Floral trichomes in some members of Bignoniaceae

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MS received 7 April 1988; revised 16 January 1989

Abstract. An organographic survey of floral trichomes along with their distribution, ontogeny, systematic and functional significance has been presented in Tabebuia rosea DC, Millingtonia hortensis Linn., Dolichandrone falcata Seem, Jacaranda mimosaefolia D Don and Stereospermum chelonoides DC of Bignoniaceae.

Four types of glandular and two of non-glandular trichomes have been recognised. Ontogenetically the different types of glandular trichomes mainly differ in the pattern of divisions in the head cells and their subsequent differentiation. The richness of total proteins of the heads of some of these suggests them to serve the function of lubrication during gliding growth of floral parts in bud condition.

Keywords. Floral trichomes; distribution; ontogeny; systematic significance; Bignoniaceae.

1. Introduction

Bignoniaceae are characterised by profusion of glandular trichomes both on vegetative and floral parts.

Earliest literature on glandular trichomes of the family is that of Bureau (1864), who for the first time illustrated their structure and diversity. Treub (1889) considered the glandular trichomes met within the inner surface of calyx in Spathodea campanulata to be hydathodes, though Rao (1927) regarded these in S. stipulata to be sugar secreting to aid normal nectary found at the base of the gynoecium. Raghavan and Venkatasubban (1940) described the ontogeny of capitate glands found on the floral parts of S. campanulata and regarded them to be hydathodic. Schumann (1895), Sandwith (1938) and Siebert (1944, 1948) have illustrated taxonomic importance of trichomes within the family and attempted to group them in 9–10 categories based on their position and structure.

In the present investigation, a survey of various types of trichomes found on floral parts in Millingtonia hortensis, Jacaranda mimosaefolia, Tabebuia rosea, Dolichandrone falcata and Stereospermum chelonoides has been undertaken along with their ontogeny.

2. Materials and methods

Materials were mainly collected from trees in local gardens in Bombay, except that of Stereospermum collected from the forests of Jog.

Successive stages of flower buds were fixed in FAA, dehydrated in alcohol-xylol series and embedded in paraffin. Serial sections of 8 μm thick were cut, mounted on slides using Haupt's adhesive and stained with 0.5% aqueous Heidenhain's iron alum haematoxylin (Johansen 1940).
The total polysaccharides and proteins were localised with periodic acid Schiff's reaction (Jensen 1962) and mercuric bromophenol blue method (Mazia et al. 1953). Terminology used in description part is after Siebert (1948).

3. Results

3.1 Types

Mainly, there are two categories of trichomes: (i) glandular and (ii) non-glandular. (i) Glandular trichome consists of a head with dense cytoplasmic cells, a stalk and a foot. The 4 basic types recognised are: (a) peltate scales (figures 1–7), (b) capitate trichomes (figures 8–17), (c) large sunken glandular trichomes (figures 18–21) and (d) funnel-shaped trichomes (figures 22, 23). (ii) Non-glandular trichomes are of two types, (a) stiff, bristly (figures 24–32) and (b) flexible (figures 33–37). They are mostly uniseriate having cells with relatively large lumen and fairly thick walls.

3.2 Structure and distribution

3.2a Peltate scales are of emergent type and consist of a glandular peltate head, a stalk and a base. The glandular head consists of a plate of radially flared up cells, supported on a stalk, consisting of a single cell. Single celled base is usually sunk in a small depression in the epidermis. The number of cells in a head varies from 8–18. They are densely cytoplasmic and stain deeply with haematoxylin. These form dense covering on the surface of pedicel, outer and inner surface of calyx, outer surface of corolla and also on the ovary wall in *Millingtonia, Stereospermum, Dolichandrone* and *Tabebuia* and are absent in *Jacaranda* (table 1).

In *Millingtonia* the head consists of 8 cells (figures 1, 2) and those covering the ovary is 12–18 cells (figure 3). The heads are 14–18 cells in *Stereospermum* (figures 4, 5); 15–16 in *Dolichandrone* (figure 6) and 12 or more in *Tabebuia* (figure 7).

3.2b Capitate trichomes are of emergent types. The head cells vary from 4–12 or more in number, forming a globose or capitate 1 or 2 tiered structure. The stalk is either uniseriate or multiseriate. The latter is multilayered and cushion-like at the base. The basal cell is sunken in the epidermis. These are present on the inner corolla wall and at the base of staminal filament; rarely they are seen on the connective. They are associated with uniseriate, flexible trichomes on corolla.

Trichomes with capitate head of 12 and more cells in *Tabebuia* (figures 8, 9) and *Jacaranda* (figure 10); with globose head of 4–8 cells in single tier in *Stereospermum* (figure 11); of 12 or more cells in two tiers in *Dolichandrone* (figures 12–14) have uniseriate stalk made up of more or less cubical cells. In *Jacaranda* the uniseriate stalk is of balloon like inflated cells (figure 10). In *Millingtonia* (figure 17) the stalk is multiseriate with a cushion-like base.

3.2c Large sunken glandular trichomes are deeply sunk in the epidermis of the organ in which they are present. The glandular head consists of a large number of cells, about 25 or more; the cells are much elongated, and richly cytoplasmic, supported on a stalk of a large distended cell and a base of a flattened cell. Very few
Floral trichomes in some members of Bignoniaceae


of these are seen on the inner wall of corolla in Tabebuia (figure 18) and on the ovary wall in Jacaranda (figures 19, 20) and Millingtonia (figure 21).
3.2d Funnel-shaped trichomes of emergent type are characteristically present in *Jacaranda*. The funnel-like body of the trichome is raised on a short 1–2 celled
Table 1. Species- and organ-wise distribution of trichomes.

<table>
<thead>
<tr>
<th>Types of trichomes</th>
<th>Millingtonia hortensis</th>
<th>Stereospermum chelleanoides</th>
<th>Tabebuia rosea</th>
<th>Dolichandrone falcata</th>
<th>Jacaranda mimosaefolia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peltate scales</td>
<td>P, KO, KI, CO, Ov</td>
<td>P, KO, KO, CO</td>
<td>P, KO, KI, CO, Ov</td>
<td>P, KO, KI, CO, Ov</td>
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<tr>
<td>Capitate Trichomes</td>
<td></td>
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<tr>
<td>a) with uniseriate stalk</td>
<td>CO, CI, f</td>
<td>Cl, f</td>
<td>Cl, f</td>
<td>Cl, f</td>
<td>Cl, f</td>
</tr>
<tr>
<td>b) with multiseriate stalk</td>
<td>CO, CI, f</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Large sunken glandular trichomes</td>
<td>Ov</td>
<td>--</td>
<td>Cl</td>
<td>--</td>
<td>Ov</td>
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<tr>
<td>Funnel shaped trichomes</td>
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<tr>
<td>Stiff and bristly trichomes</td>
<td>P, KO</td>
<td>P, KO</td>
<td>--</td>
<td>P, KO, CO, CI, Ov</td>
<td></td>
</tr>
<tr>
<td>Flexible trichomes</td>
<td>CO, CI, f</td>
<td>CO, CI</td>
<td>CO, CI</td>
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</tr>
</tbody>
</table>

P, Peduncle; KO, outer wall of calyx; KI, inner wall of calyx; CO, outer wall of corolla; CI, inner wall of corolla; f, filament; Ov, wall of ovary.

uniseriate stalk (figures 22, 23). The body of the trichome consists of a plate of cells, densely cytoplasmic, forming a 3-sided funnel-like structure, which appears Y-shaped in a vertical section (figure 23). They are distributed on pedicel, outer wall of calyx and corolla.

3.2e Stiff bristly trichomes are uniseriate, unbranched, slightly broader at the base and narrowed towards the apex. They consist of 1–5 cells with relatively large lumen, scanty cytoplasm and fairly thick walls with bristle-like thickenings.

They usually occur on the surface of the pedicel and outer wall of calyx along with glandular peltate scales in Millingtonia and Stereospermum and exclusively in Jacaranda.

In Millingtonia these are 1–2 celled (figures 24, 25). In Stereospermum they are 2–4 celled (figures 26–28), sometimes the terminal cell of a 3 celled trichome is recurved (figure 28).

In Jacaranda those on the pedicel and outer wall of calyx are single celled, with small blunt thickenings (figure 29), while the ones which densely cover the outer and inner walls of corolla are brittle and made up of 1–3 balloon like inflated cells (figures 30–32).

3.2f Flexible trichomes are uniseriate, unbranched, consisting of 2–3 or more elongated vacuolated thin-walled cells. They are found on filament surface in Millingtonia and on the inner surface of corolla-tube, near the margins of corolla lobes and sometimes on the outer surface of Stereospermum and Tabebuia as well.

In Millingtonia along with capitate glandular ones flexible trichomes are so densely distributed that they fully occupy the space between the corolla tube and ovary. Those crowded near the margins of the corolla lobes and inter-locking the margins are slightly smaller and have inflated cells (figure 33). In Stereospermum

these along with capitate trichomes densely cover the outer as well as inner surface of corolla tube and fully occupy the space between calyx and corolla and corolla and ovary (figure 34). In Tabebuia they are present on the inner wall of corolla along with peltate scales and capitate trichomes and are 1–4 celled. The stalk cells are cubical while the terminal cells are elongate and vacuolate (figures 35–37).
3.3 **Ontogeny**

3.3a *Peltate scales*: The trichome initial becomes papillate, elongate and is densely cytoplasmic (figure 38). It undergoes a transverse division to differentiate into a basal cell and a body cell (figure 39). The basal cell is sparsely cytoplasmic and remains undivided. The body cell divides by a transverse unequal division to form a smaller stalk cell and a terminal head cell (figure 40). The stalk cell may remain single celled (figure 41) or divides transversely to form a two-celled stalk (figure 42). The head cell is densely cytoplasmic. It enlarges and divides anticlinally to form two juxtaposed cells (figures 41, 42) which further divide by anticlinal walls into a number of cells; each one flares up radially so that ultimately an umbrella-shaped plate of radially arranged glandular cells, supported on a stalk is formed (figures 43–45). As the head cells undergo anticlinal divisions, the stalk cell merely gets distended to accommodate the radially flaring head cells.

3.3b *Capitate trichomes*: They are derived from a trichome initial (figure 45) which divides transversely into a foot and a body cell (figure 47). The foot cell remains embedded in the epidermis. The body cell divides transversely to form a stalk cell and a head cell (figure 40). The stalk cell undergoes repeated transverse divisions to form a uniseriate structure with a terminal convex or conical head (figure 49). The head cell undergoes repeated vertical divisions in different planes (figures 50, 51) followed by flaring up of the derivatives to produce a globose head of densely cytoplasmic cells (figures 12–17).

Ontogeny of large sunken glandular trichomes is similar to that of capitate trichomes.

3.3c *Stiff bristly trichomes*: A trichome initial gets differentiated as a papillate elongate cell with median constriction (figures 52, 53). It divides transversely and unequally into a small basal cell and a long body cell (figure 54). The latter divides to produce 2 or more cells with relatively large lumen. The outer surface of mature trichome acquires bristle like thickenings (figures 30–32, 55, 56).

3.3d *Uniseriate flexible trichomes*: They are also derived from trichome initials which divide transversely into a foot and a body cell. The body cell undergoes divisions transversely and result in thin walled cells. The terminal cell is dome-shaped and cytoplasmic (figures 57–63).

4. **Discussion**

Three aspects of floral trichomes merit consideration. They are (i) systematic significance, (ii) ontogenic pattern and (iii) functions.

4.1 **Systematic significance**

Systematic significance of glandular trichomes on vegetative organs in Bignoniaceae has been well recognized (Schumann 1895; Sandwith 1938; Seibert 1940), though glandular and non-glandular floral trichomes have not been considered even though characteristic types of glandular floral trichomes found in several members
of the family have been described (Rao 1927; Raghavan and Venkatasubban 1940; Venkatasubban 1945; Siebert 1948). In the present work, therefore, an attempt has been made to recognize the diversity and distribution pattern of different types of floral trichomes found within the species studied, primarily to assess their taxonomic utility and also to understand their trends of specializations and functions.

The organographic distribution of various types of floral trichomes found in investigated species has been shown in table 1. The distribution pattern of each type of trichome on different floral parts, its structure and association with other types of trichomes serves as an important guide in taxonomic considerations.

One or more types of trichomes appear to be characteristic feature of the family, though capitate trichomes were found on the inner surface of corolla in all the species. Using these features of trichomes, the species studied can be easily distinguished as follows:

A — Funnel shaped trichomes present; peltate scales absent ........ Jacaranda
AA — Funnel-shaped trichomes absent; peltate scales present.
B — Trichomes sunken glandular present
   on inner wall of corolla .................... Tabebuia
   on ovary wall ............................ Millingtonia
BB — Trichomes sunken glandular absent.
   Uniseriate flexible trichomes present on corolla mar-
   gin and inner wall ....................... Stereospermum
   Uniseriate flexible trichomes absent ........ Dolichandrone

4.2 Ontogenic pattern

Ontogenic pattern of glandular trichomes in the family was first reported from the floral parts of *S. campanulata* (Raghavan and Venkatasubban 1940). The present study reveals that the ontogeny of different types of glandular trichomes met within the species studied follows almost identical early course of development with specialization at later stages. They are all derived from a trichome initial which divides into a basal foot cell and an emergent body cell; the latter in turn divides into a terminal head cell and a lower stalk cell. The stalk cell may remain single or may undergo a few transverse divisions. The ontogenetic pattern of various types of glandular trichomes is mainly determined by plane of divisions in the head cell and subsequent differentiation of head cells. The developmental path of scaly and capitate trichomes differs in the plane of division in the head cell. In the former, the head cell undergoes repeated anticlinal divisions. The division pattern in the head cell and disposition of head cells at maturity are significant features which could be employed in assessing the degree of specialization. For example, the peltate scales in which the head cell undergoes divisions only in anticlinal plane and the head cells are characteristically flared up giving umbrella shaped configuration, could be taken as specialized over the capitate trichomes, where head cell undergoes vertical divisions in various planes and the head cells are least modified. On the same grounds, the sunken glandular trichomes where topography affords additional protection to the head could be taken as more specialized over emergent capitate ones as suggested by De Bary (1884).
Floral trichomes in some members of Bignoniaceae

It would be interesting to see how far these trends of specialization in trichomes could be correlated with trends of specialization in floral and vegetative features. In case of such positive correlation one can conclude that the species with less specialized trichomes stand at lower levels than those with more specialized ones.

4.3 Functions

While normal functions of protection and aeration of floral parts could be ascribed to non-glandular floral trichomes (Haberlandt 1914), the glandular trichomes merit special functional consideration. As early as 1889, Treub, who was attracted by profusion of glandular trichomes on the inner surface of calyx in *Spathodea campanulata*, attributed the function of hydathodes protecting the inner floral organs from desiccation. To support this contention, Koorders (1897) showed wide spread distribution of water calyces in tropical plants including several members of Bignoniaceae where flower buds generally grew under comparatively high temperature conditions. While hydathodic function of glandular trichomes in the family has been taken as granted by Venkatasubban (1945), Rao (1927) regarded them to be sugar secreting to aid the floral nectary in pollination. Raghavan and Venkatasubban (1940) refuted this view on the basis of failure of positive test of the exudate for Fehling's reaction for sugars. The histochemical tests for total polysaccharides and proteins carried out during this investigation show that while glandular trichomes in general show faint PAS reaction, some of them especially the capitate and sunken trichomes are appreciably rich in total proteins. The fact that these proteins are mucilagenous in nature suggests that the secretion of at least some of these glandular trichomes must be acting as lubricant facilitating smooth gliding growth of floral parts in bud condition.

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