



How to distinguish cavities from ducts in *Casearia* Jacq. (Salicaceae): Anatomical characterization and distribution

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ABSTRACT

Pellucid punctuations and lines in the leaf blade are common in *Casearia*, but for some of its species these structures are mentioned as inconspicuous, not visible or obscure. Cavities and ducts have been anatomically described and correlated with pellucid punctuations and lines, respectively, in only six species from the genus; however, the distinction between these types of secretory structures remains unclear. Therefore, we aimed to anatomically describe the pellucid punctuations and lines in leaves of 47 species of *Casearia*. Leaf blade samples were obtained from herbarium and field collected material and processed according to standard methods for light microscopy analysis. Cavities and ducts were absent in only four of the 47 species (*C. commersoniana*, *C. javitensis* and *C. spruceana* of section *Piparea*, and *C. eicheleriana* of section *Casearia*). In the remaining species, cavities corresponded to pellucid punctuations, while ducts corresponded with lines. The majority of species have both structures randomly distributed throughout the leaf blade, however, in *C. bahiensis*, these structures are concentrated along the leaf margin, while in *C. aquifolia* and *C. crassinervis* they were predominant along the midrib. Our data show that anatomical analyses are essential for distinguishing between cavities and ducts. We also demonstrate that the distribution of cavities and ducts provides useful information for the taxonomy of *Casearia* at both the species and section levels.

1. Introduction

Cavities (sacs) and ducts (canals) are internal secretory structures of plants that consist of a space (lumen) bounded by a layer of secretory cells (epithelium), which produce the secretion (Cutter, 1978; Fahn, 1979; Lersten and Curtis, 1989; Evert, 2006). Among previous anatomical descriptions of cavities and ducts, Fahn (1979) considered structures with a more or less spherical lumen as secretory cavities while those with an elongated lumen as ducts; Cutter (1978) referred to cavities that are more or less isodiametric as glands while those that are considerably elongated in one plane as ducts; and Evert (2006) recognized that secretory cavities are short secretory spaces and ducts are long secretory spaces. However, the lack of a clear method for

evaluating the dimensions of the lumen has made distinguishing ducts and cavities difficult. As a result, alternative denominations have been used, such as: elongate cavity in *Porophyllum lanceolatum* (Monteiro et al., 1995); oil reservoir in *Solidago canadensis* (Lersten and Curtis, 1989); and tubular cavities in *Eupatorium rugosum* (Lersten and Curtis, 1986), species belong to Asteraceae, and *Casearia decandra* (Thadeo et al., 2009), species belong to Salicaceae and secretory spaces as synonyms of cavities and ducts in species of the clade Dipterygeae, Leguminosae (Palermo et al., 2017).

Cavities and ducts are found in several organs, such as leaves, stems, roots and flowers (Lersten and Curtis, 1989; Ciccarelli et al., 2001; Sant'Anna-Santos et al., 2006; Ciccarelli et al., 2008). They are important taxonomic characters for many plant families (Solereider, 1908;

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Table 1
Distribution of cavities and ducts in the leaf blade of species of *Casearia* Jacq. (Salicaceae).

Cavities/Ducts	Species	Presence					
		Absent	Numerous and concentrated on the leaf margin	Numerous and randomly distributed in the leaf blade	Concentrated in the midrib and rarely present in the mesophyll	In the phloem region	In the medulla in the midrib
SECTIONS							
Casearia (35/61)	<i>C. aculeata</i>			x			
	<i>C. altiplanensis</i>			x			
	<i>C. aquifolia</i>				x		
	<i>C. arborea</i>			x		x	
	<i>C. bahiensis</i>	x					
	<i>C. combaymensis</i>			x			
	<i>C. corymbosa</i>			x			
	<i>C. cotticensis</i>			x			
	<i>C. crassinervis</i>				x		
	<i>C. decandra</i>			x			
	<i>C. duckeana</i>			x			
	<i>C. eichleriana</i>	x					
	<i>C. espirotosantensis</i>			x			
	<i>C. fasciculata</i>			x			
	<i>C. grandiflora</i>			x		x	
	<i>C. guianensis</i>			x			
	<i>C. hirsuta</i>			x			
	<i>C. lasiophylla</i>			x			
	<i>C. manausensis</i>			x		x	
	<i>C. mariquitensis</i>			x			
	<i>C. melliodora</i>			x			
	<i>C. mestrensis</i>			x		x	
	<i>C. negrensis</i>			x			
<i>C. nigricans</i>			x				
Casearia (35/61)	<i>C. nitida</i>			x			
	<i>C. oblongifolia</i>			x			
	<i>C. obovalis</i>			x			
	<i>C. paranaensis</i>			x			
	<i>C. pauciflora</i>			x			
	<i>C. pitumba</i>			x			
	<i>C. resinifera</i>			x			
	<i>C. rufescens</i>			x			
	<i>C. rupestris</i>			x			
	<i>C. sessiliflora</i>			x			
	Crateria (3/4)	<i>C. selloana</i>			x		x
		<i>C. obliqua</i>			x		
		<i>C. sylvestris</i>			x		x
Endoglossum (1/1)	<i>C. tremula</i>			x			
Gossypiorpermum (3/3)	<i>C. gossypiosperma</i>			x			
	<i>C. luetzelburgii</i>			x			
	<i>C. praecox</i>			x			
Guidonia (2/4)	<i>C. bartlettii</i>			x			
	<i>C. spinescens</i>			x			
	<i>C. commersoniana</i>	x					
Piparea (3/3)	<i>C. javitensis</i>	x					
	<i>C. spruceana</i>	x					

Metcalfe and Chalk, 1950), but their usefulness is limited by the lack of a clear distinction between them. For instance, cavities are common in Asteraceae (Anderson and Creech, 1975; Castro et al., 1997), Leguminosae (Teixeira et al., 2000; Sartori and Tozzi, 2002; Palermo et al., 2017), Rutaceae (Turner et al., 1998; Bennici and Tani, 2004; Muntoreanu et al., 2011), Myrtaceae (Fontenelle et al., 1994; Cardoso et al., 2009) and Hypericaceae (Curtis and Lersten, 1990; Ciccirelli et al., 2001), whereas ducts have been reported in Anacardiaceae (Joel and Fahn, 1980; Machado and Carmello-Guerreiro, 2001; Lacchia and Guerreiro, 2009), Asteraceae (Sacchetti et al., 1997; Castro and Demarco, 2008) and Salicaceae (Thadeo et al., 2009, 2014).

Reports by taxonomists for presence of pellucid punctuations and lines on leaf blades is normally based on stereomicroscopic analysis (Torres and Yamamoto, 1986; Tozzi, 1989; Marquete and Vaz, 2007; Marquete and Mansano, 2013, 2016), and such structures are generally recognized as being cavities and ducts, respectively (Thadeo et al., 2009, 2014). However, to confirm the presence of cavities and ducts, and to distinguish them from each other, anatomical studies are necessary (Thadeo et al., 2009, 2014). Based on anatomical analysis, the

glandular pellucid dots of *Lonchocarpus* were recognized as secretory cavities in 19 of 23 analyzed species, while in the remaining four species they corresponded to large intercellular spaces that lacked secretory epithelium, and which were termed false secretory cavities (Teixeira et al., 2000).

Clearly the distinction between lumen length and width will facilitate the establishment of a parameter for recognizing cavities and ducts, but in order to achieve this a three-dimensional view is needed. A three-dimensional view can be obtained by using three different visual planes (paradermal, longitudinal and cross sections) or serial sections, as well as cleared samples. Taxonomic descriptions have cited *Casearia* as having pellucid punctuations and lines on the leaf blade (Sleumer, 1980; Torres and Yamamoto, 1986; Marquete and Vaz, 2007; Marquete and Mansano, 2013, 2016), which have been described as being cavities and ducts, respectively, in just six of the 180 species of the genus (Thadeo et al., 2009, 2014). In this context, this study addresses the following two questions: Are cavities, ducts, or both, common among species of *Casearia*? How can cleared samples and anatomical sectioning aid in distinguishing between cavities and ducts? The goal of

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