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Perforated Ray Cells in Korean Celastraceae and Oleaceae*1

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ABSTRACT

Ray cells with perforations are recorded for the first time in the Korean Celastraceae species of *Euonymus sieboldiana* and *Tripterygium regelii* and the Oleaceae species of *Abeliophyllum distichum*, *Forsythia ovata*, *Ligustrum japonicum*, and *Osmanthus heterophylla*. All these anomalous ray cells have simple perforations, and the vessel elements of all these species have simple perforation plates. Thus, in the Korean Celastraceae and Oleaceae, the perforations of ray cells appear to be identical with the types of perforation plates in the vessel elements of the same wood. The diagnostic value of the perforated ray cells is also discussed.

Keywords : Perforated ray cells, *Abeliophyllum*, *Euonymus*, *Forsythia*, *Ligustrum*, *Osmanthus*, *Tripterygium*, Celastraceae, Oleaceae, Korean hardwoods

1. INTRODUCTION

Perforated ray cells are secondary xylem cells, derived from ray initials, that are of the same dimensions or larger than the adjacent ray cells, but have perforation plates and lateral wall pitting like those of vessel elements (Carlquist, 1988; IAWA Committee, 1989). The unusual ray cells with perforations connect a vessel on one side of a ray with a vessel on the opposite side of that ray (Bottoso & Gomes, 1982; Otegui, 1994) and are referred to as perforated ray cells (Chalk & Chattaway, 1933) or as vascular ray cells (McLean & Richardson, 1973). These perforated ray cells may occur either individually or in radial or tangential rows. Radial rows of perforated ray cells with perforations in tangential walls have been described as radial vessels (van Vliet, 1976; IAWA Committee, 1989). The type of perforation in the ray cells may be simple, scalariform, reticulate or foraminate, and it does not necessarily coincide with the type of perforation plate occurring in the vessel elements of the same wood (Rao *et al.*, 1984; IAWA Committee, 1989).

Since Chalk and Chattaway (1933) recorded for the first time the occurrence of perforated ray cells in a number of families, this cell type has been commonly found in hardwoods (Carlquist, 1960 · 1982 · 1983 · 1989; Stern, 1967; Koek-Noorman, 1970 · 1972; McLean & Richardson, 1973; Koek-Noorman & Hogeweg, 1974; Miller 1975; Nazma *et al.*, 1981; Bottoso & Gomes, 1982; Carlquist *et al.*, 1983; Teixeira, 1983; Dayal *et al.*, 1984; Rao *et al.*, 1984; Rudall, 1985; Baas *et al.*, 1988; Zhang & Baas, 1992; Norverto, 1993; Eom, 1994; Eom & Chung, 1993 · 1995 · 1996 · 1997; Otegui, 1994; Nagai *et al.*, 1994; Machado *et al.*, 1997). However, to our knowledge, there have been no previous

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records of perforated ray cells in the Korean Celastraceae and Oleaceae. This paper reports the occurrence and perforation type of perforated ray cells in the Korean Celastraceae and Oleaceae.

2. MATERIALS & METHODS

Table 1 lists the Korean hardwood species that were investigated. These species included 9 species from the genera *Celastrus*, *Euonymus*, and *Tripterygium* belonging to Celastraceae and 15 species from the genera *Abeliophyllum*, *Chionanthus*, *Forsythia*, *Fraxinus*, *Ligustrum*, *Osmanthus*, and *Syringa* belonging to Oleaceae. The scientific names of these species were based on Kim (1994).

Wood samples were obtained from the collections in Wood Anatomy and Physics Laboratory, Department of Forest Products, Kookmin University, Seoul, and from Mt. Chiri located in the southern part of the Korean Peninsula. Small cubes of about 1 cm per side were softened in water in an autoclave and immediately stored in a mixture of equal volumes of glycerine, ethyl alcohol, and water until sectioning (Berlyn & Miksche, 1976). Transverse, radial, and tangential sections of 20 to 30μm thickness were cut with a sliding microtome and permanent slides were prepared following general laboratory techniques (Japan Wood Research Society, 1985). Observations and photomicrography of perforated ray cells were made on radial and tangential sections.

Table 1. Types of perforations in vessel elements and perforated ray cells in the xylem of Korean Celastraceae and Oleaceae.

Species	Vessel element	Perforated ray cell
Celastraceae		
Celastrus orbiculatus Thunberg	Simple	None
Euonymus alata (Thunb.) Siebold	Simple	None
Euonymus alatus for. *ciliato-dentatus* Hiyama	Simple	None
Euonymus japonica Thunberg	Simple	None
Euonymus macroptera Ruprecht	Simple	None
Euonymus sachalinensis Maximowicz	Simple	None
Euonymus sieboldiana Blume	Simple	Simple
Euonymus trapococcus Nakai	Simple	None
Tripterygium regelii Sprague et Takeda	Simple	Simple
Oleaceae		
Abeliophyllum distichum Nakai	Simple	Simple
Chionanthus retusa Lindley et Paxton	Simple	None
Forsythia koreana Nakai	Simple	None
Forsythia ovata Nakai	Simple	Simple
Fraxinus mandshurica Ruprecht	Simple	None
Fraxinus rhynchophylla Hance	Simple	None
Fraxinus sieboldiana Blume	Simple	None
Ligustrum japonicum Thunberg	Simple	Simple
Ligustrum obtusifolium Siebold et Zuccarini	Simple	None
Ligustrum ovalifolium Hasskarl	Simple	None
Osmanthus asiaticus Nakai	Simple	None
Osmanthus heterophylla P.S. Green	Simple	Simple
Syringa dilatata Nakai	Simple	None
Syringa reticulata var. *mandshurica* Hara	Simple	None
Syringa velutina var. *kamibayashi* T. Lee	Simple	None

3. RESULTS & DISCUSSION

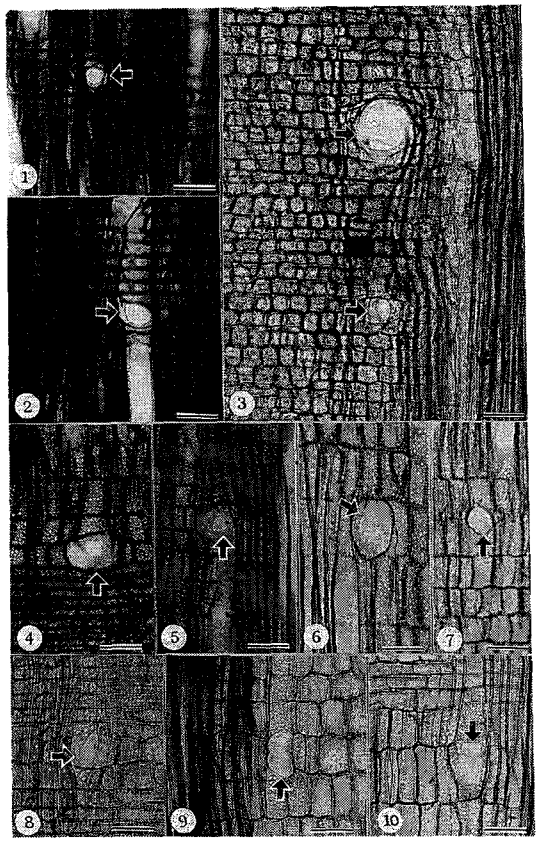
Perforated ray cells were identified in *Euonymus sieboldiana* and *Tripterygium regelii* (Celastraceae) and in *Abeliophyllum distichum*, *Forsythia ovata*, *Ligustrum japonicum*, and *Osmanthus heterophylla* (Oleaceae) (Table 1).

Perforation plates in these ray cells (Table 1, Figs. 1~10) were all simple and identical to the types of perforation plates in the vessel elements of same wood. This is in agreement with Nazma *et al.* (1981), Dayal *et al.* (1984), Rudall (1985), Eom (1994), Eom and Chung (1993, 1995), and Machado *et al.* (1997), but in disagreement with Teixeira (1983), Rao *et al.* (1984), Otegui (1994), and Eom and Chung (1996, 1997), who reported that the perforation types of perforated ray cells were different from those of vessel elements. The fact that the perforation type in a perforated ray cell does not necessarily coincide with the type of perforation occurring in the vessel element of the same wood was described by the IAWA Committee (1989). Recently, Nagai *et al.* (1994) reported that the perforation plates were mostly dimorphic with the total area of the openings in the perforated ray cells smaller than the perforation plates in vessel element ends. Machado *et al.* (1997) reported that perforated ray cells in *Styrax camporum* had simple perforation in root wood and scalariform perforation in stem wood but were more numerous in the root wood than in the stem wood.

Perforation plates occurred in the radial walls of perforated ray cells in the Korean Celastraceae and Oleaceae (Figs. 1~10). These ray cells with perforations in their radial walls were considered to possibly connect two longitudinal vessel elements in the tangential direction (Teixeira, 1983; Eom & Chung, 1993 · 1995 · 1996 · 1997), and these perforated ray cells were believed to connect a vessel on one side of a ray with a vessel on the opposite side of that ray (Botosso & Gomes, 1982; IAWA Committee, 1989).

Perforated ray cells in this study were of the same dimensions or larger than the adjacent ray cells (Figs. 1~10), which is in agreement with IAWA Committee (1989), Eom (1994), Nagai *et al.* (1994), and Eom and Chung (1993, 1995, 1996, 1997).

The diagnostic value of these perforated ray cells has been discussed by several researchers.



Figs. 1~3. Perforated ray cells with simple perforation (arrow) in radial surface in Celastraceae.
Fig. 1 & 2. *Euonymus sieboldiana* Blume.
Fig. 3. *Tripterygium regelii* Sprague et. Keda.
Figs. 4~10. Perforated ray cells with simple perforation (arrow) in radial surface in Oleaceae.
Figs. 4 & 5. *Abeliophyllum distichum* Nakai.
Figs. 6 & 7. *Forsythia ovata* Nakai.
Fig. 8. *Ligustrum japonicum* Thunberg.
Figs. 9 & 10. *Osmanthus heterophylla* P.S. Green.
Scale bars = 50μm.

Some workers (Dayal *et al.*, 1984; Rudall, 1985; IAWA Committee, 1989; Eom & Chung, 1996 · 1997) described that the presence or absence of perforated ray cells might not be useful in wood identification because of their sporadic occurrence. However, Otegui (1994) showed that perforated ray cells in *Rapanea laetevirens* and *R. lorentziana* of Myrsinaceae had diagnostic value because of their regular occurrence. The absence or presence of perforated ray cells may be due to chance because they occur irregularly.

To our knowledge, there have been no previous records of perforated ray cells in the Korean Celastraceae and Oleaceae, and thus the occurrence of this feature may be variable and of minor diagnostic significance in these families.

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