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Medicinal Forest and Threatened Species in Indian Mounds, Pampa Biome

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Abstract

Indian Mounds represent significant archaeological landmarks within the Uruguayan Pampa, extending from Los Patos Lagoon to Castillos Lagoon. Utilized by indigenous groups for more than 3,000 years, these ancient embankments exhibit considerable variation in dimensions, vegetation coverage, and soil composition. The scarcity of comprehensive data regarding indian mound flora served as the impetus for this investigation. Descriptive research was conducted at an Indian mound in the G. Ricci archaeological site to define the forest's taxonomic hierarchy and understand the ecosystem services provided by this area. The floristic survey identified 8 families, 9 genera, and 10 species, including 7 trees and 3 shrubs. Sixty percent of species are listed as threatened, supporting the idea that these ancestral forests primarily protect endangered native medicinal plants in Uruguay's pampa biome. Ten species exhibited twenty-two pharmacological properties. Most species demonstrated antimicrobial, anti-inflammatory, anticancer or anti-Alzheimer effects. Plants like Abutilon grandifolium, Celtis sp, Phytolacca dioica and Scutia buxifolia are notable for anticancer effects. This research presents also a new and practical taxonomic key that combines pharmacological properties, morphology, and major secondary metabolites for floristic studies of medicinal forests in Indian mounds.

Keywords: Botany; Conservation; Diversity; Silicophytoliths

Introduction

The Pampa biome in southern Latin America is notable for its rich biodiversity, especially the flora. In Uruguay, recent classifications like Belancourt Rial [1] divide forests into lowland or mountainous types, further categorized as coastal, vargedicolous, mesophilic, rocky, escape and ravine. This classification, like all others in Uruguay, does not consider as forests found on top of mounds, Indians Mounds Forests, which are true native forests over spaces of 3,000 years or more, the black lands anthropized by the Indigenous people. The mounds are the characteristic archaeological phenomenon of the region with a wide distribution from the south of Los Patos lagoon to the Castillos lagoon [2]. They are mountainous structures called *cerritos de indios,* earthquakes or embankments that vary in height, vegetation, and soils. These areas are physiognomically and functionally distinct from other classified forests due to their small size, composición and soil, raising questions about including them as a separate type.

This area, known as Graven de Laguna Merín according to Panário et al. [3], contains significant Indian mounds in Uruguay dating from the Holocene through the seventeenth century. Archaeological evidence from silicophytoliths documents that Indigenous people cultivated plants like corn and cucurbits on the mounds [4]. Medicinal plants, preserved by Indigenous people, are a notable feature of these forests. This study records and examines the medicinal plants of the G. Ricci/7 mound forest, focusing on their significance amid landscape changes in the Uruguayan Pampas.

Paleobotany aids research on the Indian Mounds in the Pampas by identifying silicophytoliths—calcium carbonate concretions with silicon skeletons formed in certain plant tissues. Del Puerto & Inda [5] examined an Indian mound in Laguna de Castillos, determining through 14C dating that these sites are approximately 3,050 years old. Their findings included silicophytoliths from the Cannaceae, Ciperaceae, and Arecacea families, with species such as *Butia* identified among them. These botanical families coevolved, so many species still share habitat in today's Indian mounds forests.

Other botanical families such as Cannabaceae, Urticaceae and Moraceae were also identified by Hanaine et al. [6] in the SE of

Buenos Aires through the analysis of silicophytoliths, reaching the species level by recording *Celtis* spp and *Morus alba* L. These botanical families identified from silicofitolites analysis reflect how Indigenous peoples of the Uruguayan Pampa and surrounding areas managed and cultivated local plants in prehistoric times. The research proposed herein aims to examine the contemporary flora present in the Indian mound forest (site G. Ricci) of the Uruguayan Pampa. This approach adopts a retrospective perspective, tracing from current conditions back to historical contexts.

Indigenous and riverside populations rely on native plants as medicine because they live far from medical centers. For traditional populations, forests are not just about plant diversity and balance; they are essential for survival and long-term resilience, as highlighted by Oliveira et al. al [7,8] and Santos [9], studying traditional populations in the Amazon Biome. Ethnobotany is the scientific discipline that examines medicinal plants utilized by traditional populations, with certain studies in Uruguay specifically addressing the Pampean Biome [10]. The authors note that only 14 scientific articles on ethnobotany in Uruguay have been published in the past 50 years, highlighting there remains a significant research gap in the field. Ethnobotanical prospection within the Pampa Uruguay Biome comprises sites such as Tacuarembó, Quebradas del Norte, Artigas, and Bella Unión, as cited by respective authors. While ethnobotanical research has traditionally emphasized medicinal plants, there remains a lack of investigations into the medicinal flora of Indian mound forests using ethnobotanical, taxonomic or ecosystem service methodologies.

This study analyses the medicinal plants of a specific Indian mound forest (site G. Ricci/7-Lascano, Uruguay) through a floristic survey, evaluates their pharmacological potential and introduces a new taxonomic key based on pharmacological, morphological traits and secondary metabolites.

Methodology

a) Study Site Characterization: The Indian mound forest studied is at 33º38'23.9'' S 54º04'57.8'', Lascano, Rocha Department, Uruguay. The G. Ricci archaeological site has ten mounds; we chose mound 7 since it is one of the two with forest. In April (autumn), microclimate readings were 68% humidity, 22.7°C temperature, and 0.6m/s wind speed. In this context, the Indian mound forest encompasses both the vegetation directly atop the mound (at its elevation) and the flora within a 50-meter radius of its periphery, recognizing that the forest constitutes a continuum. Because the forest canopy blocks much of the sunlight, the environment beneath it receives less luminous radiation. This setting encourages plants to rely on photosystem II. Cattle grazing sporadically on this indian mound raises soil urea and total nitrogen levels. Low light in the area reduces urea volatilization, causing it to build up.

b) Floristic composition was determined by walking throughout the Indian mound Forest, including all trees and shrubs due to the forest's small size. Branches were gathered from the plants to prepare exsiccate, which were then sent to the Herbarium of the National Museum and Botanical Garden *Prof Atílio Lombardo* (MVJB) in Montevideo for taxonomic identification of the species.

c) Bibliographic Review: Following the taxonomic identification of species, a literature search was conducted using major databases—Science Direct (https://www.sciencedirect.com/), Scielo (https://scielo.org/pt/), Capes Journals (http://www-periodicos-capes-gov-br), Latindex (https://latindex.org/latindex/), and DOAJ (https://doaj.org/)—to identify secondary metabolites and pharmacological properties of the species present in the Indian Mound Forest studied. Data compilation and graph analysis were performed with BioEstat Program version 5.3 [11].

d) Development of the taxonomic key: A taxonomic key was constructed with the primary classification criterion being *Pharmacological Property*. Within each category, the species were grouped according to their morphological characteristics and principal secondary metabolites. Unlike traditional taxonomic keys based mainly on morpho-anatomical traits, this key offers a new perspective by classifying plant communities like the forests of Cerritos de Indios according to their pharmacological properties and medicinal flora.

Results

The floristic survey of Indian mound forest identified 8 families, 9 genera, and 10 species, including 7 trees and 3 shrubs (Table 1). We view the Indian mound forest as an integrated system where every species plays a role in the forest's metabolism, particularly regarding climate change in today's Uruguayan Pampa. Of the 10 species found, 6 are on the IUCN Red List of Threatened Species, which corresponds to a high percentage, 60%. These findings underscore the significance of conserving Indian mound forests within forest parks, highlighting their role as reservoirs for threatened flora and establishing them as a distinct category of forest. These forests are important not only for their present flora but also for their archaeological value, representing a link between current plant life and historical findings.

Research shows the forest's taxonomic structure supports its medicinal profile, with species confirmed by ethnobotany and phytochemistry to have biologically active metabolites in their leaves, bark, roots, and seeds. Organic compounds with pharmacological effects are typical of the secondary metabolism found in species from these botanical families, including *Sesbania ramosissima*. De Melo et al. [12] identified 21 new synonyms and designated 15 lectotypes for South American species of *Sebastiania*. The same authors re-evaluated the nomenclature à *S. brasiliensis*, resulting in a new combination, *S. ramosissima*. *Sebastiania* is an exclusively neotropical genus according to Esser [13] composed of 79 species. This species, identified in the forest under study and referred to by the Guarani people as *Yvyra kamby* (Palo de leche), is also commonly known as tilefish, milkman,

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or lecherón. It is known for its healing effects, helping to relieve pain in mules as well as easing dental discomfort. According to Santos Biloni (1990), the decoctions of the leaves and twigs of *S. ramosissima* and *S. k*lotzschiana are known for its antiseptic properties that help treat wounds. Additionally, latex is used for removing warts and provides pain relief for dental cavities.

Table 1: Plant species identified in the Floristic Study of an Indian mound forest (G. Ricci/7), Pampa Biome, Uruguay. * Red List of Threatened Species (IUCN).

Family	Scientific Name	Common Name	Habit	Herbarium No.	Red List*
Euphorbiaceae	*Sebastiania ramosissima* (A.St.-Hil.) A.L. Melo & M.F.Sales	Blanquillo, Lechero	Tree	MVJB 34903	No
Euphorbiaceae	*Sebastiania klotzschiana* (Müll.Arg.) Müll. Arg.	Blanquillo	Tree	MVJB 34904	Yes
Malvaceae	*Abutilon grandifolium* (Willd.) Sweet	Malvarisco, Malva del Monte	Shrub	MVJB 34896	No
Malvaceae	*Pavonia sepium* A.St.-Hil.	Malvarisco amarillo	Shrub	MVJB 34905	No
Myrtaceae	*Eugenia uruguayensis* Cambess.	Guayabo blanco	Tree	MVJB 34898	Yes
Phytolaccaceae	*Phytolacca dioica* L.	Ombú	Tree	MVJB 34897	Yes
Rhamnaceae	*Scutia buxifolia* Reissek	Coronilla	Tree	MVJB 34911	Yes
Santalaceae	*Jodina rhombifolia* (Hook. & Arn.) Hook. & Arn. ex Reissek	Sombra de Toro	Tree	MVJB 34909	Yes
Thymelaeaceae	*Daphnopsis racemosa* Griseb.	Envira	Shrub	MVJB 34906	Yes
Cannabaceae	*Celtis sp.* L.		Tree	MVJB 34910	No

Penna et al. [14] found that *S. klotzschiana* antimicrobial effects are mainly from Methylgallate and protocatechuic acid, along with quercetin, kaempferol, quercitrin, and gallic acid. The presence of *S. ramosissima* and *S. klotzschiana* in the Indian mound forest under study underscores the important role these native forests play in conservation amid current climate change. These forests serve as habitats for indigenous species, including *S. klotzschiana*, which is listed on the IUCN Red List of Threatened Species [15].

Another plant family identified in the Indian mound forest research, which is significant for its pharmacological properties, was Malvaceae. The species from this family found in the study were *Abutilon grandifolium* and *Pavonia sepium.* According to Gomma et al. [16], *Abutilon* is a genus that has 150 species and presents a diversity of secondary metabolites such as flavonoids, phenolic acids, sterols, triterpenes, quinones, cumarinas, alkaloids, sphingolipids, megaestigmanes and iridoids. These metabolites are associated with anti-inflammatory, analgesic, and antipyretic properties.

In Tanzania, *Abutilon grandifolium* leaves and bark are used as tea to treat malaria and venereal diseases [17]. In Brazil, its leaves are traditionally used for cancer and fibroid treatment [18]. Its leaves are also used to make a decoction, which is applied as an enema for treating measles and insect bites [19,20]. *A. grandifolium* leaf decoctions are used as a hair tonic and for lice removal [21]. The diverse pharmacological attributes of the species support the hypothesis that the Indian mound forest under study possesses a medicinal flora of significant contemporary pharmacological relevance. These areas also function as *in situ* Germplasm Banks, meaning they preserve genetic material within the same environment where they are located, or inside a larger forest-park. This record highlights the need for updated forest typologies in the Uruguayan pampa biome, suggesting that classifications should consider the functional aspects of indigenous forests, rather than focusing solely on structure.

Pavonia sepium, a Malvaceae shrub identified in the Indian mound forest, contains notable levels of malvalic acid in its seeds [22]. The genus *Pavonia*, which includes 271 species and about 169 secondary metabolites, demonstrates diverse pharmacological properties such as anti-inflammatory, analgesic, antimicrobial, cytotoxic, antitumor, antidiabetic, and antioxidant effects.

The Myrtaceae family, identified in our survey, consists of about 130 genera and 3,800–5,800 species of shrubs or trees; *Eugenia* is a notable genus with 1,000 species [23]. Among these is *Eugenia uruguayensis* (white guava), which we found to contain α-Pinene (23.5%), β-Pinene (11.8%), and β-Caryophyllene (9.5%) in its leaves, highlighting its pharmacological potential (Apel et al., 2002). These metabolites confer antimicrobial properties to *E. uruguayensis* with good inhibitory potential against positive and negative bacteria, as well as fungi. Segundo Limberger (1998) or essential oil of *E. uruguayensis* obtained by hydro distillation of *Staphylococcus epidermidis, Escherichia coli* and *Saccharomyces cerevisae.* According to Cole et al. [24] by studying essential oils from leaves of 5 species of *Eugenia*, *Eugenia austin-smithii*, *Eugenia cartagensis*, *Eugenia haberi*, *Eugenia monteverdensis* and *Eugenia zuchowskiae*, pharmacological properties against digestive disorders were observed, antifebrile, antirheumatic, anti-inflammatory, diuretic and against diabetes, while composts such as trans-2-hexenal, α-terpineol and linalool were expressive. *E. uruguayensis* is especially significant due to its

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high phytochemical and pharmacological diversity, and its status on the IUCN Red List of Threatened Species adds further value. Its presence serves as a bioindicator for sustainability in Indian mound forests; if the species is absent, this suggests there has been some environmental disturbance.

The *Daphnopsis racemosa*, a shrub called Envira also found in this research, belonging to the family Thymelaeaceae, has an *in vitro* acaricidal effect against ticks in heifers infested by *Rhipicephalus (Boophilus) microplus,* according to Gomes et al. [25] and this is due to the phytochemical composition of the species. Considering the strong livestock activity in the Uruguayan pampas, *Daphnopsis racemosa* may be of local importance for animal health, and increasing the population of the species for use in veterinary contexts could be an option. Borris et al. [26] found that members of the Thymelaeaceae family contain diterpene esters, compounds that cause toxic reactions and can be lethal. *Daphnopsis racemosa* is listed on the IUCN Red List of Threatened Species, making it part of the 60% of threatened plant species identified in this Indian mound forest study.

The genus *Celtis sp* (family Cannabaceae) includes 73 species found in temperate and tropical regions, with South American types classed as subg. *Mertensia* [27]. In our floristic study, *Celtis* was present but lacked flowers, so full taxonomic identification was not possible. Traditional indigenous medicine utilises this substance for a wide range of conditions, including gastrointestinal, mental, pulmonary, cardiovascular, renal, and dermatological diseases, as well as for the management of pain, headaches, bruises, fever, inflammation, microbial infections, malaria, and cancer [28]. Furthermore, certain species of *Celtis* possess aphrodisiac, laxative, analgesic, and antiseptic properties. The pharmacological effects are attributed to the phytochemical profile of the genus *Celtis*, which encompasses diverse metabolic classes such as flavonoids, alkaloids, saponins, terpenoids, cerebrosides, tannins, and phenolic amides [29]. Secondary metabolites with high potential include β-sitosterol, N-trans-caffeoyltyramine, N-trans-feruloytyramine, feruloyloctopamine, p-coumaroyltyramine, N-trans-p-coumarioloctolamine, marmesin, orientin, N-trans vanillic acid, eloundemnoside, apigenin, quercetin, vitexin, and isovitexin [30]. Besides its pharmacological potential, *Celtis* sp is linked to forest regeneration. Ramírez [31] found that in native forests affected by grazing or agriculture, the regeneration layer included *Celtis iguanaea*, *Smilax campestris*, and *Heimia salicifolia*. Therefore, the genus *Celtis sp* found here may suggest that the studied Indian mound forest may be in regeneration.

Discussion

This research highlights *Scutia buxifolia* (the coronilla), which was the dominant species in the forest mound studied. According to Calil et al. [32], this tree contains significant amounts of flavonoids like rutin and quercetin, which are effective antioxidants. These compounds may help prevent diseases such as Alzheimer's and Parkinson's by protecting brain cell membranes from lipid peroxidation. Dahmer (2022) [33] notes that Rhamnaceae plants contain cyclopeptide alkaloids, which are linked to antimicrobial, antiplasmodial, immunostimulant, and antinociceptive effects. In *Scutia buxifolia* stem bark, Morell (1979, 2005) [34,35] identifies active alkaloids such as scutyanin B, D, E, H, scutian E, 28-epi-scutianene E, and 3,4,28-tri-epi-scutianene E.

According to the World Health Organization (WHO), Alzheimer's will have 139 million people in the world by 2050 and in Uruguay there will be 112,000, currently 50,000 (PAHO, 2024) and therefore, they are already a local and global health problem. *Scutia buxifolia* co-evolves with several other species during the leaf days, including *Sebastiania ramosissima*, *Sebastiania klotzschiana*, *Abutilon grandifolium*, *Pavonia sepium*, *Eugenia uruguayensis*, *Phytolacca dioica*, and *Jodina rhombifolia*, *Daphnopsis racemosa, Celtis sp)* with medicinal potential in contexts of local climate change, that is, throughout the droughts of 2022 and 2023 in the Pampa biome (INUMET, 2024) [36]. This grouping of medicinal plants forms a forest that may soon serve as an in-situ medicinal germplasm bank. This approach informs new public-environmental policies for the Uruguayan Pampa, focusing on more practical uses of the forests on Indian mounds, which support endangered species. *Scutia buxifolia* is listed as *Least Concern* (LC) by the IUCN (2022) [15], with *Near Threatened* (NT) is the next category. Thus, this research recommends boosting the population of coronilla, either by establishing planted forests or integrating it into agroforestry systems, to prevent genetic erosion of the species over time.

Santalaceae was another botanical family found in our floristic study in the Indian mound forest studied due to the presence of *Jodina rhombifolia*, a species of tree habit and commonly called bull's shade. Montanha et al. (2009) [37] report that traditional medicine uses the plant to treat skin and gastric ulcers, due to C-glycosylflavonoids in the leaves—vicenin-2 is the most abundant, alongside vitexin, orientin, and swertisin.

According to Teves et al. (2020) [38], the lyophilized aqueous extract of *J. rhombifolia* showed an antispasmodic activity on intestinal smooth muscle, reducing diarrhea events in experiments with rats, without observing symptoms of toxicity. *J. rhombifolia* is listed as a threatened species (IUCN, 2022) [15], underscoring the need to conserve Indian mound forests in the Pampean Biome. Their protection is vital not only for archaeological and anthropological reasons but especially for preserving vulnerable medicinal plant diversity.

The botanical families identified here differ notably from those reported by Gianotti et al. (2013) [39] in Cañada de los Caponcitos, where they found silicophytoliths from Poaceae, Arecaceae, and Cyperaceae—all C4 plants such as palms, canna, and corn—dated to 885 years ago. The authors state that these mounds were used for cultivation, which is justified by the species found. Our research on mound G. Ricci/7 identified tree species with C3 photosynthesis, all of which have pharmacological properties, indicating these areas may have served as medicinal forests. Notably, coronilla (*Scutia buxifolia*), bull's shadow (*Jodina*

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rhombifolia), and ombu (*Phytolacca dioica*) were also detected in silicophytoliths.

A review of the literature shows the typical secondary metabolite profiles among tree species in the studied Indian mound forest (see Table 2). The forest serves as an important *in situ* Germplasm Bank with clear medicinal potential.

Table 2: Secondary metabolites and characteristic pharmacological properties in tree and shrub species of the Indian Mound Forest, G. Ricci/7 (Lascano, Uruguay-2025).

Species	Secondary Metabolites	Pharmacological Properties	Authors
Abutilon grandifolium	Flavonoids, phenolic acids, sterols, terpenes, quinones, coumarins, alkaloids, sphingolipids, megaestigmanes and iridoids	Anti-inflammatory, analgesic, antipyretic, measles, insect bites, hair tonic, cancer, fibroid	Dyer [19]; Arbo y Tressens, [21]; Sikorska & Matlawska [17]; Gomes de Melo et al. [18]; Achigan-Dako [20]; Gomma et al [16]
Celtis sp	Flavonoids, alkaloids, Saponins, terpenoids, ceramides, cerebrósidos, taninos, amidas fenólicas; β-sitosterol, N-trans-caffeoyltyramine, N-trans-feruloytyramine, feruloyloctopamine, p-coumaroyltyramine, marmesin, orientin, N-trans vanillyl acid, eloundemnoside, apigenin, quercetin, vitexin, and isovitexin	Gastrointestinal, mental, pulmonary, cardiovascular, renal, dermal, analgesic, headache, contusions, fever, inflammation, microbial infections, malaria, cancer, aphrodisiac, laxative, and antiseptic	Hwang [30]; Vonca [40]; Jumeta [29]; Thoutouh et al, [28];
Daphnopsis racemosa	Diterpene esters	Acaricide	Borris [26]; Gomes [25].
Eugenia uruguayensis	α-Pinene, β-Pinene, β-Caryophyllene, *trans*-2-hexenal, α-terpineol y linalol	Digestive, fever-reducing, antirheumatic, antimicrobial, anti-inflammatory, diuretic, anti-diabetes	Limberger [41]; Apel et al. [42]; Cole et al. [24]; Souza [23]
Jodina rhombifolia	Flavonoids, C-glycosylflavonoids, (Vicenin-2, Vitexin, Orientin and Swertisina)	Antiulcer, Intestinal antispasmodic activity	Montanha et al. [37]; Teves et al. [38]
Pavonia sepium	Malvalic acid	Anti-inflammatory, analgesic, antimicrobial, cytotoxic, antitumor, antidiabetic and antioxidant.	Albuquerque et al. [22].
Phytolacca dioica	Alkaloids, tannins, saponins, phenols, lectins, flavonoids,	Antiviral, antimicrobial, anti-inflammatory, anti-cancer, to heal skin wounds.	Parente [43]; Di Maro [44]; Di Petrillo [45]; Bulgari [46]
Scutia buxifolia	Flavonoids, tannins, steroids, lipids, terpenes, and alkaloids (cyclopeptide alkaloids scutyanin B, C, D scutianene C)); β-sitosterol and stigmasterol, routine	Antioxidant, acetylcholinesterase inhibitor, antiviral, antibiotic, for bacterial and fungal infections, hypertension, *Alzheimer' s* and cancer.	Boligon [47]; Boligon [48]; Calil et al. [32]
Sebastiania klotzschiana, S.ramosissima	Methyl gallate, protocatechuic acid, plus quercetin, kaempferol, quercitrin, and gallic acid	Analgesic, pain of mules, tooth; antiseptic, wart, antimicrobial	Santos Biloni 1990; Penna et al. [14]; Melo et al. [12]

All tree species surveyed at the study site and reported in literature contain every phytochemical group produced by secondary metabolism, including secondary metabolites like terpenes, flavonoids, alkaloids, saponins, tannins, steroids, phenols and lecithin, which differ qualitatively and quantitatively from each other. The distinct nature of these phytochemical compounds is responsible for the wide range of pharmacological effects observed within this group of plants.

Scutia buxifolia, known as coronilla, is highlighted here because it is the most prevalent species in the forest being examined. Calil et al. (2015) [32] reports that the bark fraction of *Scutia buxifolia* stems contains the highest concentration of steroids (40.4% β-sitosterol plus stigmasterol), in contrast to the equivalent leaf fraction (20% β-sitosterol plus stigmasterol). These steroids have shown potential applications in lung cancer treatments. In addition, *Scutia buxifolia* was also described in the literature indicated in Table 2 for Alzheimer's, hypertension, antibiotic, antioxidant, and antiviral treatments. A common metabolite in all diseases on which the species acts is the flavonoid category. Thus, the predominance of *Scutia buxifolia* in the studied forest represents the predominance of an especially important medicinal species of multiple uses. Protecting these forests from human impact is essential, as *S. buxifolia* relies on insect pollinators [49]. Since changes in the landscape and native plant formations affect floral visitors [50,51], it is important to monitor how these forests on Indian mounds like those studied at G. Ricci/7 are significant as sacred spaces, preserving native memory and culture from over 3,000 years ago. Currently, within the Graven de Laguna Merín ecoregion, these forests are primarily recognized for their medicinal plant species (refer to Table 2), emphasizing their functional significance over their structural characteristics.

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We also draw attention to a different group of secondary metabolites—alkaloids—which, according to the literature, are present in species such as *Abutilon grandifolium*, *Celtis sp*, *Phytolacca dioica*, and *Scutia buxifolia*. These plants are commonly used to treat cancer. This evidence indicates that the flora found in the indigenous mounds forest studied (G. Ricci/7)—especially this cluster of species—holds significant untapped anticancer potential that warrants further sustainable research, particularly in phytochemistry and pharmacology.

Grouping plant species by pharmacological properties showed that 10 species exhibited 22 distinct pharmaceutical effects, with several species possessing multiple properties (see Table 3).

Table 3: Summary of pharmacological properties identified in the ten species documented during the floristic survey conducted in the Indian Mound Forest studied, G. Ricci/7, Lascano, Uruguay.

Pharmacological Properties	Species	Species Number
Antimicrobial	*Celtis sp, Eugenia uruguayensis, Pavonia sepium, Phytolacca dioica, Scutia buxifolia, Sebastianias*	6
Antiinflamatorio	*Abutilon grandifolium Celtis sp, Eugenia uruguayensis, Pavonia sepium, Phytolacca*	5
Anticancer	*Abutilon grandifolium, Celtis sp, Phytolacca dioica, Scutia buxifolia*	4
Dermal	*Abutilon grandifolium, Celtis sp, Phytolacca dioica, Sebastianias*	4
Analgesic	*Abutilon grandifolium, Celtis sp, Sebastianias*	3
Gastrointestinal	*Celtis sp, Eugenia uruguayensis, Jodina rhombifolia*	3
Antifebril	*Celtis sp., Eugenia uruguayensis*	2
Antiviral	*Phytolacca dioica, Scutia buxifolia*	2
Antioxidant	*Pavonia sepium, Scutia buxifolia*	2
Acaricide	*Daphnopsis racemosa*	1
Sarampión	*Abutilon grandifolium,*	1
Myoma	*Abutilon grandifolium*	1
Cardiovascular	*Celtis sp.*	1
Pulmonary	*Celtis sp*	1
Renal	*Celtis sp*	1
Alzheimer	*Scutia buxifolia*	1
Hypertension	*Scutia buxifolia*	1
Antiseptic	*Sebastiania sp*	1
Antidiabetic	*Eugenia uruguayensis, Pavonia sepium*	1
Antimalarial	*Celtis sp*	1
Antibiotic	*Scutia buxifolia*	1
Aphrodisiac	*Celtis sp*	1

The biggest group of plants is associated with antimicrobial properties, which includes Celtis sp., Eugenia uruguayensis, Pavonia sepium, Phytolacca dioica, Scutia buxifolia, Sebastiania klotzschiana, and S. ramosissima as members of this medicinal plant cluster. These data indicate the need for further archaeological research to verify silicophytoliths from native species in the G. Ricci/7 Indian mound forest, assess their antimicrobial potential, and determine whether this flora is ancient.

A separate group of five plant species, *Abutilon grandifolium, Celtis sp., Eugenia uruguayensis, Pavonia sepium* and *Phytolacca dioica* was identified as possessing anti-inflammatory properties. Notably, this group shares significant overlap with the group demonstrating antimicrobial effects, with four species common to both. This finding highlights the potential for multiple therapeutics uses and varied pharmacological. These species are notable for their roles in treating a variety of diseases.

We draw attention to a selection of plants known for their anti-cancer effects: *Abutilon grandifolium*, *Celtis sp*, *Phytolacca dioica*, and *Scutia buxifolia*. Considering that cancer is one of the diseases that kills the most in the world, being the main types of cancer in 2022; lung, breast and colorectal according to WHO (2024) and having in the Pampa Uruguay biome, *medicinal forests* such as the one studied here, this represents an enormous genetic and biotechnological potential to be explored based on the *in-situ* sustainability of these conservation units. Although previous research [2] has recognized the archaeological significance of these forests, their current value lies in their medicinal plants, which remain unexplored, especially in relation to climate change. There is also a possibility of genetic erosion occurring in these areas.

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Antimicrobial

1. *Celtis sp*: leaves alternate, simple, trinerved, margins whole or toothed, sometimes with domacies on the abaxial leaf surface, small, yellowish-green, staminate or perfect flowers; The fruit is an ellipsoid, globes to ovate drupe. Secondary metabolites: flavonoids, alkaloids, saponins, terpenoids, ceramides, cerebrosides, tannins, phenolic amides; β-sitosterol, apigenin, quercetin, vitexin, and isovitexin.

2. *Eugenia uruguayensis:* dense coronilla, rind maculated with exfoliations, simple, opposite, oval, ovoid-elliptical leaves, with ample obtuse acumen, sub-leathery, glabrous; white flowers, rarely solitary, arranged in short umbels on the woody, short-pedicellate branches. Secondary metabolites: α-Pinene, β-Pinene, β-Caryophyllene, trans-2-hexenal, α-terpineol, and linalool.

3. *Pavonia sepium:* shrubs, leaf blades mostly ovate to lanceolate (or sub-elliptical), truncate or sub chordate, serrated, acuminate, palmate with 3-5 nerves, sparsely pubescent, pubescent petioles; linear-lanceolate stipules. Solitary flowers in leaf axils or lateral axillary twigs, involuculares bracts usually 6, lanceolate or oblanceolate, calyx sometimes basally pale; corolla yellow. Secondary Metabolites: Malvalic acid.

4. *Phytolacca dioica* Hojas Simple, alternate, oval or elliptical, long petioles intact, acute apex and rounded base. Flowers**:** petals, white, small and hanging clusters**.** Secondary metabolites: Alkaloids, tannins, saponins, phenols, lectins, flavonoids, isoamericanol.

5. *Scutia buxifolia* Reissek. Leaves opposite or subaltern, whole or minutely serrated, short-petiolate, with short, deciduous stipules. Ovate-elliptical leaf blade, entire, glabrous, apex rounded or attenuated, until emarginate; rounded base; notorious main nerve; simple primary venation and pine forest. Secondary metabolites: cyclopeptide alkaloids, scutyanin B, C, D scutianene C, β-sitosterol, stigmasterol and rutin.

6. *Sebastiania ramosissima:* flat leaf, uniserial epidermis, serrated leaf margin, smooth cuticle, hypostomatic, glabrous, glandular leaves, yellow flowers, rough, greyish, milky white exudate bark, male inflorescence with yellow flowers. In *S. klotzschiana* marginal glands in the leaves. Secondary metabolites: Methylgallate, protocatechuic acid, as well as quercetin, kaempferol, quercitrin, and gallic acid.

Anti-inflammatory

7. *Abutilon grandifolium*: branches, petiole and pedicel dense, viscous, pubescent starlate, simple hairy, hispid on the stem. Leaves with petiole 4.10cm long; stipules 8-15mm long, pubescent stellate, linear-lanceolate, acuminate long; Blade 3–18cm long, ovate or lanceolate or somewhat orbicular, densely stellate pubescent on both sides, scabrous on top, velutinous on the bottom, 7–9 nerves. Axillary flowers, 1-3 or paired. Secondary metabolites: flavonoids, phenolic acids, sterols, terpenes, quinones, *coumarins, alkaloids, sphingolipids, megaestigmanes, and iridoids*

8. Celtis sp.....1
9. Eugenia uruguayensis.....2
10. Pavonia sepium.....3
11. Phytolacca dioica 4

Anticancer

12. Abutilon grandifolium.....7
13. Celtis sp.....1
14. Phytolacca dioica.....4
15. Scutia buxifolia.....5

Dermal

16. Abutilon grandifolium.....7
17. Celtis sp.....1
18. Phytolacca dioica.....4
19. Sebastiania ramosissima y klotzschiana.....6

Analgesic

20. Abutilon grandifolium.....7
21. Celtis sp.....1
22. Sebastianias

Gastrointestinal

23. Celtis sp.....1
24. Eugenia uruguayensis.....2

25. Jodina rhombifolia (Hook. & Arn.) Hook. & Arn. ex Reissek. Arboreal habit, semi-parasitic habitat, evergreen, rhombic, alternate, leathery, glabrous leaves, with a sharp thorn at the apex and two shorter spines at each of the angles, acute base, decurrent, entire margin. Pinnate primary venation, camptodrome, brochidodromous. Secondary metabolites: C-glycosylflavonoids, (Vicenin-2, Vitexin, Orientin and Swertisin)

Anti fever

26. *Celtis sp.....1*
27. *Eugenia uruguayensis.....2*

Antiviral

28. *Phytolacca dioica.....4*
29. Scutia buxifolia.....5

Antioxidant

30. *Pavonia sepium.....3*
31. Scutia buxifolia.....5

Antidiabetic

32. Eugenia uruguayensis.....2
33. Pavonia sepium.....3

Cardiovascular, pulmonary, renal, aphrodisiac, Antimalarial

34. *Celtis sp.....1*

Alzheimer, Antibiotico, Hipertensión

35. *Scutia buxifolia.....5*

Figure 1: Taxonomic key correlating morphological characteristics with pharmacological properties of species identified in the Indian mound forest at site G. Ricci/7, Lascano, Rocha, Pampa Uruguai.

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In Uruguay, 1003 people died from diabetes in 2019 (PAHO, 2024). Cross-referencing this data with local medicinal plants like *Eugenia uruguayensis* and *Pavonia sepium* highlights potential for public policies to support nurseries producing hypoglycemic herbs, which could be distributed free to low-income populations.

Since forests in Indian mounds are legally protected, species cannot be commercially exploited, however, seeds or vegetative propagules may be collected to produce seedlings in an Active Germplasm Bank, either *ex situ* or *on farm*, to safeguard medicinal flora from genetic erosion caused by reduced gene flow between populations. Erosion can occur due to changes in the landscape, such as the use of Eucalyptus in exotic forestry—a practice already common in the Uruguayan Pampas, where many clones are introduced each year [52]. Medicinal gardens and living pharmacies play a crucial role in producing seedlings for local and regional health through phytotherapy. Creating or replicating medicinal forests with similar species to Indian mound forests can serve as *ex-situ* germplasm banks, helping preserve these plant communities amid climate change in the Uruguayan Pampa [53-74].

In conclusion, we create a taxonomic key by linking information about each species' pharmacological traits with its physical features. This method offers a fresh approach to studying the forest, focusing on species' pharmacological characteristics as illustrated in Figure 1.

Conclusion

The Indian mound forest at the G. Ricci/7 site in the Laguna Merín ecoregion serves to protect and sustain a distinct group of medicinal plants: ten species with twenty-two associated pharmacological properties. Terpenes, flavonoids, phenolic compounds, steroids, and alkaloids secondary metabolites found in these plants have been associated with therapies for serious illnesses such as Alzheimer's disease and cancer. Most species analyzed showed antimicrobial, anti-inflammatory, or anticancer properties. Plants like *Abutilon grandifolium*, *Celtis sp*, *Phytolacca dioica*, and *Scutia buxifolia* are notable for anticancer effects. Silicofitolites from *Celtis sp*, *Phytolacca dioica*, and *Scutia buxifolia* found in Indian mounds suggest this flora has existed for over 3,000 years. Sixty percent of the species identified in the floristic survey are listed as threatened. Due to their medicinal significance and current risk status, this forest presents an opportunity to function as an in-situ Germplasm Bank. Establishing such a bank would help safeguard the long-term survival and reproduction of these medicinal germplasms within the context of climate change affecting the Uruguayan Pampas biome, thereby reducing the likelihood of genetic erosion among these species soon. This research introduces a taxonomic key based on pharmacological properties, morphology and major secondary metabolites, offering a practical tool for floristic studies of medicinal forests in Indian mounds.

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