Sapindales
Zygophyllaceae
Bulnesia sarmientoi Lorentz ex Griseb.

Commercial names:
Spanish: palo santo
English: holy wood
Portuguese: pau santo vera, verawood, lignum vitae
Paraguay: lignum vitae
Argentina: lignum vitae, guaiac

Common names:
Paraguay and Argentina: palo santo
Argentina: ibocaí
Guaraní (Paraguay): yvyrá ocái
Bolivia: guayacan, guayacán morado, palo santo
Maskoy pidgin: meemong
Maka: ticiyuk
Nivaklé (Paraguay): jooc
Ayoreo: arai
Menno dialect: palosaunda

CITES-listed: logs, sawn wood, veneer sheets, plywood, powder and extracts.

Macroscopic characteristics of the wood
Organoleptic
Sapwood: yellowish-white (Hue 2.5Y Munsell 8/6)
Heartwood: yellowish-brown to greenish-brown with light chestnut tones; in longitudinal section, stripe-like veining (Hue 7.5GY Munsell 5/2 to 6/2)
Shine or lustre with surface untreated: sheen
Grain: interlocked
Texture: fine and homogeneous
Veining: gentle stripe- or feather-like
Porosity: dendritic or flame-like
Odour: pleasant, characteristic
Natural durability: resists attack from fungi and insects

Mechanical
Static bending: modulus of rupture: 891 kg/cm^2; modulus of elasticity: 98.8 kg/cm^2
Axial compression: modulus of rupture: 843 kg/cm^2
Janka hardness: perpendicular to the fibres: 14.48 units

Highly valued wood, very hard and heavy.
Principal defects in the roundwood: basal ribs; out-of-roundness; rot; grooves or voids; shakes; fissures; fire damage, insect borings, discoloured wood and included bark.

Moisture content	Density (kg/m^3)	Weight per sq. ft. (kg/sq. ft.)	Remarks
Anhydrous wood	1,090	2.57	Wood dried in a kiln at 103±2°C until constant weight reached
Wood at 10 % moisture	1,120	2.64	Wood dried in a drier
Wood at 12 % moisture	1,132	2.67	Wood dried in a drier
Wood at 15 % moisture	1,150	2.71	Wood left in open air
Wood at 25 % moisture	1,225	2.89	Weathered wood
Green wood	1,260	2.97	Wood with moisture content equivalent to that of the standing or recently cut tree (30 %)
Saturated wood	1,330	3.13	Wood with a moisture content higher than that of the standing tree, which can be achieved by soaking up to the maximum absorption permitted by its structure and density (40 %)

Source: INTI

Microscopic characteristics of the wood

A highly evolved wood, with complete stratification and non-uniform diffuse porosity of a dendritic pattern. Axial parenchyma having fine marginal bands, homogeneous pith rays, with complete stratification. Fusiform axial parenchyma cells. Apotracheal parenchyma diffuse and paratracheal parenchyma scanty, vasicentric and confluent. Vessels small to medium, moderately numerous to very numerous. Arranged in diagonal or radial patterns (multiple, commonly short radial rows (2-3 vessels). The vessels retain their shape despite clustering and intermingle with vasicentric tracheids. Average tangential vessel diameter 52.30 µm (between 40 and 70 µm), small to medium. Average number of vessels/mm^2: 57.33 (between 38 and 90). Vessel element length 98 µm (between 75 and 130 µm), short type. Perforation plates simple, with alternating intervessel pits, small and hexagonal in shape, average diameter 4-6 µm. Vessel-ray pits with distinct borders, similar to intervessel pits, of uniform size and type, of the same type in adjacent elements, located throughout the ray. Heartwood vessels occluded by organic substances greenish-brown in colour, soluble in water. Vulnerability index 0.91, mesomorphy index 0.0093. F/V index (fibre length/vessel member length) 7.857. Rays homogeneous, Kribs type 1, with all cells procumbent, very numerous (between 14 and 18 per mm), biseriate (66 %), uniseriate (20.5 %) and, less commonly, triseriate (13.5 %), short with a height averaging 70.8 µm. The growth rings at microscopic level are small, average thickness 2.077 mm (between 1.18 and 3.27 mm). The ring is characterized by vessels arranged in an oblique branching pattern forming different sections separated by areas without vessels. This oblique arrangement has to do with vessels that appear redundant but which ensure water conduction by the presence either of vasicentric tracheids or of very thin vessels combined with the wider vessels. In general the bands of vessels intersect, thereby enhancing the possibilities for conduction. (Source: Spagarino, Gimenez; 2007).

Characteristics of the tree

Inerm tree up to 20 metres in height and 0.80 metre in trunk diameter; stem relatively short (3 to 4 m), straight.
Greyish-brown bark, not very thick, with shallow fissures and small irregular plaques.
Small bifoliate leaves, large quantity of branches, and fruit in the form of three-winged orbicular capsules, dark green in colour.
Yellowish-white hermaphroditic flowers, making up spikes of one or two flowers.
Between the fibres, there are crystalliferous cells containing calcium oxalate and abundant resins dark brown in colour which provide resistance to attacks by fungi or insects and outstanding durability.
Slow-growing species. Heliophilous, mesoxerophilous and long-lived.

Distribution

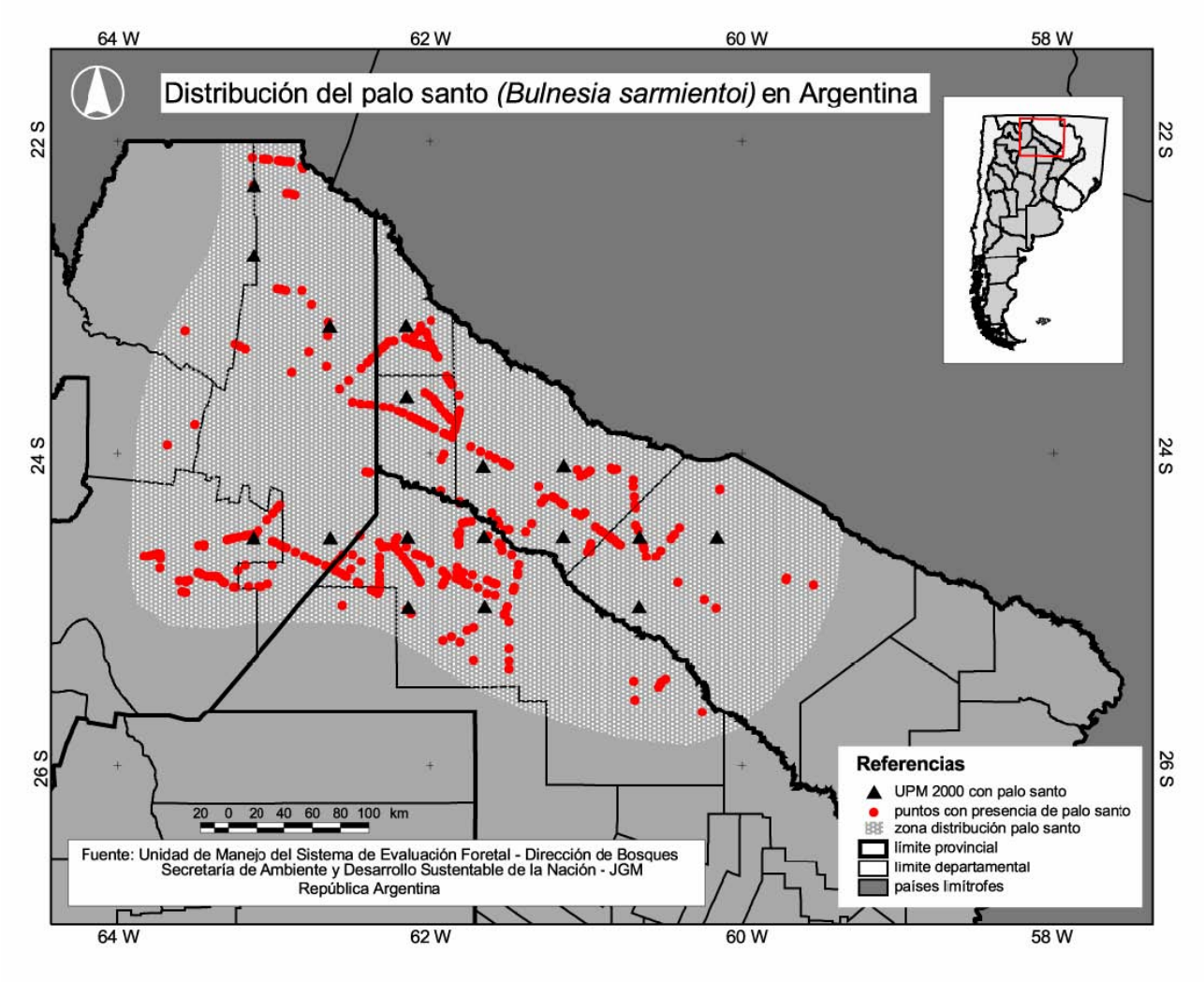
Argentina: in different settings to the west of Formosa and Chaco and east of Salta. Is found in two types of physiognomic category: scrubland or low woods over paleochannels and in a variety of locations on alluvial plains of minor watercourses.

Distribution in neighbouring countries

- Bolivia: south-east (departments of Santa Cruz, Tarija and the south of Chuquisaca)
- Brazil: south-west (isolated reports in the state of Mato Grosso do Sul).

- Paraguay: west (departments of Alto Paraguay, Boquerón and Presidente Hayes).

Distribution of palo santo (*Bulnesia sarmientoi*) in Argentina



Translation of References:

UPM…	UPM 2000 with palo santo
puntos …	Sites where palo santo found
zona …	Range of palo santo
limite …	Provincial border
limite …	Departmental border
países …	Neighbouring countries

Characteristics of trade

Highly significant international trade. Primarily traded as logs, sawn wood, oils and extracts. In addition there is trade in another species also known as “palo santo”: *Bursera graveolens* from the family Burseraceae, native to the dry tropical forest of the Pacific coast of South America

Uses

This species is highly prized for its versatility. It can be used for outdoor purposes as turnery work, carvings, floors, frames, long-lasting posts, and construction work that is installed underground. Its exceptional resistance to wear make it highly suitable for parts that need to stand up strongly to friction, such as propeller shaft bearings for ships.

Craft items and numerous utensils are made from the wood, including pipes, mortars and axes. At the present time, the wood is widely used in works of art and high-quality craft items. It is also used for certain musical instruments, luxury furniture, and other items that require excellent finishing and durability.

Extracts and derivatives

The essential oil of palo santo is extracted from the tree's oil glands.

The extraction process used is known as steam distillation, and is performed by passing a jet of steam through the sawdust; this causes the oil glands to open, thereby allowing the essential oil contained in them to evaporate and mix with the steam. When the steam condenses under the influence of a cooling system, the essential oil and the water naturally separate owing to their different densities.

Thus this type of distillation does not use any form of chemical solvent, which means that the essential oil of palo santo wood is 100 % natural.

The distillation method using a jet of steam produces an essential oil of a golden yellow colour, which gives off an intense aroma.

Chemical composition of the essential oil of palo santo wood

Analysis by gas chromatograph mass spectrometry:	
α-pinene	0,70-0,66
Limonene	62,88-34,16
Menthofuran	0,70-6,07
Terminene-4-ol	0,60-0,54
α-terpineol	23,53-19,67
Carvone	3,68-4,05
Sesquiterpene	3,95-25,53
Acetic acid V.O.	0,1360
Guaiaretic acid C.R.	0,007
Characteristics:	
Boiling point	40-50 °C
Specific gravity	0,960-0,980
Optical rotation	-3 to -12°
Refractive index	1,502-1,507
Soluble in 70 % alcohol	
Insoluble in water	
Melting point	200°C

The essential oil of palo santo, known as "guayacol", "guajol" or "guayaco", is widely used in the perfume industry owing to its sweet and pleasant fragrance, similar to that of roses or violets.

It is also used to make biochemical products, including insect repellents and medicines. It is used as a melliferous plant, and has dyeing properties. It is also used in the manufacture of varnishes and dark-coloured paints.

Similar species

The genus comprises nine species divided between two subgenera, *Gonopterodendron* and *Bulnesia*. The nine species are *Bulnesia* (*Gonopterodendron*) *arborea*; *Bulnesia* (*Gonopterodendron*) *carrapo*; *Bulnesia* (*Bulnesia*) *chilensis*; *Bulnesia rivasmartinezii*; *Bulnesia* (*Bulnesia*) *schickendantzii*; *Bulnesia* (*Gonopterodendron*) *bonariensis*; *Bulnesia* (*Bulnesia*) *foliosa*; *Bulnesia* (*Bulnesia*) *retama* and *Bulnesia* (*Gonopterodendron*) *sarmientoi*, the latter five being native to Argentina.

Similar woods known in Central America include the guaiac (*Guaiacum* sp.), also of limited distribution. Like *B. sarmientoi*, it belongs to the family Zygophyllaceae, oil is also extracted from it, and it shares the common names of palo santo and guayacán, as well as the commercial name of "lignum vitae" and "guaiac". This situation, together with the difficulty of differentiating among the species in the course of Customs inspections, justifies considering the species of the genus *Guaiacum* and also *Tabebuia* (ipê) as "look-alike" species.

Sections shown at microscopic level

Fig. 1- Wood of non-uniform diffuse porosity, showing a dendritic pattern.
Fig. 2 - Vessels arranged in diagonal or radial patterns.
Fig. 3 - Short vessel member.
Fig. 4 - Vessel member with alternating intervessel pits, hexagonal in shape.
Fig. 5 - Vascular tracheids.
Fig. 6 - Vascular tracheids with appendices.

Note: the black line on the pictures represents 100 µ.

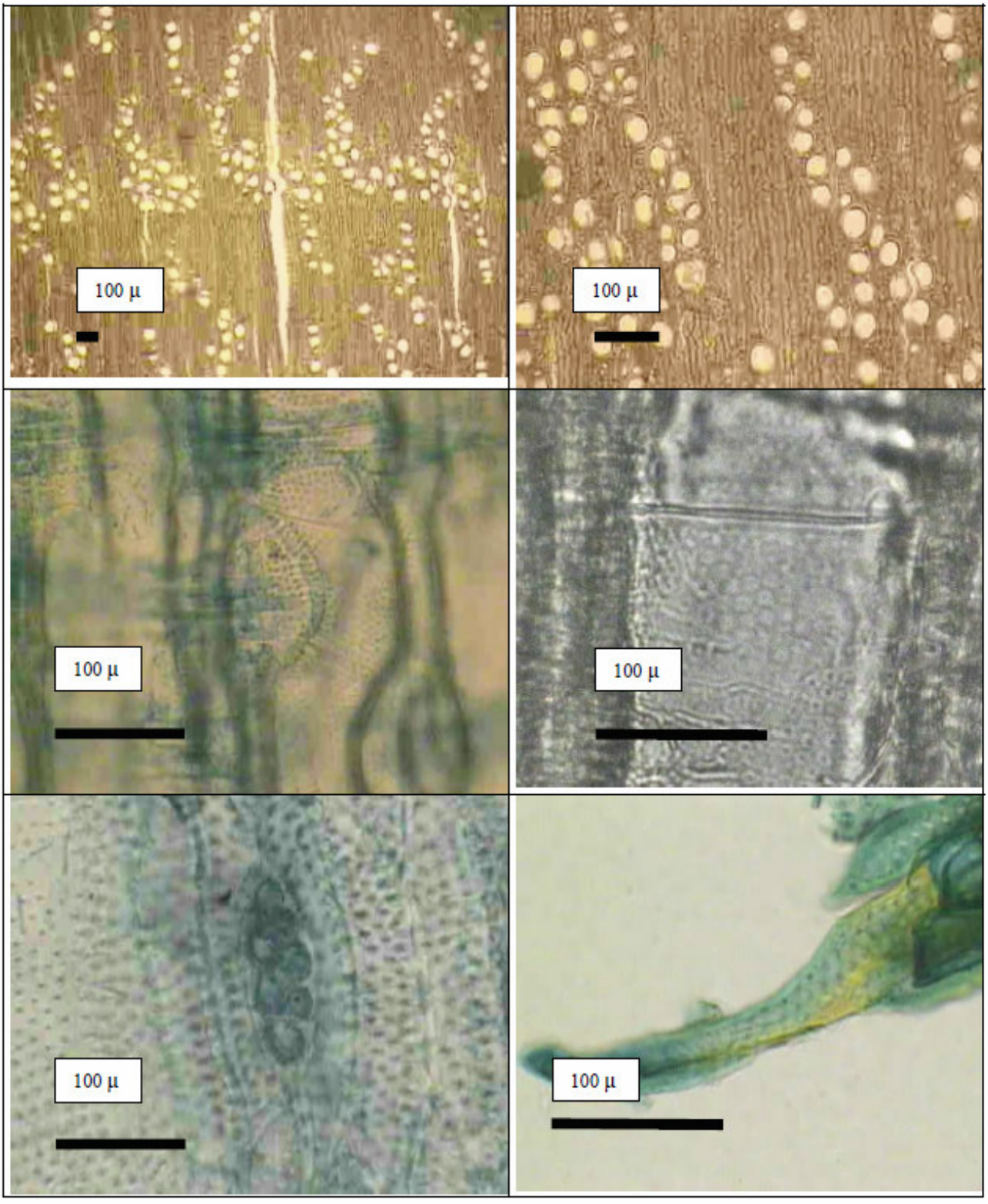


Fig. 7 - Short pith rays, uniseriate and biseriate.
Fig. 8 - Wood with complete stratification.
Fig. 9 - Very thick-walled fibres.
Fig. 10 - Septate crystalliferous cells of the axial parenchyma, with one crystal per chamber.

Note: the black line on the pictures represents 100 µ.

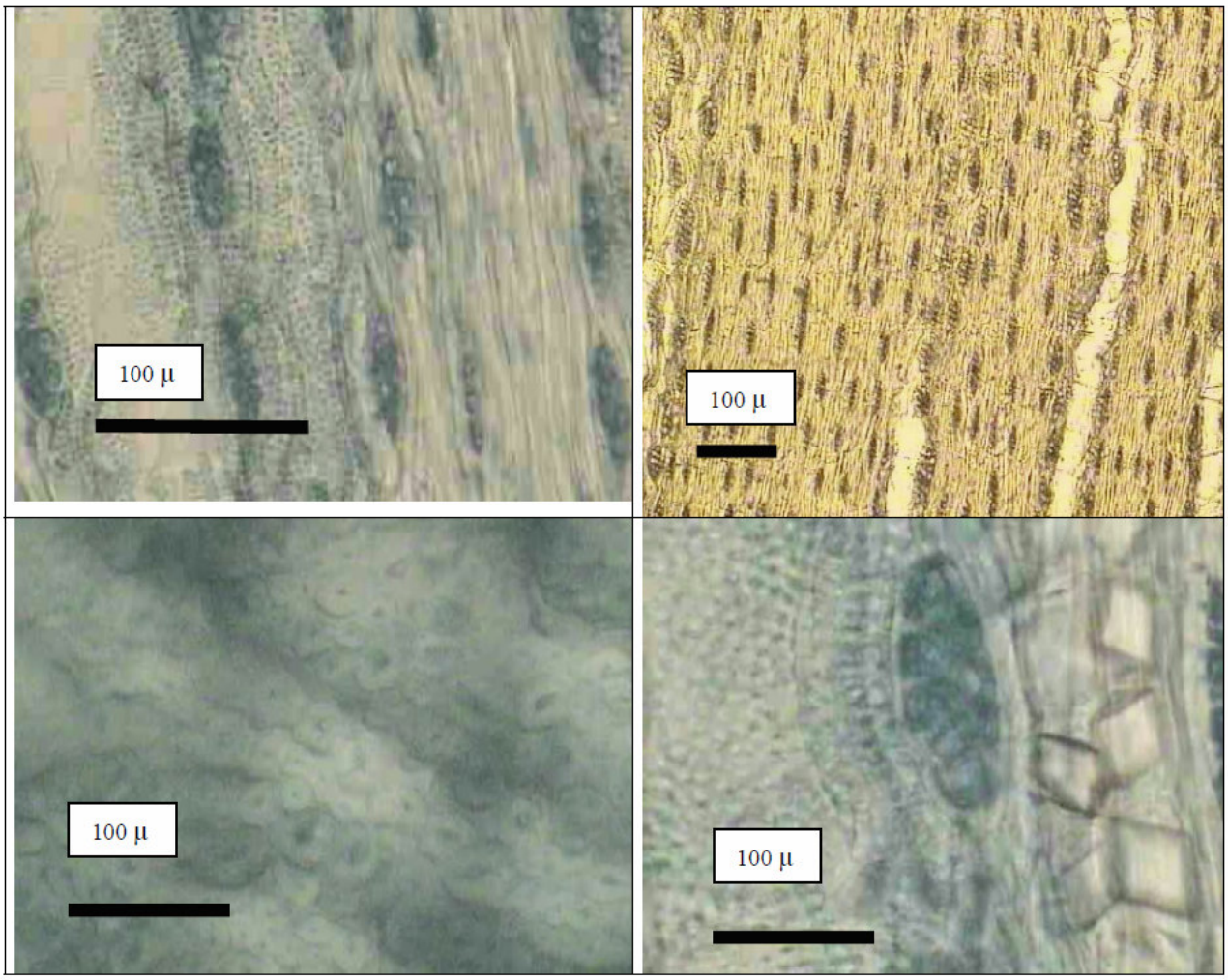
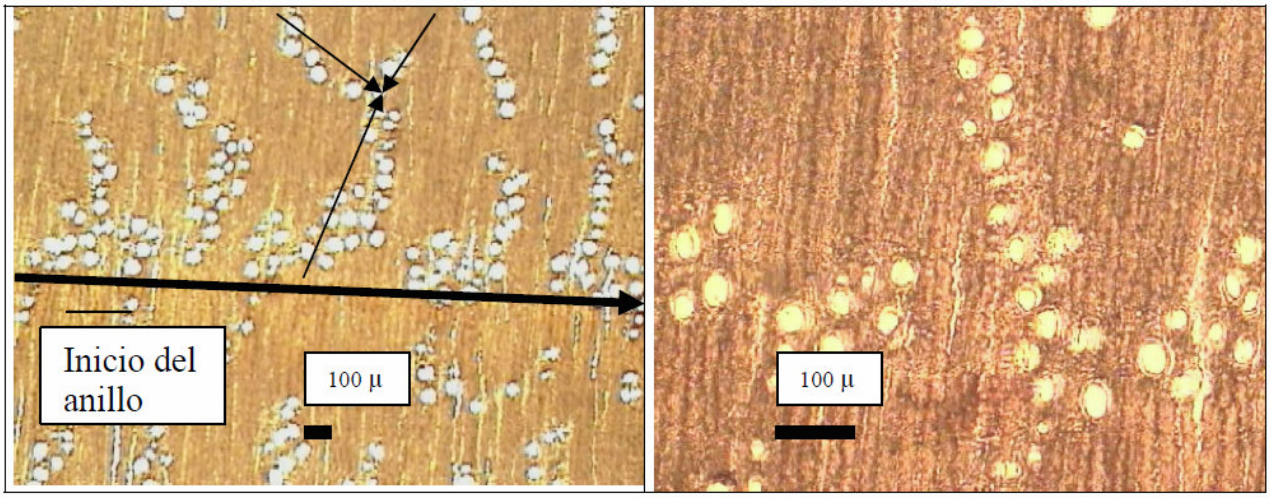


Fig. 11 - Start of the growth ring.
Fig. 12 - Detail of the frequency of vessels in the ring.

Note: the black line on the pictures represents 100 µ.



Inicio del anillo: Start of the ring

Fig. 13 a - Demarcation of the ring in radial section.

b – View of the stripe-like grain.

c - Demarcation of the ring in transversal section.

Source: Giménez, A. M.; Hernández, P.; Gerez, R.; Spagarino, C.-Anatomía de leño y anillos de crecimiento de Palo Santo (*Bulnesia sarmientoi* Lorenz ex. Grises Zygophyllaceae)

Photos: Lic. Luis Arenas

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