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LONGITUDINAL AND RADIAL VARIABILITY OF THE PHYSICAL PROPERTIES OF *ESCALLONIA PENDULA* WOOD IN ANDEAN PREMONTANE ECOSYSTEMS

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Resumo

Variabilidade longitudinal e radial das propriedades físicas da madeira de Escallonia pendula em ecossistemas pré-montanos andinos. Ecossistemas premontanos desempenham um papel crucial na biodiversidade e na oferta de serviços ecossistêmicos, mas têm sido menos estudados em comparação com outros ecossistemas. *Escallonia pendula*, uma espécie nativa desses ecossistemas, se destaca pelo seu potencial na estabilização do solo e sua contribuição para a regeneração de áreas degradadas. Este estudo tem como objetivo avaliar as propriedades físicas da madeira de *E. pendula* e sua variabilidade longitudinal e radial para determinar seu potencial como recurso madeireiro nos ecossistemas premontanos andinos. A coleta de amostras foi realizada em uma floresta úmida premontana no nordeste do Peru, especificamente na Fazenda Tesoro Perdido. Três árvores representativas foram selecionadas, e amostras de madeira foram coletadas de diferentes alturas do tronco e posições radiais. As propriedades físicas analisadas incluíram teor de umidade, densidade, encolhimento e estabilidade dimensional, seguindo as Normas Técnicas Peruanas. Os resultados mostraram que, em termos de variação longitudinal, a densidade básica foi maior na seção basal, enquanto o teor de umidade foi maior na seção central. Nenhuma diferença significativa foi encontrada na variação radial das propriedades físicas, indicando alta uniformidade das características da madeira ao longo do tronco. A madeira de *E. pendula* foi classificada como de densidade média e apresentou boa estabilidade dimensional. Esses resultados sugerem que *E. pendula* tem alto potencial para uso na indústria madeireira, particularmente em aplicações que exigem estabilidade dimensional e resistência moderada, como na fabricação de móveis e estruturas leves. Este estudo fornece uma base para o uso sustentável desta espécie na indústria e em projetos de restauração ecológica.
Palavras-chave: Contração volumétrica, Densidade básica, Estabilidade dimensional, Madeira nativa, Uso adequado.

Abstract

Premontane ecosystems play a crucial role in biodiversity and the provision of ecosystem services, but they have been studied less than other ecosystems. *Escallonia pendula*, a native species of these ecosystems, stands out for its potential in soil stabilization and for its contribution to the regeneration of degraded areas. This study evaluated the physical properties of *E. pendula* wood and its longitudinal and radial variability to determine its potential as a timber resource in Andean premontane ecosystems. Sampling was conducted in a premontane humid forest in northeastern Peru, specifically at Fundo Tesoro Perdido. Three representative trees were selected, and wood samples were collected from different trunk heights and radial positions. The physical properties analyzed included moisture content, density, shrinkage, and dimensional stability, following Peruvian Technical Standards. Results showed that, along the longitudinal axis, basic density was higher in the basal section, while moisture content was greater in the central section. No significant differences were found among radial positions for the evaluated physical properties, indicating high uniformity in wood characteristics across the trunk radius. The wood of *E. pendula* was classified as medium-density and exhibited good dimensional stability. These results suggest that *E. pendula* has high potential for use in the timber industry, particularly in applications requiring dimensional stability and moderate strength, such as furniture manufacturing and lightweight structural components. This study provides a foundation for the sustainable use of this species in industrial applications and ecological restoration projects.
Keywords: Appropriate use. Basic density. Dimensional stability. Native wood. Volumetric shrinkage.

INTRODUCTION

Premontane ecosystems, located between lowland areas and high mountain zones, are strategic for biodiversity conservation and the provision of ecosystem services. In the Andes, these ecosystems include diverse vegetation formations, such as dry tropical forests and cloud forests, and occur along strong elevation and climatic gradients. They contribute to water regulation, carbon sequestration, and soil stabilization, particularly on steep slopes where vegetation reduces erosion and landslide risk. Despite this importance, premontane ecosystems have received less scientific attention than lowland tropical forests, especially regarding their role in hydrological regulation, carbon balance, and ecological restoration (SAN-JOSÉ *et al.*, 2022; POLK *et al.*, 2020).

Native Andean woody species are key components of these landscapes because they support soil conservation, hydrological regulation, biodiversity maintenance, and the recovery of degraded areas. Their ecological value is especially relevant in premontane and montane forests, where vegetation improves soil quality, increases water retention, and creates favorable conditions for other plant and animal species (CASTAÑO-VILLA *et al.*, 2014; MARIAN *et al.*, 2020). In this context, the sustainable use of native forest resources requires knowledge not only of their ecological functions but also of their wood properties. Physical characteristics such as density, shrinkage, moisture behavior, strength, and durability determine the suitability of wood for construction, furniture production, panels, and other timber-based applications (QUICHIMBO *et al.*, 2017).

The characterization of native wood species remains a challenge because physical and mechanical properties vary among species and within the same tree. This variability affects dimensional stability, drying behavior, durability, and the predictability of wood performance in commercial applications. Previous studies have shown that some native species present homogeneous density along the stem, whereas others show lower dimensional stability or variations in heartwood proportion with tree height, influencing strength and durability (TENORIO *et al.*, 2016; DURÃES *et al.*, 2024). Consequently, systematic information on longitudinal and radial variation is necessary to define potential uses, improve forest management, and integrate native species into sustainable production and restoration strategies (SZABOLCS AND VARGA, 2020).

Escallonia pendula, a native species of the Escalloniaceae family, represents a promising resource for premontane Andean ecosystems because of its adaptability to different soil and environmental conditions. Although it is mainly known for ornamental and landscaping purposes, its wood properties may allow sustainable use in applications that require durable materials resistant to adverse climatic conditions (ZAPATA AND VILLARROEL, 2019). In addition, its capacity to grow in eroded or inaccessible areas suggests potential for ecological restoration, slope stabilization, soil improvement, and carbon sequestration. Thus, *E. pendula* could contribute simultaneously to ecosystem recovery and the supply of renewable wood materials.

However, information on the physical properties of *E. pendula* wood is still limited, particularly regarding radial and longitudinal variation along the stem. These patterns are essential for determining wood quality, dimensional stability, drying behavior, and possible industrial uses. Studies on other species, such as *Eucalyptus grandis*, *Pinus patula*, and *Cariniana micrantha*, indicate that density and mechanical performance often vary from the pith to the bark and along the tree height, affecting both stiffness and dimensional movement during drying (RIOS *et al.*, 2018; CRUZ *et al.*, 2019). Understanding these variations is also relevant for ecological applications, since denser and more stable wood may be more suitable for soil stabilization and decay resistance, whereas inner stem portions may have different restoration-related uses (LIMA *et al.*, 2021).

Therefore, this study evaluated the physical properties of *Escallonia pendula* wood and their variability according to longitudinal and radial trunk positions, with the aim of determining its potential as a timber resource in premontane Andean ecosystems of northeastern Peru.

MATERIAL AND METHODS

Study Area

Tree sampling was conducted in a premontane humid forest located on the eastern slopes of the Andes, specifically between the Amazonian alluvial plain and the cloud forests, within the condensation belt. The study area corresponds to Fundo Tesoro Perdido, situated in the district of Cuispes, Bongará province, Amazonas region (Figure 1). This estate covers an area of 5,052 hectares at an average altitude of 1,550 meters above sea level and is notable for its remarkable plant diversity and the implementation of significant agroforestry systems.

The region's climate is rainy, temperate, and very humid throughout the year. According to historical records from the period 1981–2010, maximum temperatures range between 25°C and 29°C, while minimum temperatures vary from 11°C to 17°C. Annual precipitation fluctuates between 1,200 mm and 3,000 mm, with a relatively uniform distribution due to the high atmospheric humidity in the area (DOMÍNGUEZ *et al.*, 2021). Although summers are brief, warm, and relatively dry, winters are characterized as prolonged, cool, and persistently cloudy. In terms of soil characteristics, the soils in Bongará province range from deep to moderately deep, although some areas are limited by the presence of cobbles. They exhibit textures ranging from clay loam to sandy loam, with a friable consistency. However, their natural fertility is classified as medium to low (GORE Amazonas, 2013).

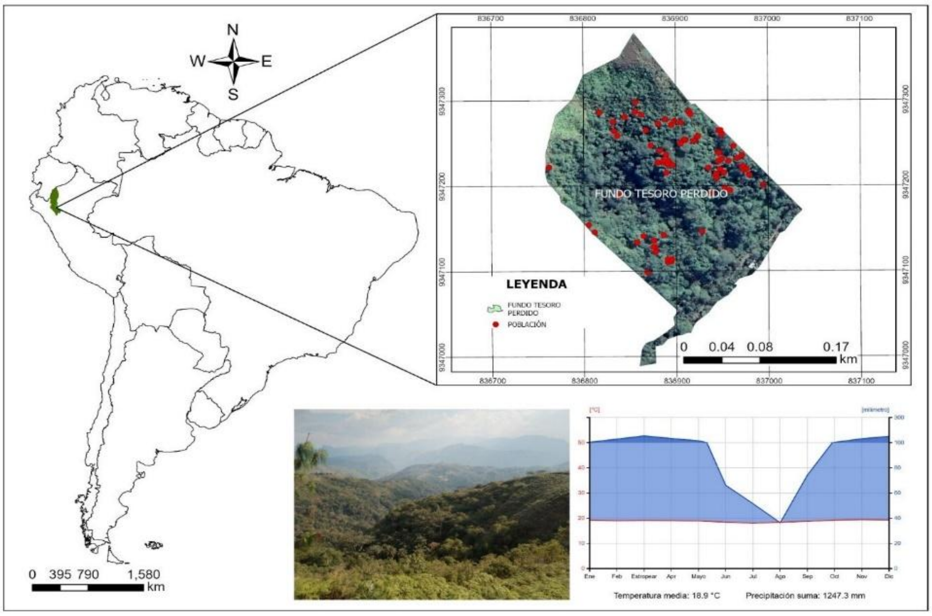

Figure 1. Map of the Study Area. The study area is located in the Amazonas region, in northeastern Peru, within a premontane humid forest (highlighted in green on the map). The figure illustrates the characteristics of the local landscape.

Figura 1. Mapa da Área de Estudo. A área de estudo está localizada na região amazônica, no nordeste do Peru, dentro de uma floresta úmida premontana (destacada em verde no mapa). Apresenta-se uma imagem ilustrando as características da paisagem local.

Selection, Collection, and Processing of the Species

Escallonia pendula, commonly referred to as “Chishka brava” is a native Andean species distributed in montane and premontane forests of Peru (Rascón *et al.*, 2020). This species is part of the characteristic flora of high-altitude ecosystems and plays an important ecological role in these areas. Its tolerance to moderately fertile soils and rapid growth make it a key species for stabilizing steep slopes.

An inventory was conducted in the study area, documenting 80 *E. pendula* individuals located in a natural forest environment. These trees ranged in total height from 3 to 22 meters, with an average total height of 11 meters, and diameters at breast height (DBH) ranging from 7 to 36 cm, with an average DBH of 20.86 cm. Predominant characteristics in this population include bifurcated trunks, mostly straight forms, frequent presence of bromeliads, absence of flowers, and generally favorable phytosanitary conditions.

For this study, three *E. pendula* trees were selected following the criteria established in the Peruvian Technical Standard (NTP) 251.008:2016, which considers aspects such as the identification of the sampling area, sector, or block, as well as the specific location of each individual. This selection aimed to ensure sample representativeness concerning the total population (NTP N°251.008, 2016). Samples were taken from different trunk levels, including the Basal (0.35 to 1.65 m), Central (1.65 to 2.95 m), and Apical (2.95 to 4.25 m) sections, to analyze the longitudinal variation in wood physical properties. Additionally, for radial analysis, the portion of the trunk located between 0.20 and 0.35 m was considered. This design allowed for a detailed evaluation of the variability in the physical properties of the wood in both longitudinal and radial directions, providing comprehensive information about its behavior.

Samples were collected during a guided visit to the study area, using an opportunistic design that enabled the selection of three E. pendula individuals. Collection was carried out using a chainsaw to fell and segment the selected trees. Subsequently, the trees were delimbed and cut into sections corresponding to the trunk levels: Basal (B), Central (C), Apical (A), and an additional segment between 0.20 and 0.35 m in height (Fig. 2). Each section was marked and coded following the Peruvian Technical Standard NTP 251.008:2016, using a system identifying the species, tree number, and trunk level. The logs obtained were carefully transported to the carpentry workshop to preserve the integrity of the samples.

Additionally, botanical samples of leaves, branches, and flowers were collected from the selected trees for identification and documentation. These botanical samples were sent to the “Herbario Kuélap” of Universidad Nacional Toribio Rodríguez de Mendoza de Amazonas, where they were analyzed to confirm the taxonomic identification of the species. In the carpentry workshop phase, the logs were subjected to transverse and longitudinal cuts to obtain slices and planks. From these, standard-sized test specimens of 3×3×10 cm (Figure 2)

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were extracted, as stipulated in NTP 251.008:2016. The test specimens were labeled in detail to ensure proper traceability throughout the analysis process. This procedure allowed the evaluation of the wood's physical properties in both longitudinal and radial directions, providing a comprehensive understanding of the structural variability of *E. pendula*.

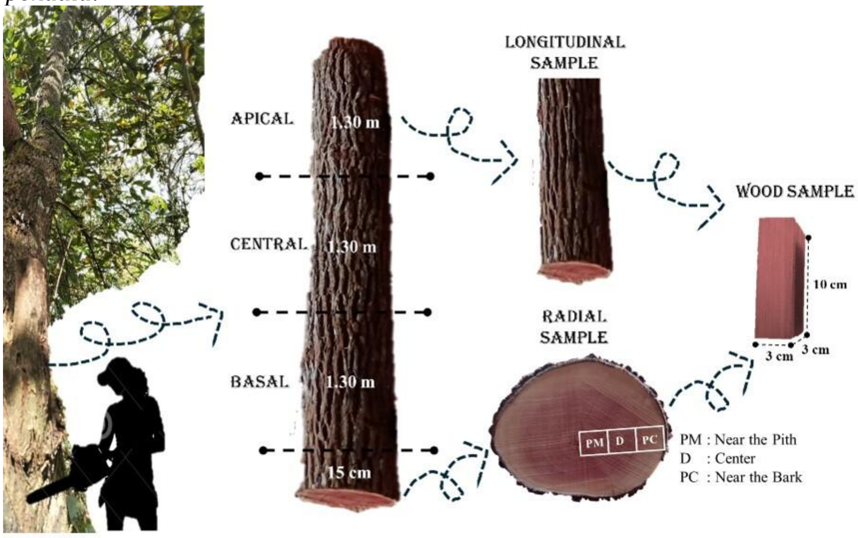

Figure 2. Schematic Representation of the Wood Sample Collection and Preparation Process. The figure illustrates the collection of wood samples at both longitudinal and radial levels for the species *Escallonia pendula*.

Figura 2. Representação Esquemática do Processo de Coleta e Preparação de Amostras de Madeira. A figura ilustra a coleta de amostras de madeira nos níveis longitudinal e radial para a espécie *Escallonia pendula*.

Physical Properties of the Wood

Samples were selected considering the orientation of the growth rings and radial and tangential cuts. Since the species has faintly visible growth rings, a Euromex sb.1903-p trinocular stereoscope was used to precisely define radial ("Rd") and tangential ("Tg") cuts, which were marked with a pen. Sixty (60) samples were selected per tree: ten (10) from the Basal, Central, and Apical levels to evaluate longitudinal variation, and ten (10) additional samples to analyze radial variation, corresponding to the regions near the pith (PM), intermediate zone (D), and near the bark (PC). Each sample was coded according to the Peruvian Technical Standard NTP 251.008:2016, linking it to the originating slice or plank to correlate the results with their source. Finally, the samples were prepared by marking an "X" on each face and labeling each cut to ensure accuracy during measurements.

The evaluation of the physical properties of *E. pendula* wood was conducted at the "Xiloteca Gocta" of the Universidad Nacional Toribio Rodríguez de Mendoza de Amazonas, following the relevant Peruvian Technical Standards (NTP). The samples, prepared according to specific dimensions (3 × 3 × 10 cm), were subjected to detailed tests to determine their moisture content, density, and shrinkage.

Moisture content was evaluated using a progressive drying process in an oven, according to NTP N°251.010 (2016), by determining the initial and oven-dry weights to calculate the percentage of moisture. Density was measured under green, basic, and oven-dry conditions, using the weight-to-volume relationships in green and dry conditions, following the guidelines of NTP N°251.011 (2016). Finally, wood shrinkage was analyzed in longitudinal, radial, tangential, and volumetric directions, applying methods based on NTP N°251.012 (2016), using specific samples and a digital micrometer to obtain precise measurements.

The physical properties were evaluated using established equations, including basic density, volumetric shrinkage, dimensional stability index, and shrinkage anisotropy expressed as the tangential-to-radial shrinkage ratio (T/R ratio). These parameters allowed the assessment of wood quality and dimensional behavior under different moisture conditions. The classification of these properties was based on the quantitative and qualitative criteria proposed for Peruvian woods by Sibille (2006). According to this classification, basic density was categorized as very low (<0.30 g cm^{-3}), low (0.31–0.40 g cm^{-3}), medium (0.41–0.60 g cm^{-3}), high (0.61–0.75 g cm^{-3}), or very high (>0.75 g cm^{-3}). Volumetric shrinkage was classified as very low (<7%), low (7.1–10%), medium (10.1–13%), high (13.1–15%), or very high (>15%). The dimensional stability index was classified as very stable (<1.50), stable (1.51–2.50), unstable (2.51–3.00), or very unstable (>3.00). These criteria were used to interpret the physical performance of Escallonia pendula wood.

In addition, according to the Technical Standard E.010 Wood of the National Building Regulations (2021) issued by the Ministry of Housing, Construction, and Sanitation, wood intended for structural use is classified into three groups (A, B, and C) based on its basic density. Group A includes woods with a basic density greater than or equal to 0.71 g/cm³, Group B encompasses those with a basic density between 0.56 and 0.70 g/cm³, and Group C comprises woods with a basic density ranging from 0.40 to 0.55 g/cm³. This regulation also establishes that woods classified into groups A, B, or C can be presented in various forms, such as sawn, round, or laminated wood. Additionally, a variety of derived products can be manufactured from these woods, such as plywood, particleboard, or fiberboard.

Determination of Potential Uses

The determination of the potential uses of Escallonia pendula was based on the results of its physical properties analysis, following the classifications proposed by Sibille (2006) for forest species in Peru.

Data Analysis

To analyze the longitudinal and radial variations in the physical properties of Escallonia pendula wood, the statistical software R (R Core Team, 2019) was used. A two-way analysis of variance (ANOVA) was applied to assess significant differences in the physical properties based on longitudinal positions (basal, central, and apical) and radial positions (near the pith, intermediate zone, and near the bark). To specifically identify which groups showed significant differences, Tukey's multiple comparison test was employed. All analyses were conducted at a significance level of 0.05, and descriptive graphs were also generated in R using specialized packages such as ggplot2.

RESULTS

Table 1 presents the results of the longitudinal and radial variation of the physical properties of *Escallonia pendula*.

Table 1. Longitudinal and Radial Variation in the Physical Properties of *Escallonia pendula* Wood. P. Bark = Near the bark, P. Pith = Near the pith, ND = Normal density, OD = Oven-Dry Density, BD = Basic Density, LS = Longitudinal Shrinkage, RS = Radial Shrinkage, TS = Tangential Shrinkage, VS = Volumetric Shrinkage, DESI = Dimensional Stability Index. Different letters indicate significant differences ($p < 0.05$) among sections, according to Tukey's test.

Tabela 1. Variação Longitudinal e Radial nas Propriedades Físicas da Madeira de *Escallonia pendula*. P. Casca = Próximo à casca, P. Medula = Próximo à medula, ND = Densidade Normal, OD = Densidade a Seco no Forno, BD = Densidade Básica, LS = Encolhimento Longitudinal, RS = Encolhimento Radial, TS = Encolhimento Tangencial, VS = Encolhimento Volumétrico, DESI = Índice de Estabilidade Dimensional. Letras diferentes indicam diferenças significativas (p < 0,05) entre as seções, de acordo com o teste de Tukey.

Variation	Position	Moisture Content (%)	Density (g/cm³)			Shrinkage (%)				DESI
			ND	OD	BD	LS	RS	TS	VS	
Longitudinal	Apical	83.26ab	0.99a	0.61b	0.54b	0.21a	4.22a	7.76a	11.82a	1.93a
	Central	84.32a	0.98a	0.60b	0.53b	0.15a	4.08a	7.93a	12.08a	1.96a
	Basal	78.14b	0.99a	0.63a	0.55a	0.26a	4.07a	8.15a	12.17a	2.03a
Radial	P. Bark	98.16a	0.95a	0.55a	0.48a	0.19a	5.76a	6.30a	12.87a	1.12a
	Center	92.77a	0.98a	0.58a	0.51a	0.19a	4.56a	9.00a	12.89a	1.99a
	P. Pith	77.94a	0.99a	0.63a	0.56a	0.14a	3.73a	9.07a	11.79a	2.72a
Average		85.77	0.98	0.60	0.53	0.19	4.40	8.04	12.27	1.96

In the longitudinal variation, the physical properties of *E. pendula* wood that showed significant differences were moisture content, oven-dry density (OD), and basic density (BD). Oven-dry density was highest in the basal position (0.63 g/cm³), followed by the apical (0.61 g/cm³) and central (0.60 g/cm³) positions. Similarly, basic density (BD) was highest in the basal position (0.55 g/cm³), followed by the apical (0.54 g/cm³) and central (0.53 g/cm³) positions. (Figure 3). Moisture content was significantly higher in the central position (84.32%) than in the basal position (78.14%), while the apical position showed an intermediate value (83.26%).

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Other properties, such as normal density (ND), longitudinal shrinkage (LS), radial shrinkage (RS), tangential shrinkage (TS), volumetric shrinkage (VS), and dimensional stability index (DESI), did not show statistically significant differences along the longitudinal axis and remained relatively consistent among the three positions (Figure 3).

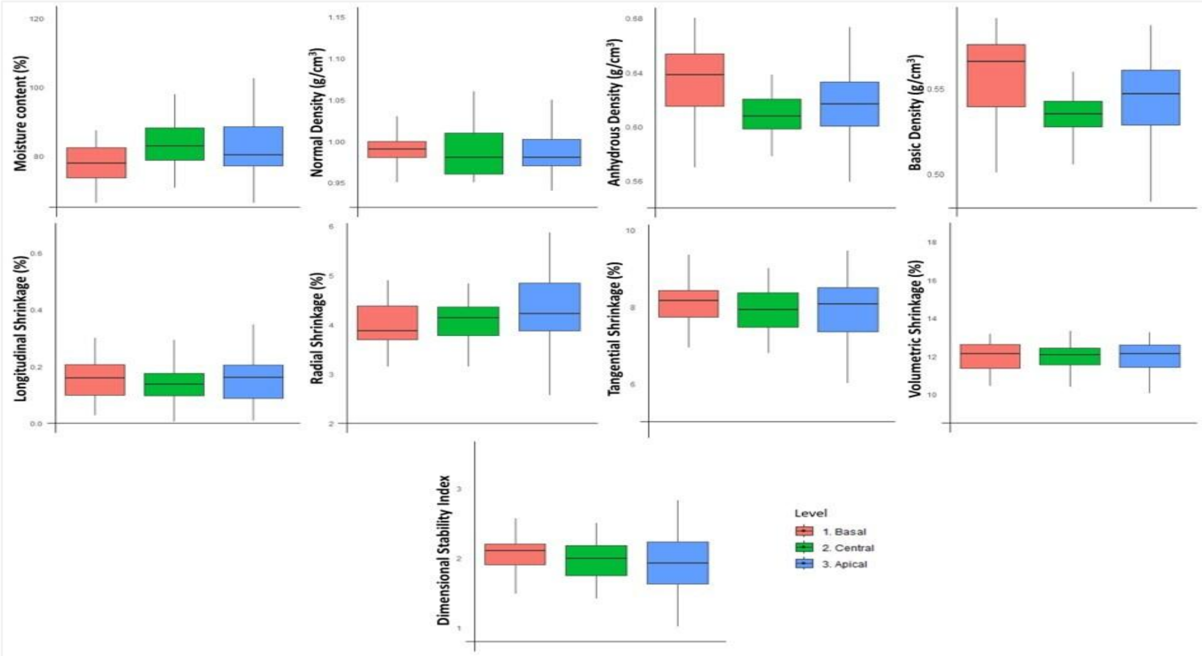

Figure 3. Longitudinal variation in the physical properties of *Escallonia pendula* wood.
Figura 3. Variação Longitudinal nas Propriedades Físicas da Madeira de *Escallonia pendula*.

In the radial analysis, none of the evaluated physical properties showed statistically significant differences. Moisture content, density, shrinkage, and dimensional stability remained relatively uniform among the radial positions considered: near the bark, intermediate zone, and near the pith.

These results indicate statistically significant variation in certain properties along the longitudinal axis, but not along the radial gradient, suggesting greater uniformity in the physical characteristics of the wood along the radial axis.

Potential Uses

The wood of *E. pendula* exhibited statistically significant variations in basic density along the longitudinal axis. However, these differences do not affect its overall classification, which remains within Grade III, corresponding to medium-density wood (SIBILLE, 2006). Therefore, the recommended uses for this species remain unchanged. Regarding the radial variation in basic density, no significant differences were observed among the averages, allowing all samples to be grouped within the same Grade III, reaffirming its classification as medium basic density wood (SIBILLE, 2006).

Recommended uses for this species include furniture, cabinetry, heavy-duty boxes, handicrafts, laminated wood, doors, windows, interior carpentry, parquet flooring, structural elements, tool handles, moldings, and tongue-and-groove boards.

With a basic density of 0.542 g/cm³, this wood is classified as structural wood in Group C according to the Technical Standard E.010 Wood of the National Building Regulations (2021). This makes it suitable for various design and construction applications. Furthermore, it is appropriate for the production of several types of wood-based panels, including particleboard, plywood, medium-density and high-density fiberboard, and wood-wool boards.

Regarding volumetric shrinkage, no significant differences were found between radial and longitudinal directions. The wood is classified within Grade III, with medium volumetric shrinkage, indicating relatively stable dimensional behavior. This property is relevant to the durability and stability of manufactured products, as it directly influences the material's ability to maintain its dimensions over time.

Finally, for the Dimensional Stability Index (DESI), no significant variations were observed either longitudinally or radially, suggesting that the wood is stable. This stability is particularly advantageous during the drying process, ensuring that the material's behavior is not affected by the orientation of the wood's cut.

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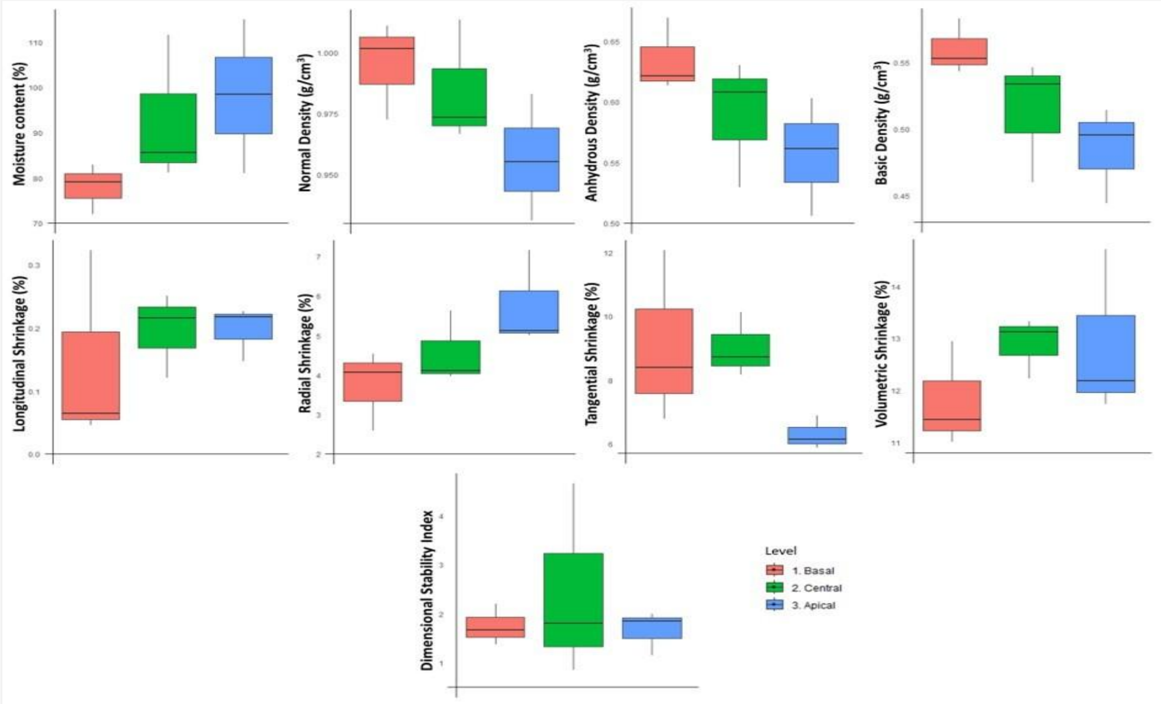

Figure 4. Radial variation in the physical properties of *Escallonia pendula* wood.
Figura 4. Variação Radial nas Propriedades Físicas da Madeira de *Escallonia pendula*.

DISCUSSION

This study on the longitudinal and radial variation in the physical properties of *Escallonia pendula* wood contributes to understanding how wood characteristics vary within the tree trunk. The results obtained for moisture content, density, shrinkage, and dimensional stability are crucial for determining the potential industrial applications of this species. In addition to their statistical significance, these variations must be interpreted from anatomical and technological perspectives, because density, moisture movement, shrinkage, and dimensional stability are closely associated with xylem structure, including fiber morphology, vessel distribution, and the proportion of juvenile and mature wood.

Longitudinal Variation in Physical Properties

The results show that, along the longitudinal axis, moisture content, basic density, and oven-dry density differed significantly. This is consistent with previous studies on other species. Notably, moisture content was highest in the central section (84.32%). Basic density (BD) was also highest in the basal section (0.55 g/cm³) compared to the apical (0.54 g/cm³) and central (0.53 g/cm³) sections. From an anatomical perspective, the higher density observed in the basal portion may be related to a greater proportion of mature xylem, thicker fiber walls, and more compact wood tissue, which generally increase wood mass per unit volume. Similar anatomical-density relationships have been reported in tropical and Andean species, where changes in fiber length, fiber wall thickness, and vessel traits help explain variations in wood density and quality (CAHUANA *et al.*, 2023; CHAMBI-LEGOAS *et al.*, 2026).

The higher moisture content in the central position may be related to active wood formation in that zone. This result may also be associated with a higher proportion of functional sapwood or conductive tissues, where larger lumina, vessel distribution, and parenchyma activity could favor greater water storage and movement. Although anatomical traits were not directly evaluated in the present study, similar anatomical patterns have been reported in Andean wood species, where variation in vessel traits, fiber length, and fiber wall thickness was associated with differences in wood density, mechanical stability, and potential technological use (CHAMBI-LEGOAS *et al.*, 2026). From a technological perspective, the higher moisture content observed in the central section suggests that this portion of the stem may require greater attention during drying, because uneven moisture distribution can increase the risk of drying stresses, differential shrinkage, surface checking, or deformation. This phenomenon was also observed by Rios *et al.* (2018) in *Eucalyptus camaldulensis*, where higher moisture content was found in recently grown areas of the trunk. Ribeiro *et al.* (2011) documented similar trends in studies on *Acacia mearnsii*, noting higher water content in apical sections due to greater metabolic activity in rapidly growing zones.

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Radial Variation in Physical Properties

The observed radial uniformity in *E. pendula* is consistent with the results reported by Salvo *et al.* (2017) for *Eucalyptus nitens*, where minimal variability between external and internal layers of the trunk was observed. This uniformity could indicate a homogeneous structure in fast-growing species or those with inherently uniform physical characteristics. Anatomically, the absence of significant radial differences in density and shrinkage may suggest limited contrast between juvenile and mature wood or a relatively uniform distribution of anatomical elements from pith to bark. This interpretation should be considered cautiously because anatomical traits were not directly measured in the present study. However, wood density is strongly influenced by anatomical characteristics, such as cell size, fiber wall area, fiber wall thickness, vessel lumen area, vessel diameter, and vessel frequency. In *Acacia mangium*, Nugroho *et al.* (2012) reported that wood density increased from the pith toward the bark and was strongly correlated with fiber wall area, indicating that radial anatomical variation can directly affect wood quality.

The lack of variability in density, shrinkage, and other radial parameters in *E. pendula* may be associated with the morphology and distribution of conductive vessels within the trunk. For species like *E. pendula*, which exhibit homogeneous growth, these vessels tend to be more uniform across the radial axis. Wang *et al.* (2021) observed similar behavior in *Schima superba*, where the wood showed minimal radial variation, particularly in species with small structural differences between bark and pith. From a technological perspective, this radial uniformity may be favorable because it suggests more homogeneous raw material for drying, sawing, machining, and product manufacturing.

Comparison with Other Species and Previous Studies

Previous studies on other species, such as those by Cruz *et al.* (2019) on *Pinus radiata* and Bhekti *et al.* (2018) on *Cinnamomum verum*, have also reported significant variations in the physical properties of wood according to longitudinal position, but less radial variability. In anatomical terms, these patterns are commonly related to changes in the proportion of juvenile and mature wood. Juvenile wood generally contains shorter fibers, thinner cell walls, and a higher proportion of less dense tissue, whereas mature wood tends to have longer fibers, thicker cell walls, and greater mechanical stability. Chambi-Legoas *et al.* (2026) reported that increases in fiber length and wall thickness toward the outer wood contributed to higher density and better mechanical stability in Alnus acuminata. Similarly, Domínguez *et al.* (2021) found in *Trichilia dazae* that longitudinal variation in density and shrinkage was closely linked to anatomical changes in fiber morphology and wall thickness. Radial variation studies, such as Cahuana *et al.* (2023), further show that fiber morphology and wall thickness are strongly associated with wood density and mechanical properties in tropical Andean species. Therefore, the longitudinal differences observed in *E. pendula*, particularly in density, may reflect developmental changes in xylem formation along the stem, with anatomical traits driving the observed physical variation.

The Dimensional Stability Index (DESI), which measures the tendency of wood to change volume in response to humidity fluctuations, showed relatively homogeneous values along the trunk of *E. pendula*. This indicates good dimensional stability, which is particularly valuable for applications requiring wood to maintain its dimensions over time, such as furniture manufacturing and carpentry. This behavior is similar to that reported by Lima *et al.* (2021) for Tectona grandis, which demonstrated high dimensional stability in tropical woods with low radial and longitudinal variability.

Probable Uses of the Wood

The wood of *Escallonia pendula*, with a medium basic density (0.54 g/cm³), is suitable for a wide range of applications in the wood industry, including furniture, cabinetry, heavy-duty boxes, laminated products, and handicrafts, similar to other species with comparable characteristics (SIBILLE, 2006). Its medium density, low radial variability, and dimensional stability make it an ideal choice for products like doors, windows, moldings, furniture, and interior carpentry, where moderate strength and stability under environmental changes are required (CRUZ *et al.*, 2019).

The low radial variability in properties such as density and shrinkage suggests that it is suitable for particleboard, plywood, parquet flooring, tool handles, and other products requiring precision, durability, and uniformity. The Dimensional Stability Index (DESI), which showed relatively homogeneous values along the trunk of E. pendula, reinforces its suitability for applications demanding stable dimensions over time (LIMA *et al.*, 2021).

Practical Implications and Study Limitations

The observed longitudinal and radial variations in density, moisture content, and dimensional stability in *Escallonia pendula* indicate that certain sections of the trunk may be more suitable for specific applications. Understanding these patterns allows for optimized selection and processing of the wood, ensuring predictable performance and efficient utilization of the raw material.

Finally, a limitation of this study is the small sample size, as only three trees were analyzed. While this restricts the statistical power and generalizability of the results, the detailed longitudinal and radial measurements obtained for each tree provide valuable insights into the physical variability of *E. pendula* wood. These data contribute to the understanding of the species' wood characteristics and serve as a baseline for future studies with larger sample sizes. Moreover, the consistent trends observed across the sampled trees suggest that the patterns reported here are likely representative of the species' general behavior, although further research is needed to confirm these findings across different sites and tree populations.

CONCLUSIONS

The analyses carried out allow us to conclude that:

- The wood of *Escallonia pendula* shows consistent physical characteristics along both longitudinal and radial axes, indicating a generally homogeneous and structurally stable wood. This consistency suggests that the species can provide reliable raw material for industrial processing, reducing variability-related defects.
- The variations in basic density and moisture content do not compromise the overall classification of the wood, confirming its suitability for Grade III applications. These findings highlight that even within-tree variation can be accommodated in practical uses, allowing efficient utilization of different trunk sections.
- The observed dimensional stability and predictable drying behavior make *E. pendula* suitable for a range of products, including furniture, doors, windows, moldings, and light structures. This underscores the practical relevance of the species for industries where uniformity, durability, and precision are critical.
- Despite limited radial variability, the species demonstrates versatility across industrial applications. Its anatomical and physical traits provide opportunities for optimizing material selection and processing, which could enhance product quality and reduce waste.
- This study deepens the understanding of the physical properties of *Escallonia pendula* wood and provides a solid foundation for future research in wood technology, contributing to the improvement of strategies for its industrial utilization.

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