; Mitchell *et al.* 2022; Muñoz 1990, 1999, 2000; Pell 2009; Pell *et al.* 2011; Pirani & Silva-Luz 2018; Santos *et al.* 2008; Silva-Luz 2011; Silva-Luz *et al.* 2019).

Scientific names and authors were verified in the nomenclatural database The International Plant Names Index (IPNI 2021). Terminologies were used according Lindley (1951), general terminology according Font Quer (1953), Hickey (1973) for morphology and leaf venation patterns, Stearn (1992) for Latin terminology and Ellis *et al.* (2009) for leaf architecture.

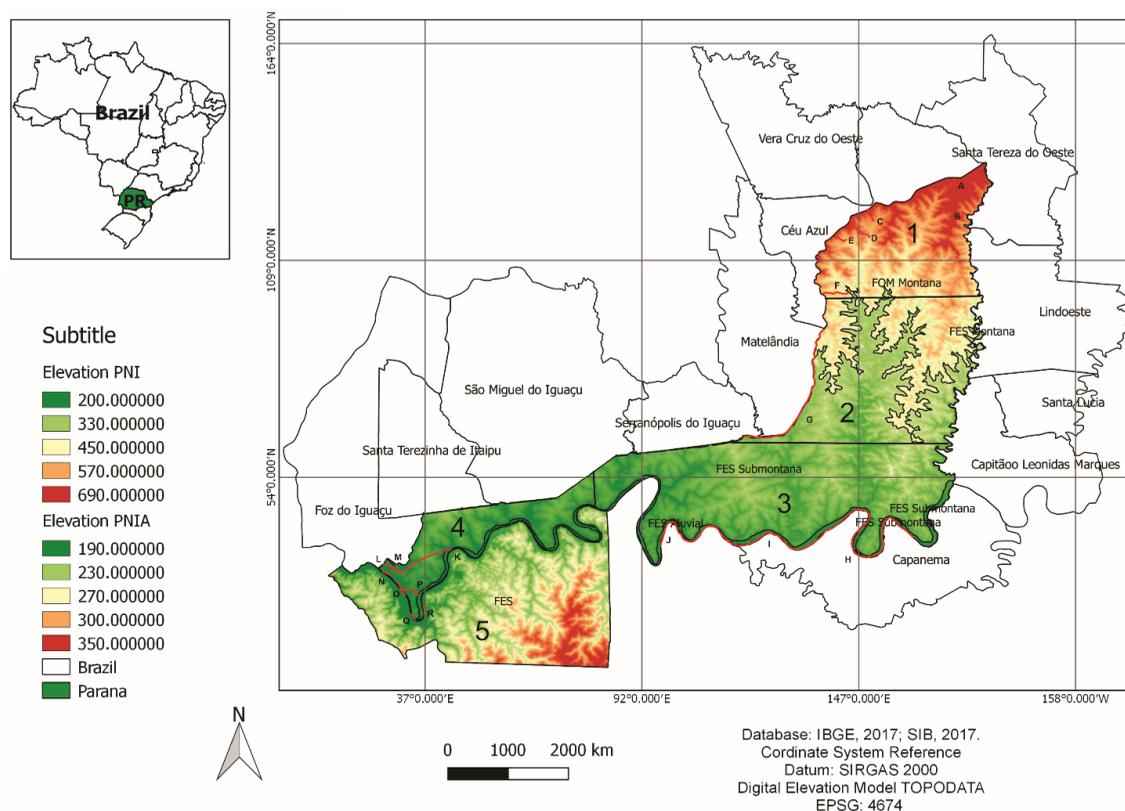
## Results

A total of 12 field expeditions were completed and six of our own gatherings plus six gatherings from other collectors were analyzed, identifying two exotic and two native species in the ParNa Iguaçú Park. In the Argentinian side, ParNa Iguazú Park, seven field expeditions were completed with only one own gathering and 10 from other collectors, identifying only one native species (Tab. 1).

## Taxonomic treatment

### Anacardiaceae.

Trees or shrubs, evergreen or deciduous, with or without thorns, aromatic, with resin ducts in the whole plant, with tannins, resins or toxic latex, caustic or irritating, dioecious, monoecious, andromonoecious or polygamous. Leaves alternate, rarely opposite or verticillate, simple or composite imparipinnate; leaflets alternate, opposite or subopposite, blades oblong, lanceolate, elliptic or obovate, membranous, chartaceous or coriaceous, margin entire, serrated, dentate or crenate, venation pinnate. Inflorescences panniculate or cymose, rarely spikes or solitary flowers, terminal and/or axillar, non-elongated; bracts and bracteoles deciduous or persistent. Flowers bisexual and/or unisexual by abortion of one sex, actinomorphic, cyclic, (3–4)5-merous with valvate



**Figure 1** – Map of ParNa Iguaçú and ParNa Iguazú areas with the trailed sampled. – Area 1 - Céu Azul, A: Fazenda Rio Butu; B: Nascentes do Jumelo; C: Araucárias; D: Cachoeira Rio Azul; E: Manoel Gomes; F: Jacutinga. Area 2 - Matelândia / Serranópolis, G: Matelândia. Area 3 - Capanema, H: Banks of Rio Iguaçú on the Brazilian side; I: Cachoeira Rio Silva-Jardim; J: Ilha do Sol. Area 4 - Foz do Iguaçú, K: Poço Preto; L: Represa São João; M: Antiga Usina; N: Escola Parque; O: Macuco Safari; P: Bananeiras; Q: Cataratas; R: Hidrante. Area 5 - ParNa Iguazú (Modified from Hammes *et al.* 2021).

or imbricate aestivation, heteroeclymydeous, sometimes monochlamydeous or naked, iso to obdiplostemonous, sessile or with generally articulated pedicel; calyx (3–)4–5-merous, sepals free, basal or rarely totally welded and cupular, deciduous to persistent; corolla (3–)4–5(–8)-merous, petals free; stamens (1–)5–10(+), diadelphous, anthers oblong or ovoid;

intrastaminal nectariferous disc present, rarely extrastaminal, annular, crenate or lobed; ovary superior, (1–)3–5(–12)-carpelate, 1–(5–12)-locular, 1-ovulated, styles 1–5 free, terminal or lateral. Drupe, samara, achene or berry, sometimes with fleshy hipocarp or fleshy or cretaceous accrescent calyx, resinous black mesocarp, bony endocarp. Seeds 1–5(–12).

**Table 1** – List of species in BAAP with status (exotic, native), state of conservation according IUCN (2020) and CNCFlora (2021) (LC = little concern; NE = not evaluated) and vegetation type (FES = Semideciduous Seasonal Forest; FOM = Ombrophilous Mixed Forest) by area in ParNa Iguaçu and ParNa Iguazú.

Specie	Status	UICN	CNC	ParNa Iguaçu				ParNa Iguazú
				1	2	3	4	5
<i>Lithraea molleoides</i> (Vell.) Engl.	Native	LC	NE	FOM	-	-	-	-
<i>Mangifera indica</i> L.	Exotic	-	-	-	-	-	FES	-
<i>Schinus terebenthifolia</i> Raddi	Native	NE	NE	FOM	FES	-	FES	FES
<i>Spondias purpurea</i> L.	Exotic	-	-	FOM	-	-	-	-

### Key for Anacardiaceae species in the Alto Paraná Atlantic Forest

1. Simple leaf; nectariferous disc extrastaminal, gynoecium 1-carpelar; drupe more than 7 cm long ..... 2.1. *Mangifera indica*
- 1'. Compound leaf; nectariferous disc intrastaminal, gynoecium 3–5-carpelar; drupe up to 5 cm long.
  2. Leaf rachis wingless, leaflet with intramarginal venation; flower reddish to purple, gynoecium 5-carpelar; drupe oblong or ovoid with thick non-papyraceous exocarp ..... 4.1. *Spondias purpurea*
  - 2'. Leaf rachis winged, leaflet without intramarginal venation; flower white or yellow, gynoecium 3-carpelar; drupe globose, with thin papyraceous exocarp.
    3. Leaf 3–5-foliolate, prominent marginal vein; flowers yellow, corolla valvar, anthers basifixed; drupe laterally compressed, cream and greyish ..... 1.1. *Lithraea molleoides*
    - 3'. Leaf 9–11-foliolate, non-prominent marginal vein; flowers white, corolla imbricate, anthers dorsifixed; drupe non-laterally compressed, pinkish, reddish to purple ..... 3.1. *Schinus terebinthifolia*

#### 1. *Lithraea* Miers, Trav. Chile 2: 529 (1826).

Trees or shrubs, evergreen, without thorns, polygamous-dioecious. Leaves alternate, simple or compound, imparipinnate, coriaceous, petiole and rachis winged. Panicles axillar or terminal. Flowers unisexual, 5-merous, obdiplostemonous, pedicellate, articulate; calyx 5-parted, open and imbricated; corolla 5-parted, valvar; stamens 10, equal, anthers basifixed; gynoecium 3-carpelar, 1-locular, 1-ovulated, style 3, stigmas extrorsed, truncated. Drupe globose, exocarp thin, lustrous,

papyraceous splitting when mature from the mesocarp, resiniferous, black, endocarp rough bony. Seed 1.

South American genus with 3 species, distributed from central Chile to Bolivia, Paraguay, Uruguay, Argentina and south of Brazil (Muñoz 2000; Silva-Luz 2011; Flora Argentina 2021).

From *litre*, common name given in Chile to *Lithraea caustica* (Molina) Hook. & Arn. (Muñoz 2000).

**1.1. *Lithraea molleoides* (Vell.) Engl., *Fl. bras.* (Martius) 12(2): 394, t. 83 (1876).** Fig. 2a-d

Tree up to 8(–12) m height, without thorns, greyish bark with lenticels. Leaves compound imparipinnate, 3–5(–7)-foliolate, 7–14 cm long, petiole and rachis winged and canaliculated; leaflets 3–12 × 0.7–2(–2.5) cm, the terminal one larger, opposite, sessile, glabrous, blade lanceolate or oblong-lanceolate, margin integral, apex acuminate, base cunate, marginal vein prominent, intramarginal vein absent. Panicles 2.5–7(–10) cm length, puberulous. Flowers green-yellowish and yellow, fragrant; intrastaminal nectariferous disc, 10-lobed. Drupe globose, laterally compressed, 0.5–0.8 cm length, cream to greyish, exocarp thin, papyraceous.

**Examined material:** Céu Azul, ParNa Iguaçu, cercanias da BR-277, 16.IX.2016, fl., *Caxambu et al. 7506* (HCF, IBGE, UFMT); 7.I.2020, fr., *Panizza & Hentz 154* (EVB).

In Bolivia, central-west and southeast Brazil, east of Paraguay, Uruguay and central Argentina; inhabits FES, riverside forest and “cerrado” forming islets (Muñoz 1990, 2000; Silva-Luz 2011; BFG 2015; Pirani & Silva-Luz 2018). Common in river margins and streams, in low and floodable soils and anthropized areas (Muñoz 1990; Silva-Luz 2011; BFG 2015). Found only in a single area North of the five areas evaluated in the present study.

The epithet probably due to its resemblance to “molle” (pepper tree), common name of *Schinus*.

Flourishes in September with fruits in January, agreeing with Muñoz (1990) who verified it blooms mainly in August and September, with weaker blooming in April; fructifies from September to December, with fruits remaining in the plant deteriorating slowly; while according Silva-Luz (2011) it flourishes and fructifies practically the whole year.

The common names are “Aroeira branca”, “Aroeira brava”, “Aroeira miuda”, “Aroerinha”, “Chichita”, “Corazón de bugre”, “Molle de beber”, “Molle dulce”, “Molle guasú” (molle is the designation for all trees from the genus *Schinus* and guasú = big), “Palo Negro” (Cabrera 1938; Barkley 1962; Muñoz 1990, 1999, 2000; De La Peña & Pensiero 2011; Silva-Luz 2011).

Quality timber for carpentry, lamppost fabrication and firewood, the bark is rich in tannins which provide resistance against putrefaction and an essential oil is extracted from the exudate gum-resin (Cabrera 1938; Muñoz 2000; Juárez

de Varela & Novara 2012). Medicinal as diuretic and digestive, syrup is obtained from the plant and alcoholic beverage (“aloja de molle”) by fermentation; produces a strong contact dermatitis, allergies, fever and other disturbances (Cabrera 1938; Muñoz 2000; Silva-Luz 2011; Juárez de Varela & Novara 2012).

Lower leaves sometimes simple oblong-elliptic (Muñoz 1990, 2000). This species is easily identified in the field due to their discolored leaflets with the adaxial surface being shiny dark green and paler abaxial surface.

Species characterized by the imparipinnate leaves with 3–5 leaflets, petiole and rachis winged, glabrous, entire margin white cartilaginous; yellow unisexual flower and globose drupe laterally compressed, cream to greyish, with papyraceous exocarp.

## 2. *Mangifera* L., Sp. Pl.: 200. 1753.

Trees, evergreen, without thorns, andromonoecious. Leaves alternate, simples, coriaceous, petiole wingless. Panicles terminal. Flowers bisexual and masculine unisexual, 4–5-merous, haplostemenous, pedicellate, articulated; calyx 5-parted, imbricate; corolla 5-parted, imbricate; stamens 1–5, equal, anthers dorsifixed; gynoecium 1-carpelar, 1-locular, 1-ovulate, style 1, lateral, stigma simple, punctiform. Drupe ellipsoidal, kidney-shaped, thick, not papyraceous, mesocarp fleshy, endocarp woody-fleshy. Seed 1.

Genus with 69 species in tropical Asia and India, to the east of Malaysia and Salomon Islands, with higher diversity to the west of Malaysia (Pell *et al.* 2011); many with edible fruits, extensively cultivated in the tropical regions of the world (Muñoz 1990).

The epithet probably due to the latinized term constituted of *manga*, *mangai*, *man-kay* or *manghi* from Malayan and Tamil origin, along with *fero*, *fers* or *ferre* Latin suffix = to carry; meaning: to carry or having mangoes” (González 2021).

### 2.1. *Mangifera indica* L., Sp. Pl. 1: 200 (1753).

Fig. 3a-d

Trees up to 45 m height, without thorns, rough bark, dark grey. Leaves simple, 9–35 × 2–7 cm, petiole wingless and canaliculate, blade oblong-lanceolate, glabrous, margin entire, apex acuminate, base symmetrical, marginal and intra-marginal venation absent. Panicles 15–50 cm long, glabrous. Flowers yellow to



**Figure 2** – a-d. *Lithraea molleoides* – a. habit; b. detail of the winged rachis; c. detail of mature fruits; d. terminal branch with mature fruits (a-d: photos of the specimen *Panizza & Hentz 154* by E. Hentz).

white-pinkish, sometimes with glandular ridges yellowish or pinkish, perfumed; extra-staminal annular nectariferous disc, 4–5-lobed; stamen 1, staminodes 4. Drupe ellipsoid, 7–20 cm long, yellow to orange or reddish, exocarp thick, non-papyraceous.

**Examined material:** Foz do Iguaçu, ParNa Iguaçu, trilha do Hidrômetro, 10.VIII.2016, fl., *Siqueira et al.* 2017 (HCF).

From tropical Asia, extensively cultivated due to their edible fruits and therefore naturalized, through the entire Neotropical region; grows as sub-spontaneous near inhabited sites (Muñoz 1990). Found only in a single area from the five areas evaluated in the present study, probably cultivated.

The epithet refers to the origin of the species or states that it was published based on a specimen originated from India (González 2021).



**Figure 3** – a-d. *Mangifera indica* – a. leaves; b. terminal branches with inflorescences; -c. detail of the inflorescence; d. immature green and mature yellow fruits (a-d: photos by A.M. Panizza).

Flourishing in August, no fruits are registered; according to Muñoz (1990) flourishes the whole winter and fructifies in summer.

The common names are “Mango”, “Mangueira” (Muñoz 1990).

Edible fruits of agricultural and traditional importance, beverages are also produced, widely used in perfumery (Font Quer 1964).

Categorized as invasive in many countries of the globe (I3N Brasil 2021), especially in the Tropical Ombrophilous Forest, Subtropical Seasonal Forest and FES in the BAAP (Zenni & Ziller 2011).

Species characterized by simple leaves, oblong-lanceolate, coriaceous, panicles with yellowish to intense pink axis, yellowish to white-pinkish flower, only one fertile stamen developed and yellow to orange drupe, fleshy, pendulous.

### 3. *Schinus* L., Sp. Pl. 1: 388. 1753.

Trees or shrubs, with or without thorns, evergreen, dioecious or polygamous-dioecious. Leaves alternate or whorled, simple or compound, membranous, chartaceous or coriaceous, sessile or petiolate. Panicles or pseudo-clusters, rarely spikes, axillar or terminal. Flowers unisexual, 5-merous, obdiplostemonous, pedicellate, articulate; calyx 5-parted, imbricate; corolla 5-parted, imbricate; stamens (8–)10, unequal, anthers dorsifixed; gynoecium 3-carpelar, 1-locular, 1-ovulated, style 3-fids or 3-lobed, stigma truncated. Drupes globose, exocarp thin, papyraceous, lustrous, reddish or pinkish to purple, separating when mature from the mesocarp, fleshy, resiniferous, black, endocarp bony. Seed 1.

Is the richest genus in the family in South America, with approximately 45 species, from Ecuador along the Andes until Patagonia, but absent in the Amazon; the vast majority found in diverse types of arid vegetation which extent to the Andean and Atlantic humid forests, with a distribution center in Northern Argentina (Barkley 1944; Pell *et al.* 2011; Silva-Luz *et al.* 2019). Natural distribution of the genus is restricted to South America, however, it is currently establishing in warm temperate regions from the New and Old World with many species being introduced as ornamental (Barkley 1944; Silva-Luz *et al.* 2019).

Some species of *Schinus* can present polymorphic leaves. The leaves and fruits produce a distinctive resinous balsamic aroma (Font Quer 1964) or similar to Mango (Silva-Luz *et al.* 2019). Drupes of some species are used as peppers, hence

the name “false pepper” or “american pepper” (Font Quer 1964).

Epithet probably due to the latinized name derived from Greek feminine *schinos* = mastic, one of the common names for pistachio (*Pistacia lentiscus* L.) (Muñoz 2000). According to Zona (2015) there is a nomenclature controversy regarding the specific epithets for some species within the genus, historically without distinction between masculine and feminine; and currently understood as feminine in the construction of combinations.

### 3.1. *Schinus terebinthifolia* Raddi, Mem. Mat. Fis. Soc. Ital. Sci. Modena, Pt. Mem. Fis. 18: 399 (1820). Fig. 4a-f

Trees or shrubs up to 15 m height, without thorns, rough brown-reddish to dark gray bark. Leaves compound, imparipinnate, (3–)9–11(–15)-foliolate, 7–20 cm long, petiole and rachis narrowly winged; leaflets 1.5–7 × 1–3.5 cm, the terminal one larger, opposite, sessile, glabrescent to pubescent, blade broadly lanceolate, elliptical or obovate, slightly asymmetric, margin entire, crenate or serrate, apex sharp or obtuse to mucronate, base attenuated, marginal vein absent, intra-marginal vein not prominent. Panicles 2–13 cm long, glabrous to pubescent. Flowers white, fragrant; intrastaminal nectariferous disc, 10-lobed, yellowish. Drupes globose, not laterally compressed, 0.4–0.5 cm long, pink, reddish to purple, exocarp thin, papyraceous.

**Examined material:** Céu Azul, ParNa Iguacu, Ruta BR-277, Puesto de Peaje, 7.I.2020, fl. and fr., Panizza & Hentz 153, 155 (EVB). Foz do Iguacu, ParNa Iguacu, 19.II.1960, fl., Pereira 5359 (RB). 19.II.1963, fl., Hatschbach 9928 (MBM, UPCB). Poço Preto, 25.X.1990, fl., Cervi 3188 (UPCB). Matelândia, ParNa Iguacu, entrada de Matelândia-Serranópolis do Iguacu, 21.II.2020, fl. and fr., Panizza *et al.* 217 (EVB). Santa Tereza do Oeste, limite leste PN Iguacu, App Rio Gonçalves Dias, 6.III.2016, fl., Jesus & Souza 47 (MBM, RB, UNOP). ARGENTINA. MISIONES: Iguazú, ParNa Iguazú, Cataratas, 5.V.1969, fr., Eskuche 416 (CTES); camino al viejo aeropuerto, 8.VIII.1991, fr., Vanni *et al.* 2832 (CTES); antiguo Hotel Cataratas, 4.XII.1993, fr., Vanni *et al.* 3231 (CTES). Sendero Jacaratiá, 4.XII.1993, fl., Vanni *et al.* 3244 (CTES); camino a Garganta del Diablo, 19.III.2017, fl., Ferrucci *et al.* 3363 (CTES); Sendero Superior, 21.III.2017, fr., Ferrucci *et al.* 3440 (CTES); centro de informes, 15.III.1991, fl. and fr., Placci 45 (CTES); ruta 101, Ayo, Nandú, 11.I.1972, fl., Mroginski *et al.* 312 (CTES); Ayo. Sto. Domingo, 12.I.1972, fl., Mroginski *et al.* 349 (CTES); de Cataratas a Caburei, 23.II.2005, fl., Zuloaga



**Figure 4** – a-f. *Schinus terebinthifolia* – a. habit; b. terminal branch with inflorescences and leaves with detail of the winged rachis; c. reddish young apical branch; d. inflorescence detail; e. mature fruits; f. branch with inflorescences and immature and mature fruits (b and d: photos of the specimen Panizza 244, and photos of a-f by A.M. Panizza)..

*et al.* 8879 (SI); anfiteatro, 1.XI.2020, fl., *Panizza 244* (CTES, SI).

**Additional examined material:** ARGENTINA. MISIONES: Iguazú, ParNa Iguazú, Rio Iguazú, 29.II.1900, *Gerling* (SI11980). BRASIL. PARANÁ: Foz do Iguacu, Foz do Iguacu, 7.V.1949, fl., *Falcão 145* (RB).

Is the most widely distributed species of the genus in the Neotropics, found in Brazil, Paraguay, Uruguay and Argentina, in different environments from sandbanks and mangrove boundaries to ombrophilous forest, FES, riverside forest and anthropized areas (Silva-Luz 2011; BFG 2015; Pirani & Silva-Luz 2018; Silva-Luz *et al.* 2019). In anthropized areas it turns sub-spontaneous where the species is not native (Santos *et al.* 2008). Found in four of the five evaluated areas in the present study, probably widely distributed in both protected areas.

The etymology refers to Latin composed epithet which refers the Turpentine (*Terebinthus* Mill.), along with the Latin word *folium* = leaf, due to the similarity of their leaves with Turpentine.

Flourishes and fructifies almost the whole year.

The common names are “Aguará yvã miri”, “Areira mansa”, “Chichita”, “Molle colorado”, “Molle pytã” (Cabrera 1938; Muñoz 2000; De La Peña & Pensiero 2011).

Wood used in rural manufacturing and as an urban ornamental, as well as in reforestation in disturbed areas (Muñoz 2000; Silva-Luz 2011). In popular medicine its bark, leaves and fruits are used as antiseptics, astringent, anti-inflammatory, febrifuge, balsamic, detergent and cicatricial for external lesions (Muñoz 2000; Flora Argentina 2021). The fruits, of mild and slightly peppery flavor, are frequently mixed with black pepper (*Piper nigrum* L., Piperaceae) and widely used in domestic and international cooking (Silva-Luz 2011; Silva-Luz *et al.* 2019).

Great morphologic plasticity according the habitat and different luminosity conditions (Sabbi *et al.* 2010 *apud* Silva-Luz 2011). It is one of the most-aggressive invasive species in the world, present in EEUU, Caribbean islands, Hawaii and Australia, with high control cost and damage for native vegetations (Lowe *et al.* 2004; Silva-Luz *et al.* 2019).

Species characterized by the imparipinnate leaves with 9–11 leaflets, petiole and rachis winged, pubescent, margin generally crenate to serrate, white flower and globose drupe pinkish to purple with papyraceous exocarp, calyx and staminodes persistent.

#### 4. *Spondias* L., Sp. Pl. 1: 371. 1753.

Trees, deciduous, with or without thorns, monoecious, rarely polygamous-dioecious. Leaves alternate, compound, membranous, chartaceous or coriaceous, petiole and rachis wingless. Panicles terminal, axillar or ramiflorous. Flower bisexual or unisexual, 5-merous, obdiplostemonous, pedicellate, articulate; calyx (4–)5-lobate, imbricate or open; corolla (4–)5(–6)-parted, valvar; stamens (8–)10, unequal, anthers dorsifixed; gynoecium (3–4)5-carpelar, (3–)5-locular, 1-ovulated, style 1, stigma capitate, spatulate. Drupe globose, ovoid or ellipsoid, exocarp thick, smooth, lustrous, mesocarp fleshy, endocarp bony, frequently operculate. Seeds 1–5.

Tropical genus of fruit trees with approximately 18 species, distributed in the neotropical region, tropical Asia and Madagascar (Mitchell & Daly 2015). Many species with edible fruits and regional consume (Silva-Luz 2011).

The etymology refers to From the Greek name for plum (*Prunus domestica* L., Rosaceae) referring to the similarity to their fruits (González 2021).

##### 4.1. *Spondias purpurea* L., Sp. Pl., ed. 2. 1: 613 (1762). Fig. 5a-d

Tree of up to 15 m height, with or without corky thorns, bark smooth, grey-pinkish to dark, dioecious. Leaves compound, imparipinnate, (2–)13–25-foliolate, 6–28 cm length; leaflets 1.4–6.8 × 0.9–2.9 cm, opposite, sub-sessile, glabrous, blade obovate, oblong-lanceolate or elliptic-obovate, margin entire or crenate, apex obtuse, acuminate, base asymmetric, marginal vein absent, intra-marginal prominent. Panicles axillary, ramiflorous, 1–16 cm length, glabrous or with trichomes uncinates, disperse or dense. Flowers unisexual, reddish to purple, without information concerning aroma; intrastaminal nectariferous disc, 10-lobed, pink to yellowish-green; gynoecium 5-carpelar. Drupe oblong to ovoid, 2.5–5 cm length, red to purple, exocarp thick, not papyraceous.

**Examined material:** Céu Azul, ParNa Iguacu, PIC, Sendero de Sede Central, 7.XI.2019, fl., *Panizza et al. 130* (EVB); 19.II.2020, fr., *Panizza & Vieiras 201* (EVB).

In dry tropical deciduous forests from the Northeast of Mexico to Panama, probable North of Colombia and Southeast Ecuador; but with a truly complex distribution range due to its association with humans, in a wide variety of habitats and soil types (Mitchell & Daly 2015). Found in only one area from the five evaluated areas under study, probably cultivated in the North head office of the Park.



**Figure 5** – a-d. *Spondias purpurea* – a. habit; b. branch; c. leaf; d. leaflets with intramarginal vein and immature green fruits (a-d: photos of the specimen Panizza & Vieiras 201 by A.M. Panizza).

The etymology is probably referring to the purple color of the reproductive organs, both flowers and mature fruits.

Flourishes in November and fructifies in February, according Mitchell & Daly (2015) flourishes before leaf loss; due to its wide distribution the plant phenology changes according to the region.

The common names are “cajás”, “ciriguela”, “ciruelo” (Font Quer 1964; Mitchell & Daly 2015).

Widely cultivated in the tropics due to their edible fruits with various cultivars; ornamental and in live fences, used to produce juices, alcoholic beverages and tinned foods, leaves and buds also used in salads or boiled foods (Mitchell & Daly 2015). In traditional medicine is used in various regions to “clean” blood, it has dermatological uses, as abortive and as antifebrile, against malaria and diarrhea (Mitchell & Daly 2015).

Dispersed by diverse mammals such as monkeys, deers, coatis and foxes (Mitchell & Daly 2015).

Species strongly aromatic, characterized by having imparipinnate leaves with 13–25 leaflets, crenate margin, intra-marginal vein, purple flower and oblong or ovoid drupe with thick exocarp.

## Discussion

Native species (Tab. 1) are found in almost all phytophysiognomies in the Atlantic Forest, both in FOM as well as in FES (Stehmann *et al.* 2009; Silva-Luz 2011; Silva-Luz *et al.* 2019), although in the ParNa Iguazu Park *L. molleoides* was found only in FOM, while *S. terebinthifolia* was observed profusely and frequently in both forests. Additionally, in the ParNa Iguazu, these species were found together in FOM, in a dryer campo type environment; agreeing with Fontana (1996), when both species are verified together forming forest islets in the savanna. This is in contradiction with Santos *et al.* (2008), who found both species with wide distribution, but occurring in different environments: *L. molleoides* found in environments from cerrado and *campo rupestre*, while *S. terebinthifolia* in woods or forests and caatinga. According Martínez-Crovetto (1983), both native species are pioneer and Rios (2010) mentions *S. terebinthifolia* as one of the main pioneers found in all stages of the regeneration, as a part of the inferior substrate of the canopy in FOM. Our results agree with Srur *et al.* (2009), who refer only *Schinus terebinthifolia* in the ParNa Iguazú, probably because there isn't

FOM in this park, where *L. molleoides* is found. However, Souza *et al.* (2019) verified three native species: *Astronium graveolens* (MBM7412), *Lithraea brasiliensis* (without voucher) and *S. terebinthifolia*, in addition to two exotic species: *Mangifera indica* and *Toxicodendron striatum* (Ruiz & Pav.) Kuntze (MBM83904). Vouchers (MBM7412, MBM83094) of the species mentioned by the authors were checked, but the locations of sampling were actually outside of the ParNa Iguazu, in other areas of the state of Paraná and São Paulo, respectively. Therefore, this study did not confirm the presence of *A. graveolens*, *L. brasiliensis* and *T. striatum* and reduced the number of species confirmed in the ParNa Iguazu.

Probably both exotic species, *Mangifera indica* and *Spondias purpurea*, were cultivated due to their edible fruits in settlements previous to the constitution of the ParNa Iguazu. Gris & Temponi (2017) observed that the abundance of some invaders, such as *M. indica*, point towards the need for management in the ParNa Iguazu. This species is a specialist that tolerates disturbances but has slow growth, so its control is efficient locally, but in the local biodiversity it may cause impact in the dispersion of native zoochoric species by diminishing the consumption of fruits and consequently dispersion (I3N Brasil 2021). *Spondias purpurea* produces parthenocarpic fruits, where the species is not native and also propagates asexually (Mitchell & Daly 2015), so it may be pertinent to include it in the exotic species management planning in the ParNa Iguazu.

With respect to the phenology of *S. terebinthifolia*, the species seems to flourish the whole year, similar to what was observed by Silva-Luz (2011) and Fleig (1989), although with differences regarding months. This occurs due to the blooming periods of each individual which masquerades due to the wide variation of the flowering extension along the populations of the species (Silva-Luz 2011). Unisexual flowers of *S. terebinthifolia*, exhale an acid and discrete peppery aroma during the whole day, which together with the nectar drops from the nectariferous disc attract the entomofauna constituted mainly by bees, flies and wasps (Lenzi & Orth 2004). Its generalist pollination is an important issue due to the availability of resources for the entomofauna (Lenzi & Orth 2004; Silva-Luz 2011). In addition, the similarity between its unisexual flowers along with the synchrony of its reproductive phenophase, the anthesis and the contribution of

trophic resources, fosters the reproductive success attracting flower visitors (Lenzi & Orth 2004; Silva-Luz 2011). In the case of *L. molleoides*, we were unable to corroborate information once it was sampled in one locality only.

The species of Anacardiaceae show a parallel floral morphology, suggesting a general pattern (Lenzi & Orth 2004). In contrast they show a remarkable range of fruit morphology and seed dispersion syndromes, mainly through animals such birds, bats and various mammals, with some members dispersed by winds and few by water (Pell *et al.* 2011; Weeks *et al.* 2014). Native and exotic species are zoochoric, in addition *M. indica* may also be hydrochloric (Pell *et al.* 2011). Jesus & Monteiro-Filho (2007) registered 13 species of birds potentially dispersers of *S. terebinthifolia* seeds, suggesting its fruits constitute an important food resource for the regional bird fauna due to its extended fructification, including the winter period, when the supply of other foodstuffs is scarce. Furthermore, the authors emphasize the importance of the species for birds, not only as a food resource but also as a place to rest, search for food and/or eat insects.

Regarding the conservation status, only *L. molleoides* is categorized as a species of minor concern and with stable population, while *S. terebinthifolia* has not yet been evaluated (IUCN 2020), but probably falls in the same category.

The present work will expand the knowledge about the Anacardiaceae within the local biodiversity, specifically in the forest constitution of the Mixed Ombrophilous Forest (FOM) and Semi-Deciduous Seasonal Forest (FES) in the BAAP. And the results contribute to the management planning and constitute basic sources for future investigation in biotechnology, environmental education, phytochemistry and ecological restoration, once the accurate identification and location of species within both protected areas is compulsory.

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### Data availability statement

In accordance with Open Science communication practices, the authors inform that all data are available within the manuscript.

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