Systematics value of stomata in some Nigerian hardwood species of Fabaceae

M. IDU, D.J. OJORUNFEMI and A.C. OMONHINMIN

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ABSTRACT - Epidermal morphology and the structure and development of stomata in 10 species of Fabaceae are described. The epidermal cells varied from irregular to straight-walled and in some taxa sinuous patterns were observed. The leaves are hypostomatic. Anomocytic stomata follow an agamospermous ontogenetic pathway, while paracytic stomata are eumesogynously derived. These stomatal features are considered to be of systematic value in delimiting hardwood species in this family.

KEY WORDS - Stomatal distribution, Nigerian hardwoods, Fabaceae

The Fabaceae comprise 600 genera and 12000 species, and are cosmopolitan in distribution. They are the third largest family of flowering plants. Some, like the Mimosoideae and Caesalpinoideae, are mostly found in the tropics. However, Papilionoideae are both tropical and temperate in distribution (WILLIS & AIRY-SHAW, 1973). The importance of stomatal features and ontogeny as taxonomic criteria at various levels of the systematic hierarchy is well established in comparative anatomical, phylogenetic and paleo-botanical studies (METCALFE & CHALK, 1950; TATEOKA et al., 1959; STACE, 1965; METCALFE, 1969; VAN-COTTHEM, 1973; VAN WYK et al., 1982; GILL & KARATELA, 1983; KARATELA & GILL, 1984; NYAWUAME & GILL, 1990, 1991, 1993).

In spite of the importance of the stomatal apparatus in physiology and taxonomy, information on its structure, distribution and size in tropical trees is lacking. Earlier contributions on the ontogeny of stomata of leguminous plants are by MISRA et al. (1968), SHAH (1969a, 1969b), SHAH & GOPPAL (1971), GILL & KARATELA (1986), and NYAWUAME & GILL (1990).

Since no comprehensive account exists on the epidermal morphology and ontogeny of tropical trees, the present study was undertaken. This paper describes stomatal types and ontogeny of stomata in ten taxa of Nigerian Fabaceae.
MATERIALS AND METHODS

Foliar material was collected fresh from plants growing under natural conditions in the Okomu Forest Reserve in Benin City (Lat. 6.5°N, Long. 6.0°W). Samples were fixed in formalin-alcohol-acetic acid (FAA) for 24 hours and washed in 70% ethanol. Epidermal peels were obtained following the method of NYAWUAME & GILL (1993). Measurements were carried out on a minimum of 50 mature stomata of each taxon investigated. Line drawings were made at a uniform magnification of x260 using "Abbe" drawing apparatus. The terminology of mature stomata and stomatal ontogeny used in this paper is that of FRYNS et al. (1973) and RASMUSSEN (1981).

RESULTS

The taxa studied, along with their stomatal features (distribution, morphological type, ontogenetic type, size and frequency), are summarized in Table 1.

Albizia adianthifolia Linn.

The cells of the upper and lower epidermal layers have straight walls. The leaves are hypostomatic with mature stomata restricted to the abaxial surface only. The stomata are anomocytic and follow the arogenous ontogenetic pathway. The meristemoid does not divide but is transformed into a guard mother cell which enlarge considerably before dividing to form the guard cells. Trichomes are simple, unicellular and glandular (Figure 1a, b, c).

Albizia zygia Linn.

The cells of the upper and lower epidermal layers have irregular walls. The leaves are hypostomatic. The mature stomata are anomocytic and follow the arogenous ontogenetic pathway. The meristemoid does not divide but is transformed into a guard mother cell which enlarge considerably before dividing to form the guard cells (Figure 2a, b).

Figure 1 - Epidermis (a), stomata ontogeny (b), and trichomes (c) from mature leaves of Albizia adianthifolia

Figure 2 - Epidermis (a) and stomata ontogeny (b) from mature leaves of Albizia zygia.
The taxa studied along with their stomatal features viz: distribution, morphological type, ontogenetic type, size and frequency. **U** = upper, **L** = lower

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Leaf surface</th>
<th>Wall pattern</th>
<th>Distribution of stomata on leaf</th>
<th>Morphological type of stomata</th>
<th>Ontogenetic type of stomata development</th>
<th>Length (μm) ± S.E.</th>
<th>Breadth (μm) ± S.E.</th>
<th>Pore size (μm) ± S.E.</th>
<th>Frequency (No./mm²)</th>
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</thead>
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<td><em>Albizia adiantifolia</em> L.</td>
<td>U</td>
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<td>Anomocytic</td>
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<td>Anomocytic</td>
<td>Agenous</td>
<td>30.72±0.14</td>
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<td>Anomocytic</td>
<td>Agenous</td>
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<td>Anomocytic</td>
<td>Agenous</td>
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<td>Agenous</td>
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**Amphimas pterocarpoides** Harms.

The upper epidermal cells have straight walls while the lower cells have sinuous walls. The stomata are restricted to the lower epidermis. Mature stomata are anomocytic. The anomocytic stomata follow an agenous ontogenetic pathway. Each meristemoid cell simply enlarges and is transformed into a guard mother cell without cutting off subsidiary cells (Figure 3a, b).

**Baphia nitida** Lodd.

The upper and lower epidermis have cells with irregular walls. The leaves are hypostomatic. Mature stomata are restricted to the abaxial surface of the leaf. The stomata are anomocytic. They follow the agenous ontogenetic pathway. Each meristemoid simply enlarges and is transformed into a guard mother cell without cutting off subsidiary cells (Figure 4a, b).

**Baubinia rufescens** Linn.

The upper and lower epidermal cells have straight walls. The leaves are hypostomatic with mature stomata restricted to the lower epidermal cells. The mature stomata are paracytic and follow the agenous ontogenetic pathway. Each meristemoid cell enlarges and is transformed into a guard mother cell without cutting off subsidiary cells. Trichomes are simple, unicellular and glandular (Figure 5a, b, c).

**Distemonanthus benthamianus** Baill.

The upper and lower epidermal cells have straight walls. The leaves are hypostomatic. Mature stomata are restricted to the abaxial surface. The mature stomata are paracytic and follow the eumesogenous ontogenetic pathway. The meristemoid divides twice to give rise to two mesogenes; the guard mother cell eventually divides to form two guard

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**Figure 3** - Epidermis (a) and stomata ontogeny (b) from mature leaves of *Amphimas pterocarpoides*.

**Figure 4** - Epidermis (a) and stomata ontogeny (b) from mature leaves of *Baphia nitida*. 
cells with a pore between them. Multicellular glandular trichomes are present (Figure 6a, b, c).

**Gossweilerodendron balsamiferum** Harms.

The upper and lower epidermal cells have walls that are irregular. The leaves are hypostomatic with mature stomata restricted to the abaxial surface. The stomata are paracytic and follow the eumesogenus ontogenetic pathway. The meristemoid divides twice to give rise to two mesogenes and the guard mother cell. The guard mother cell eventually divides to form two guard cells with a pore between them (Figure 7a, b).

**Hylodendron gabunense** Taub.

Both the upper and lower epidermal cells have sinuous walls. The leaves are hypostomatic with mature stomata.
restricted to the abaxial surface only. The mature stomata are anomocytic in nature. They follow an agenous ontogenetic pathway. Each meristemoid simply enlarges and is transformed into a guard mother cell without cutting off subsidiary cells (Figure 8a, b).

**Pilostigma thomningii** Hochst.

The upper and lower epidermal cells have straight walls. The leaves are hypostomatic, with mature stomata restricted to the abaxial layer. The stomata are anomocytic. They follow the agenous ontogenetic pathway. Each meristemoid simply enlarges and is transformed into a guard mother cell without cutting off subsidiary cells. Trichomes are simple, unicellular and glandular (Figure 9a, b).

**Tetrapleura tetraptera** Schum.

The cells of the upper and lower epidermal layers have irregular walls. The leaves are hypostomatic with mature stomata restricted to the abaxial surface only. The stomata are anomocytic and follow the agenous ontogenetic pathway. The meristemoid does not divide but is transformed into a guard mother cell which enlarges considerably before dividing to form the guard cells (Figure 10a, b, c).

**DISCUSSION**

In the present study, ten species distributed in nine genera were investigated for epidermal structure and
ontogeny of stomata. The epidermal cells of the species are variable.

From the data in Table 1, it is apparent that there is a correlation between life form and stomatal type as eight of the ten tree taxa investigated have anomocytic stomata, the other two have the paracytic type. This is expected as the anomocytic stomatal type is considered to be more primitive than the paracytic one, and the woody life form is more primitive than shrubby and herbaceous habits (HUTCHINSON, 1969).

A correlation also exists between life form and stomatal distribution as all the woody taxa are hypostomatic with mature stomata restricted to the lower surface of the leaflets. A similar correlation for woody taxa has been reported by CARPENTER & SMITH (1975) in Appalachian hardwoods, by GILL et al. (1982) in arborescent taxa of Leguminosae, and by KARATELA & GILL (1984) in some Nigerian hardwoods. According to STACE (1965), distribution of stomata is of considerable taxonomic value though, occasionally, it is influenced by ecological factors.

Epidermal cells are straight-walled on the upper surface only in D. benthamianus, A. pterocarpoidea, B. rufescens, P. thomningii and A. adiantifolia. Epidermal cells are straight-walled on both surfaces in D. benthamianus, B. rufescens, P. thomningii and A. adiantifolia. On the other hand, epidermal cells have sinusous walls on both surfaces only in H. gabunense, and on the lower surface only in A. pterocarpoidea.

The leaves are hypostomatic with mature stomata restricted to the lower surface of the leaflets, which confirms the earlier report of GILL et al. (1982). Earlier papers concerning this family (METCALFE & CHALK, 1950; GILL et al., 1982; KARATELA & GILL, 1984) did not describe the epidermal cell walls. Present observations confirm the previous report on the variable nature of epidermal cell walls in this family.

The ontogenetic pathway of stomata for the ten species is reported here for the first time. The agenosous type of stomatal ontogeny was found in all the taxa studied except G. balsamiferum and D. benthamianus where an eumesogenous ontogeny is reported. Paracytic stomata arise through the eumesogenous ontogenetic pathway in these taxa. Stomatal abnormalities were not observed in any of the 10 species studied.

Stomatal ontogeny is not a very reliable taxonomic character. However, in some instances, this same character is fairly reliable and can be used as a diagnostic taxonomic feature in separating the species of a genus. The species with trichomes had simple, unicellular and glandular hair types. These are P. thomningii, A. adiantifolia, and B. rufescens. An exception is found in D. benthamianus with simple multicellular trichomes. Similar observations have been reported earlier for this family by METCALFE & CHALK (1950).

According to STACE (1965), stomatal size may vary on the same leaf, but this may not prevent it from being used as an important taxonomic character in delimiting different species within a genus. It is a common practice to mention stomatal size in present day florals. From the present investigation, it is apparent that stomatal size does not vary much among the different genera. Thus, it does not seem to have any taxonomic value in this family. Stomatal size can be used as a taxonomic tool at the generic level. For example, A. adiantifolia (29.44 x 23.60 µm) can be separated from D. benthamianus (14.08 x 7.68 µm). However, STACE (1965) stated that the variation in stomatal size in any particular taxon should...
be fully ascertained before it is used as a taxonomic parameter.

Stomatal frequency is one of the most widely used characters in pharmacognostic studies (Timmerman, 1927), but its taxonomic significance has not yet been fully realised. Stace (1965) states that the frequency of stomata is a much used, but frequently misused, character. He used this character to separate the species of the genus Lumnitzeria (Combretaceae).

From the present study, it is apparent that stomatal frequency does not vary much in this family. Consequently, stomatal frequency is an unreliable character and cannot be used for the separation of species. Stomatal abnormalities of any kind were not observed in any of the ten species studied.

In conclusion, it is evident that ontogenetic studies of stomata, in conjunction with other evidence, serve as an effective character in determining the systematic position of problematic taxa. The predominance of a particular stomatal type in a taxon is interpreted as indicating the evolutionary position of the taxon concerned. The analysis of relative frequencies of the stomatal types in this family brings out the taxonomic as well as the phylogenetic significance of stomatal characters.

REFERENCES


AUTHORS

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