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Unusual perforation plates in *Bathysa nicholsonii* K. Schum.

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ABSTRACT - (Unusual perforation plates in *Bathysa nicholsonii* K. Schum.). The Rubiaceae have almost exclusively simple perforation plates. However, the present study has detected a variation in the form of the perforation plates in *Bathysa nicholsonii*, from atypical simple, with reniform aspect, including the typical circular and multiples forms to ones resembling an operculum. Such atypical forms may be present in both the extremities of the vessel element or in just one of them. The multiple perforation plates occur when the extremity of the vessel element contacts a perforated ray cell.
Key words: wood anatomy, Rubiaceae, perforated plates, perforated ray cell

RESUMO - (Placas de perfuração incomuns em *Bathysa nicholsonii* K. Schum.). Para Rubiaceae menciona-se a ocorrência quase que exclusivamente de placas de perfuração do tipo simples. No entanto, este trabalho relata uma variação na forma das placas de perfuração presentes em *Bathysa nicholsonii*, desde atípicas simples, com aspecto reniforme, passando a circulares e múltiplas típicas, até formas muito semelhantes a um opérculo. Essas formas atípicas da placa de perfuração simples podem estar presentes em ambas as extremidades do elemento de vaso ou em apenas uma delas. As placas de perfuração múltiplas ocorrem quando a extremidade do elemento de vaso está em contato com uma célula perfurada de raio.
Palavras-chave: anatomia de madeira, Rubiaceae, placa de perfuração, célula perfurada de raio

Introduction

The wood anatomy of the Rubiaceae was subject of a series of investigations (Koek-Noorman 1969a, b, 1970, 1972, 1976, 1980; Koek-Noorman & Hogeweg 1974; Hogeweg & Koek-Noorman 1975; Robbrecht, 1988; Ceccantini & Angyalossy-Alfonso 2000; Jansen et al. 2002). The genus *Bathysa* C. Presl comprises 12 neotropical species (Anderson 1992), seven occurring in Brazil: *B. australis* (A.St.-Hil.) Hook. f., *B. cuspidata* (A.St.-Hil.) Hook. f., *B. gymnocarpa* K. Schum., *B. mendoncaei* K. Schum., *B. nicholsonii* K. Schum, *B. stipulata* (Vell.) C. Presl and *B. sylvestrae* Germano-Filho & M. Gomes (Germano Filho 1998).

Since the distribution of the species of *Bathysa* in Brazil is almost restricted to the Atlantic rain forest domain, most of them are in danger of extinction due to the impact of the antropic action (Germano Filho 1998). In agreement with the IUCN (1995) *B. nicholsonii* is considered rare, due to its restricted and fragmentary populations (Germano Filho 1998).

The species also occurs in the State of Minas Gerais, at Serra do Cipó (Giulietti et al. 1987), the extreme southern part of Chapada Diamantina, beyond the main distributions of Atlantic rain forest. From where Luchi (1990) studied anatomical features of *Bathysa nicholsonii* for the first time.

Many authors agree that perforation plates in Rubiaceae are simple. However Meylan & Butterfield (1975) observed in some species of *Coprosma*, the presence of simple to reticulate combination of plates and simple to scalariform combination plates. In *Canthium barbatum*, Rudall (1982) observed simple perforations surrounded by a ring of pits, although reticulate or scalariform perforation plates also occurred, and Ohtani (1984) reported simple to scalariform combination perforation plates in *Lasianthus japonica*, and simple to multiple combination perforation plates in *Damnacanthus indicus*.

This paper reports the occurrence of a previously unknown perforation plate type that has not been cited in literature, and gives a short report on wood anatomical characters of *Bathysa nicholsonii*.

Material and methods

Wood samples were obtained from adult plants of *Bathysa nicholsonii* from a gallery forest at 1200 m altitude, at Serra do Cipó, in the Municipality of Santana do Riacho, Minas Gerais State, Brazil, at 19°12'S and 43°30'W. One voucher (SPF42470) is deposited at the Herbário do Departamento de

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Botânica of the Instituto de Biociências da Universidade de São Paulo, and the other (SP288109) at the Instituto de Botânica of the Secretaria do Meio Ambiente do Estado de São Paulo, where the wood samples (SPw 700 and SPw 1699) remain deposited in the wood collection.

The samples were obtained from the stem at breast height, with 5.5 and 3.5 m tall and of 9.5 and 3.0 cm in diameter, respectively. Histological sections, with thickness varying from 15 to 20 µm, were prepared according to usual techniques (Johansen 1940, Sass 1951), stained with safranin or fast green and mounted in permanent slides with "Permount" synthetic medium. From the histological sections, 1580 perforated plates were analyzed. The macerate tissue was prepared with modified Franklin's solution (Berlyn & Miksche 1976) and stained with safranin. An Olympus BX-50 photomicroscope with Nomarski interference contrast was used for some photographs. For scanning electron microscopy (SEM) samples of wood were taken in radial section and coated with gold.

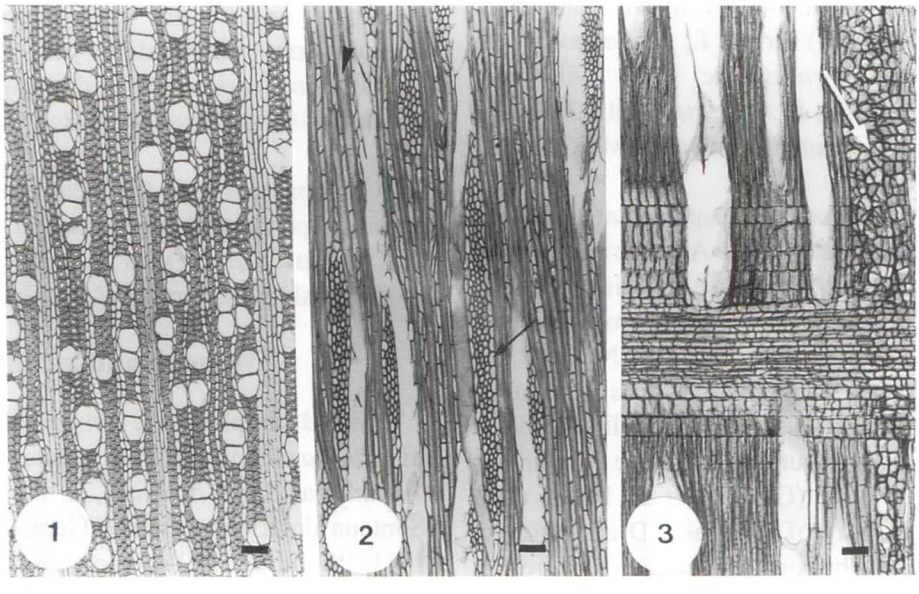
Results

Anatomical description of *Bathysa nicholsonii* K. Schum.

Vessels arranged in a diffuse-porous pattern (figure 1), solitary (54%), multiples of 2 (41%), multiples of 3-4 (5%), angular in outline, tangential diameter of vessel lumina (39-)72(-99) µm, (22-)31(-41) vessels per square mm, (760-)1120(-1570) µm vessel element length, tails present (100%), simple, vestigial and multiple perforation plates (figure 4), intervessel pits alternate, polygonal to circular, (3-)4(-5) µm in diameter, vestured, vessel-ray pits with (5-)9(-15) µm in diameter, circular to elongated with coalescent apertures. Axial parenchyma absent (figure 1). Rays uniseriate (34%), multiseriate 2-4 cells wide (32%), 5-10 cells wide (34%) (figure 2), variable height (0.18-)0.89(-1.79) mm, fused rays (1.97-)3.23 (-5.57) mm, (5-)9(-13) rays per millimeter, heterocellular with 2-13 marginal rows of upright and/or square cells (figure 3), compartmented rays by fibres (4%), sheath cells (figure 2 arrow). Perforated ray cells isolated with multiple perforated plates and bordered pits similar to the intervessel pits (figure 14, 15). Fibres (25-)34(-46) µm diameter, with bordered pit (2.4 µm on average), thick-walled (7-)10(-20) µm (87%), septate (figure 2 arrowhead), length (0.66-)1.64(-2.19) mm. Pith fleck present (figure 3).

Perforation plates

A great variation was observed in the perforation plates as compared to the type of simple perforation occurring in most of the vessel elements. Such variation ranges from a form atypical simple, with reniform aspect, to multiple forms (figure 4). Among



Figures 1-3. Wood sections of *Bathysa nicholsonii*. 1. Transverse section, parenchyma absent. 2. Tangential section, uniseriate and multiseriate rays, sheath cells (arrow), septate fibre (arrowhead). 3. Radial section, heterocellular rays and pith fleck (arrow). Scale bars = 100 µm.

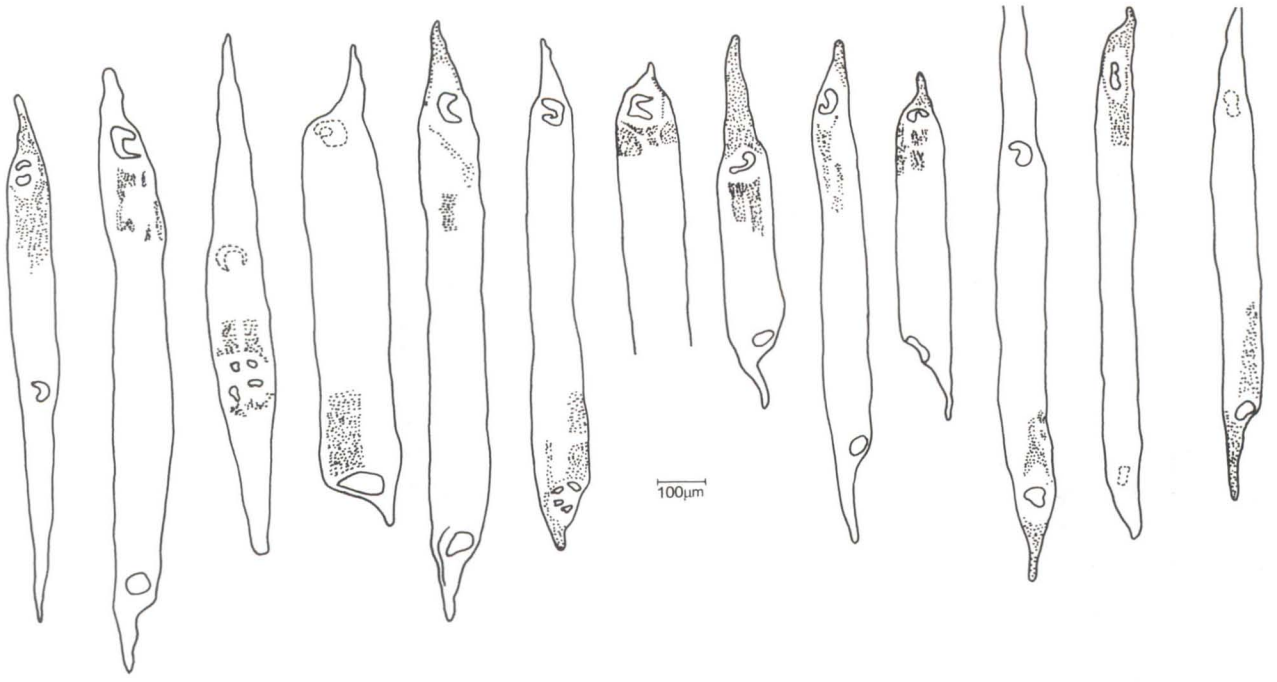


Figure 4. Vessel elements of *Bathysa nicholsonii*, showing variation on perforated plates.

the observed plate types, there is one with two great simple reniform plates, where the concavities are disposed one in front of the other (1.3%) (figure 5).

Another type presents a structure, most of the times circular, centrally positioned in the area of the perforation plate, and linked to its border by means of a stalk of variable size (7.6%) (figures 6, 8-11). This type is easily identified in morphologically reminding an operculum in the opening of the plate, not occupying, however, the whole perforation area.

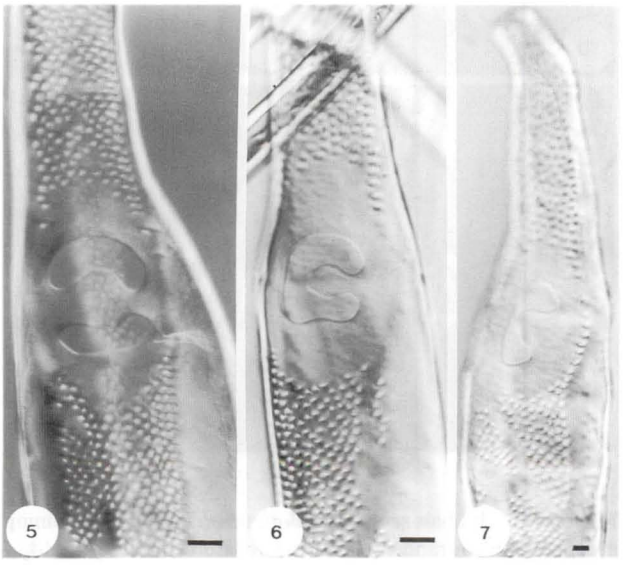
Another type, reniform, possibly just represents a vestigial stage of the structure previously mentioned (6.3%) (figures 7, 12).

The multiple type, formed by the presence of several simple plates (circular or elongate) of reduced size (14.6%) (figure 13), can be observed in the extremities of vessel elements, as well as in perforated ray cells (figures 14, 15).

The atypical forms may be present in both extremities of the vessel element or in only one of them (figure 4).

Discussion

Koek-Noorman (1977) differentiates two types of secondary xylem in rubiaceous wood: I) xylem with fibre-tracheids, axial parenchyma apotracheal, vessels mainly solitary and narrow rays with long uniseriate margins; II) xylem with septate libriform fibres, axial parenchyma absent or scanty paratracheal, vessels in short radial multiples (2-4 or more) and solitary, rays wider, with few rows of upright/square ray cells. The

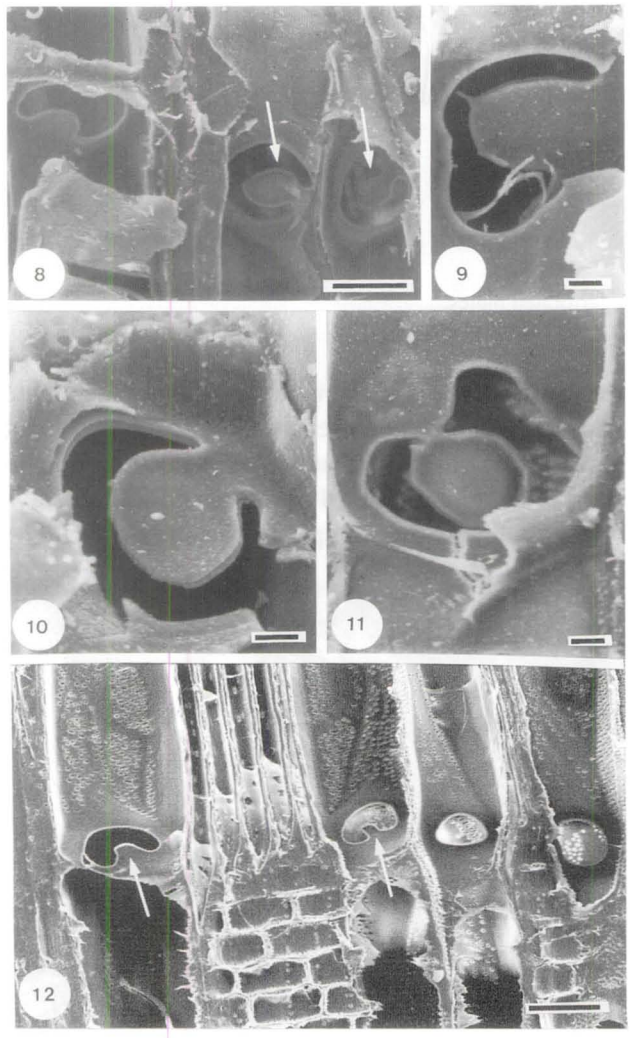


Figures 5-7. Macerated tissue in Nomarski interference contrast. 5. Two simple reniform plates, with the concavities one in front of the other. 6. Perforated plate with like-operculum structure. 7. Vestigial reniform perforated plate. Scale bars = 50 µm.

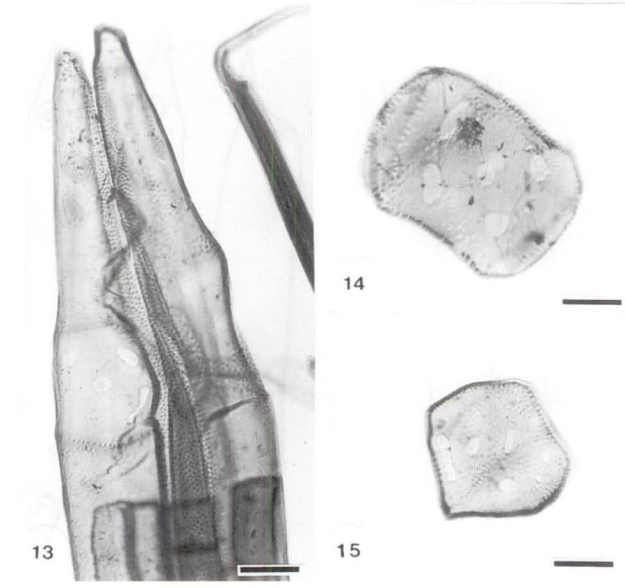
wood of *B. nicholsonii* is type II. Based on this characteristic, Jansen et al. (2002) suggested the exclusion of *Bathysa* from Rondeletideae, characterized by wood type I.

The absence of axial parenchyma in *B. nicholsonii* was mentioned by Metcalfe & Chalk (1950), who pointed out that in the Rubiaceae the parenchyma absence happens in those species with septate fibers, as observed in this work.

The tendencies of specialization of the perforation plates in dicotyledons woods were observed by Frost (1930a, b). According to those tendencies, the simple perforation plates were developed from the scalariform perforation plates by gradual losses of bars. In *B. nicholsonii* it is possible to find a similar pattern of perforation plates when observing the sequence exhibited in figures 5-7. Here, the type with two great simple reniform plates, disposed face to face (figure 5), would be a primitive stage and the one reminding an operculum (figure 6) together with the vestigial type (figure 7) would be an intermediary, previous to the final simple perforation plate stage.



Figures 8-12. Radials sections of *Bathysa nicholsonii* in scanning electron micrograph. 8. Two perforated plates with like-operculum structure (arrows) and one vestigial reniform plate. 9-11. Perforated plate with like-operculum structure; observe the wide to narrow operculum joining with the rim. 12. Two simple perforated plates and two vestigial reniform perforated plates (arrows). Scales bars: figures 8 and 12 = 50 μm; figures 9-11 = 10 μm.



Figures 13-15. Macerated tissue of *Bathysa nicholsonii*. 13. Two vessel elements with multiple perforated plate. 14-15. Perforated ray cells with multiple perforated plates. Scales bars: figures 13 and 15 = 50 μm, figure 14 = 30 μm.

In *B. meridionalis*, Ceccantini & Angyalossy-Alfonso (2000) found two or even three perforation plates in perforated ray cells, and although they found mostly one (96%) or rarely two perforation (4%) on each end of vessel elements, the authors suggested that they are the most frequent connection with perforated ray cells, since the occurrence of the latter is also small. In *B. nicholsonii*, the frequency of vessel element with multiple perforated plates is 14.6%, and the occurrence of the perforated ray cells is visually very common, and should be nearly the same.

Rudall (1982) had already suggested that, in *Canthium barbatum* most of the irregular types of perforation plates occur where a vessel passes through a ray. In *B. nicholsonii* the multiple type of perforation plates formed by some simple plates suggests they

are related with the perforated ray cells since the first occur in the end of vessel elements and in perforated ray cells.

In *B. nicholsonii* 30% of perforated plates are unusual. The multiple perforated plates, related to perforated ray cells, present the largest occurrence (figure 13). The most primitive type is also the most rare (figure 5), and those considered intermediary forms are practically equal in occurrence (figures 6, 7). The presence of perforated plates resembling an operculum (figure 6) is recorded here for the first time in literature.

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