STRUCTURE OF STOMATA IN MONOCOTS

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Abstract

Eight types of stomatal pattern have been described with examples from the published literature to enhance the utility of stomata in taxonomy. Description of each type has been given. The position and number of subsidiary cells are considered as the important characters for distinguishing the stomata recorded in the monocots.

Introduction

Considerable work has been accomplished during the last two decades on the structure and ontogeny of stomata, cuticular structures including their appendages of dicots, but the progress in monocots has been somewhat tardy.

Structure and ontogeny of stomata in monocots received attention as early as 1886-1887 by Strasburger, and later by many other workers, viz., Duval-Jouve (1872), Campbell (1881), Benecke (1892), Solla (1884) and Treviranus (1820). Considerable work has been done after sixtees of the present century by Stebbins & Jain (1960), Stebbins & Khush (1961), Tomlinsom (1961, 1965, 1969, 1974, 1982), Pant & Kidwai (1966), Paliwal (1969), Kam (1971), Gopal & Shah (1970), Sah & Gopal (1970, 1972), Williams (1975), Atwood & Williams (1979), Comprehensive work on the subject has been done by Metcalfe (1961), Solereder & Meyer (1930), Cutter (1969) and Dunn *et al.* (1965). Terminology used here is as suggested by Dilcher (1974).

Description

In the present paper, different types of stomata occurring in monocots have been described.

1. ANOMOCYTIC TYPE

Stomata generally with two guard cells but devoid of subsidiary cells; they are however, surrounded by ordinary epidermal cells (Text-fig. 2). This type of stomata occur in about half of the total families of monocots.

Stomata usually with a pore, two guard cells and one subsidiary cell, the other side of the stoma is covered by ordinary epidermal cell (Text-fig. 3). This type of stomata are common in the families like Liliaceae, Dioscoreaceae, Araceae and Orchidaceae and described as hemiparacytic (Dilcher, 1974).

2. PARACYTIC TYPE

Stomata usually with two subsidiary cells which are parallel to the guard cells. Subsidiary cells almost cover the guard cells. Such stomata belong to paracytic type (Text-fig. 5) and occur commonly in Zingiberales, Commelinales, Glumiflorae and

Helobieae. In some families like Cyperaceae, Juncaceae, Alismataceae and Proteaceae lateral subsidiary cells cover only the long axis of the guard cells while the poles are covered by the epidermal cells (Text-fig. 7). These stomata are described as brachey-paracytic (Dilcher, 1974).

3. TETRACYTIC TYPE

Stomata usually with four subsidiary cells surrounding the guard cells. The two subsidiary cells parallel to the guard cells are the lateral subsidiary cells and those occurring on the poles are the terminal or polar subsidiary cells. Generally the lateral subsidiary cells are quite elongated as in some members of Palmae (Trivedi & Upadhyay, 1979) and *Pandanus* (Tomlinson, 1965; Kam, 1971). The lateral subsidiary cells are as long as the entire stomatal complex. This type of stoma is tetracytic (Text-fig. 14). They are common in the families like Palmae Pandanaceae, Cyclanthaceae, Commelinaceae, Araceae and Scheuchzeriaceae. Stomata with dumbell shaped guard cells which are enclosed by 4 subsidiary cells. Stomata usually narrow with pore, slit like and vertically oriented (Text-fig. 6). Such stomata occur in the Poaceae and Cyperaceae.

4. HEXACYTIC TYPE

Stomata have six subsidiary cells which surround the guard cells. Stomata have either four lateral subsidiaries and two terminal (polar subsidiaries) or four terminal subsidiaries may be as long or as broad as the stomatal complex itself and two lateral subsidiary cells (Text-figs. 1, 9). This type of stomata commonly occur in Musaceae, Commelinaceae, Araceae and some Palmae.

5. CYCLOCYTIC TYPE

Stomata with a number of subsidiary cells surrounding the guard cells. The subsidiary cells form one or more rings round the guard cells. These subsidiary cells are smaller than the remaining cells. In monocots usually there is only one ring of subsidiaries round the stomatal complex (Text-fig. 12). They are common in Araceae, Musaceae, Sparganiaceae, Alismataceae and Marantaceae.

6. TRICYTIC TYPE

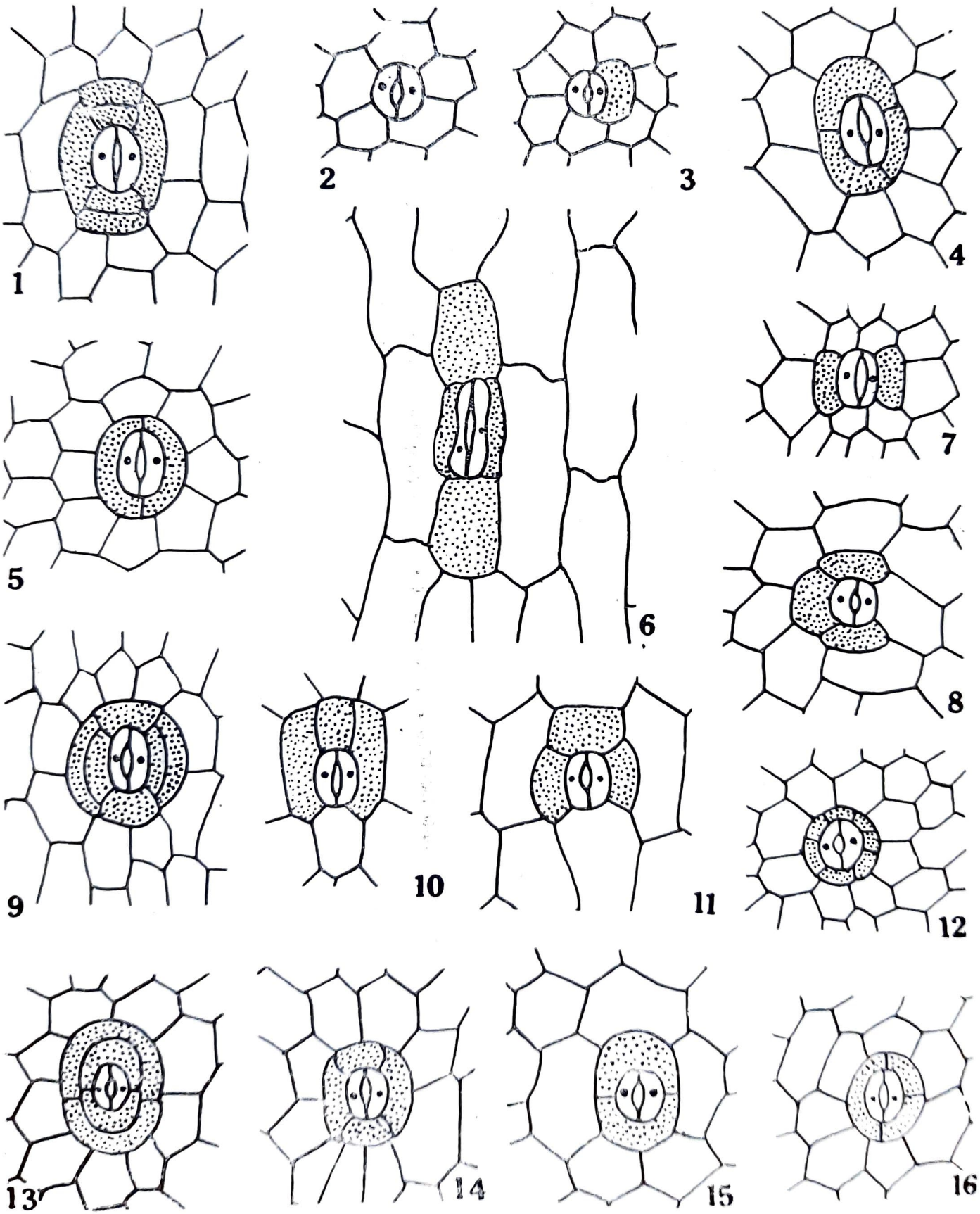
Guard cells of the stomata are surrounded by the three subsidiary cells. This type of stomata first described by Pant and Kidwai (1966). The stomata often look typical anisocytic type. Tricytic stomata may be secondarily derived from tetracytic one by one of the polars or sometimes a lateral being transformed into an epidermal cell (Text-figs. 8, 10-11, 16).

7. DICYTIC TYPE

Guards cells are surrounded by two subsidiary cells which are at right angle to the long axis of the guard cells (Text-fig. 15). This type of stomata are rare in monocotyledons. Williams (1975) reported this type of stomata in some members of Orchidaceae. Sometimes two rings of subsidiary cells are present at right angle to guard cells. Such stomata are described under Amphidiacytic type (Text-fig. 13).

8. ANISOCYTIC TYPE

This type of stomata are rarely occur in monocots. Williams (1975) described the stomata with three distinct subsidiary cells round the guard cells, of which one is smaller,



Text-fig. 1

typical anisocytic in some taxa of Orchidiaceae (Text-fig. 4). These stomata are distinct from the tricytic type.

Conclusions

The eight types of stomata mentioned above are commonly found in the monocots. After going through the literature it has been noticed that anomocytic stomata occur in about half of the total families of monocots. Next to anomocytic, the stomata of most common occurrence in monocots are tetracytic and hexacytic. Paracytic, cyclocytic and other intermediate types occur infrequently and may characterise particular genera.

Leaves in monocots are mostly amphistomatic and the frequency of stomata usually is higher on the lower surface. Distribution of stomata is either irregular as in some members of Araceae, Alismataceae, Orchidaceae, Marantaceae, Dioscoreaceae, Iridaceae, Amaryllidaceae, Juncaceae, Xyridaceae, Eriocaulaceae, etc. While in some families like Palmae, Cyclanthaceae, Pandaceae, Sparganiaceae, Poaceae, Cyperaceae etc. stomata are in regular file in intercostal regions. Leaves are hypostomatic in some member of the Butomaceae, Mydrocharitaceae, Dioscoreaceae, Amaryllidaceae, Velloziaceae etc.

In some families stomata are totally absent from leaves, i.e. they are astomatic. These families are Potamogetonaceae, Zannichelliaceae, Posidoniaceae (marine herbs), Cymodoceaceae, Zosteraceae, Najadaceae and Triuridaceae (Saprophytic herbs). Stomata occasionally are present towards the apical end of the leaf in *Groenlandia dense* (Potamagetonaceae), *Aponogenton distachyos* (Aponogetonaceae) and in all the species of *Zannichellia* (Zannichelliaceae). They are usually small with a pore and a pair of guard cells which are usually thin walled.

Many intermediate forms of tetracytic stomata have been reported and their course of development have also been discussed by various workers (Williams, 1975, Shah & Gopal, 1970, 1972). Shape, size and number of terminal and lateral subsidiary cells vary in some taxa. Sometimes these features are very important and help in distinguishing closely related genera. Pant and Kidwai (1966) have added one more type of stomata-tricytic in monocots. Later emphasis of this type of stomata has been given by various workers (Williams, 1975; Shah & Gopal, 1970, 1972). Different types of stomata and their structure as discussed by Huber (1977) and Mecuse (1975) help in the classification and evolution of the monocotyledons. Cytological features of stomatal development in some members of monocotyledons have also been discussed by Stebbins and Khush (1961), Stebbins and Shah (1960) and Stebbins *et al.* (1967).

Text-fig. 1—Hexactyic stomata showing two lateral and four terminal subsidiary cells × 500; 2, Anomocytic stomata without subsidiary cells × 400. 3, Hemiparacytic stomata with one lateral subsidiary cell × 450; 4, Anisocytic stomata showing three subsidiary cels of which one smaller × 500; 5, Paracytic stomata with two lateral subsidiary cell × 500. 6, Tetracytic stomata showing four subsidiary cells and dumbell shaped guard cells × 400; 7, Paracytic stomata showing two lateral subsidiary cells × 400; 8, Tricytic stomata showing only three subsidiary cells × 400; 9, Hexacytic stomata with four lateral and two terminal subsidiary cells × 500; 10-11, Tricytic stomata with three subsidiary cells × 450; 12, Cyclocytic stomata with a ring of smaller subsidiary cells × 500; 13, Diacytic (amphidiacytic) stomata showing two ring of subsidiary cells × 500; 14, Tetracytic stomata showing two lateral and two terminal subsidiary cells × 500; 15, Diacytic stomata showing two subsidiary cells at right angle to guard cells × 500: and 16, Tricytic stomata with three subsidiary cells × 500.

Known types of stomata among different families of monocots have been given in Table 1, yet much work remains to be accomplished on the structure of stomata and their ontogeny in this large group of Angiosperms.

Table 1

Order	Families	Type of stomata
1. Pandanales	(i) Pandanaceae	Tetracytic, Tricytic
	(ii) Sparganiaceae	Anomocytic, tetracytic
	(iii) Typhaceae	Anomocytic, Paracytic
2. Helobiae	(i) Aliamataceae	Paracytic, tetracytic (often)
	(ii) Aponogetonaceae	Stomata absent (Present in *Aponogeton distachyos*)
	(iii) Butomaceae	Paracytic
	(iv) Hydrocharitaceae	Paracytic
	(v) Najadaceae	Stomata absent
	(vi) Potamogetonaceae	Stomata absent (apex of leaf anomocytic in some taxa *Groenlandia densa*)
	(vii) Saheuchzeriaceae	Tetracytic
3. Triuridales	(i) Triuridaceae	Stomata absent
4. Glomiflorae	(i) Cyperaceae	Paracytic, cyclocytic (often)
	(ii) Gramineae	Anomocytic (*Triticum*), Paracytic
5. Princepes	(i) Palmae	Hexacytic, tetracytic
6. Synauthae	(i) Cyclanthaceae	Tetracytic
7. Spathiflorae	(i) Araceae	Anomocytic, tetracytic, tricytic
	(ii) Lemnaceae	Anomocytic
8. Farinosae	(i) Bromeliaceae	Anomocytic, Paracytic, cyclocytic (often)
	(ii) Centrolepidaceae	Paracytic
	(iii) Commelinaceae	Hexacytic, Paralytic, Tetracytic
	(iv) Cyanastraceae	Paracytic, Anomocytic (often)
	(v) Eriocaulaceae	Anomocytic
	(vi) Flagellariaceae	Anomocytic, paracytic
	(vii) Mayacaceae	Paracytic, anomocytic
	(viii) Philydraceae	Paracytic
	(ix) Pontederiaceae	Anomocytic, Cyclocytic (often)
	(x) Rapteaceae	Anomocytic
	(xi) Restionaceae	Anomocytic, Paracytic

Table 1—(*Contd.*)

Order	Families	Type of stomata
	(xii) Thurniaceae	Paracytic, anomocytic
	(xiii) Xyridaceae	Anomocytic, tetracytic
9. Liliflorae	(i) Amaryllidaceae	Anomocytic, Tetracytic, Tricytic
	(ii) Dioscoreaceae	Anomocytic, Cyclocytic, Tetracytic, Tricytic
	(iii) Haemodoraceae	Anomocytic, Paracytic (often)
	(iv) Iridaceae	Anomocytic, Cyclocytic (often)
	(v) Juncaceae	Paracytic, less tetracytic
	(vi) Liliaceae	Anomocytic, usually paracytic, less tetracytic
	(vii) Stemonaceae	Anomocytic, Paracytic (often)
	(viii) Taccaceae	Anomocytic
	(ix) Velloziaceae	Anomocytic
10. Scitamineae	(i) Cannaceae	Paracytic, tetracytic (often)
	(ii) Marantaceae	Paracytic, less cyclocytic
	(iii) Musaceae	Hexacytic, Paracytic, cyclocytic
	(iv) Zingiberaceae	Paracytic
11. Microspermae	(i) Burmanniaceae	Anomocytic, less Paracytic
	(ii) Orchidaceae	Anomocytic, Tetracytic, Tricytic, and anisocytic

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