

STUDIES ON *EQUISETUM* : STOMATA FROM ANNULUS OF *EQUISETUM RAMOSISSIMUM* CONE AND ITS SIGNIFICANCE*

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ABSTRACT

The existence of stomata in the annulus of *Equisetum* cone was not reported till now. A study of annulus of *E. ramosissimum* cone by the author shows the presence of stomata in the annulus. This study opens a new approach to the morphological nature of annulus.

INTRODUCTION

Several papers have been published on the stomata in *Equisetum*, but their presence in the annulus has not been reported so far. The structure of stomata, its shape and size are rather interesting in annulus of *Equisetum* cone as compared with stomata found in leaf and stem. The distribution of stomata and silica bands are also peculiar in annulus. It was, therefore, thought desirable to put it on record for further investigations.

There are different opinions on the morphological nature of annulus among the workers. It has been described to be leafy in nature or a reduced leaf by KASHYAP (1930), TSCHUDY (1939), BROWNE (1920), EAMES (1936) and FOSTER AND GIFFORD (1967), against the view of BARRATT (1920) who states that it is axial in nature. This paper clearly reveals the presence of stomata in annulus and supports the former view.

MATERIAL AND METHODS

Cones of *Equisetum ramosissimum* with aerial branches were collected by the author from Kathgodam (U. P.) in November, 1973. Epidermal peels were taken from cone axis below the annulus ring (stalk of cone), from the annulus, and from cone axis above the annulus ring. Peels were kept in 20% HNO₃ for 24 hours, permanent slides were prepared by staining the peels in fast-green. For detailed investigation, specimens of *E. ramosissimum* were borrowed from Jardim Botânico, Rio-de-Janeiro, Brazil; Botany Department of Hebrew University, Israel, and Plant Research Institute, Central Experimental Farm, Ottawa, -Canada.

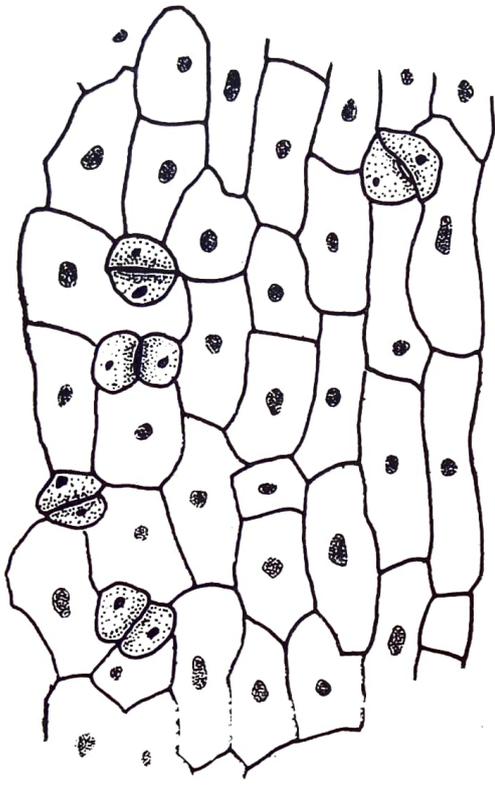
OBSERVATIONS

The peels taken from the annulus have stomata while those from below and above the annulus have no stomata. This shows that stomata are present in annulus only and not in cone axis below or above the annulus. Besides this, the stomata which are present in annulus are rather peculiar in the distribution and morphology.

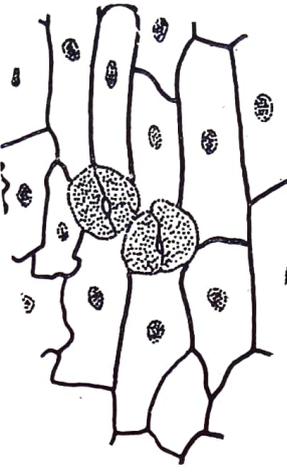
DISTRIBUTION OF STOMATA

An interesting feature of *Equisetum* is the presence of stomata arranged in groups of vertical rows (Fig. 13) in aerial branches and leaves with one to four rows in each group.

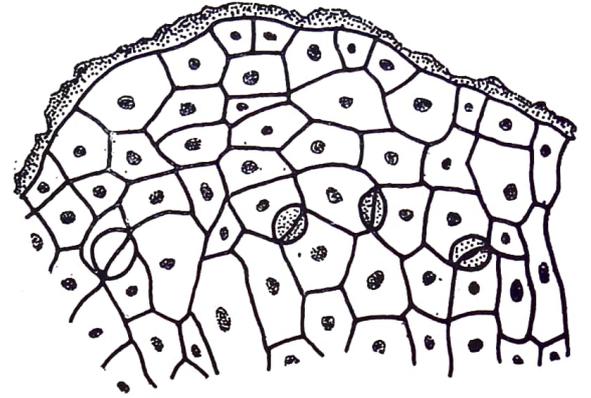
*Paper presented at the Second Indian Geophytological Conference, Lucknow, March, 11-12, 1978.



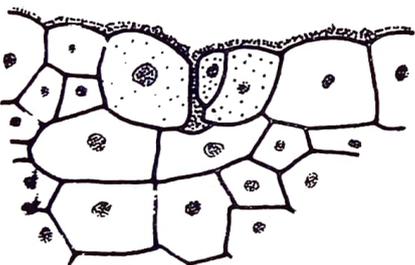
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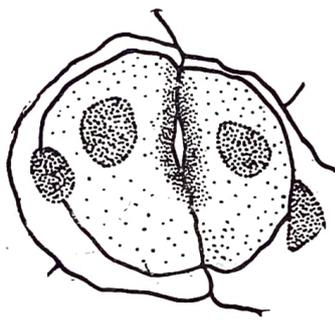
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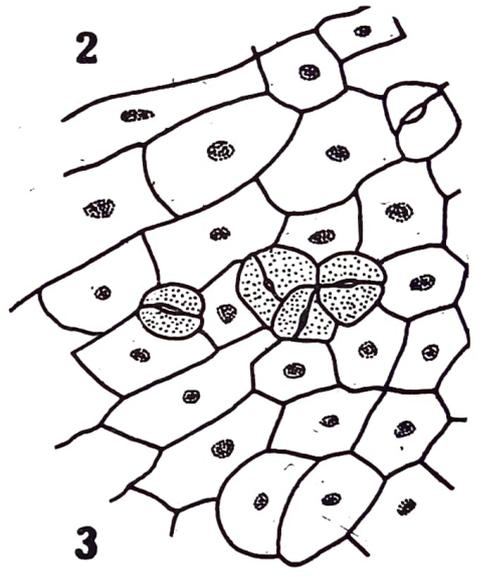
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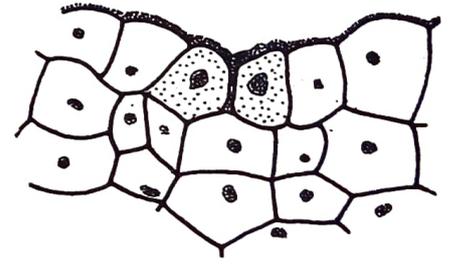
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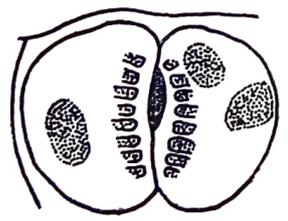
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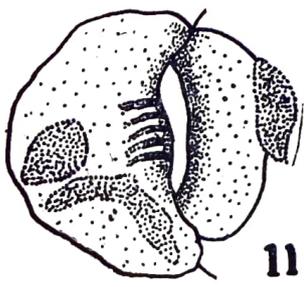
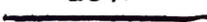
60μ



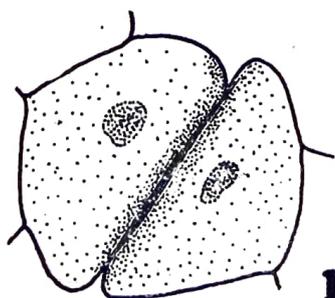
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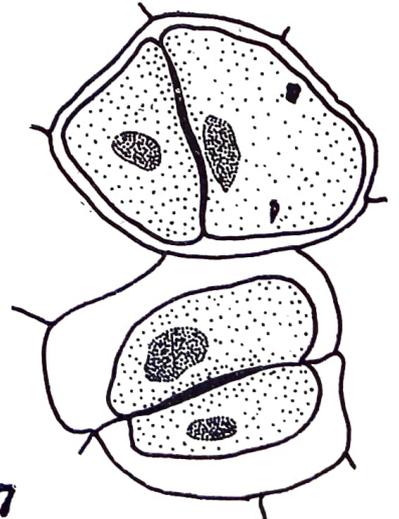
5μ



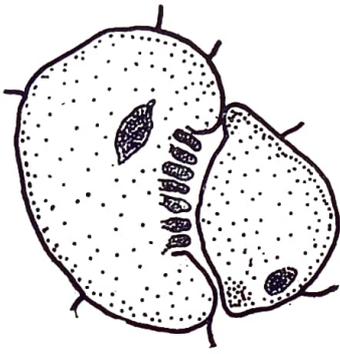
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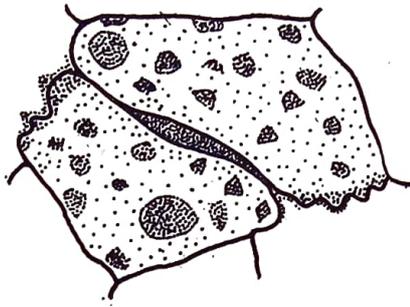
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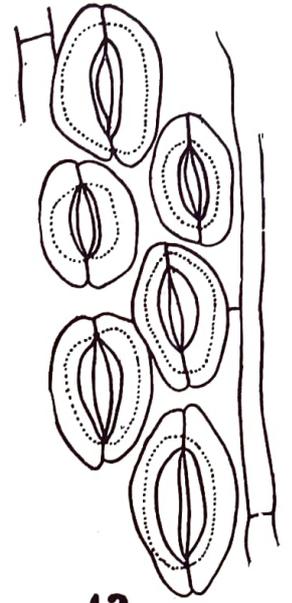
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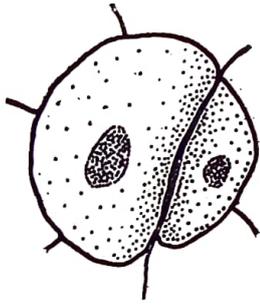
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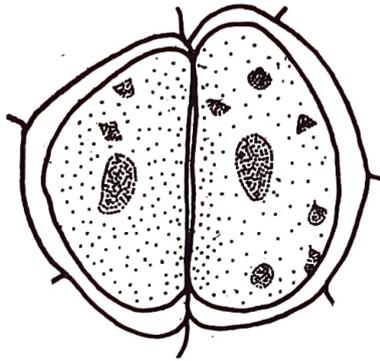
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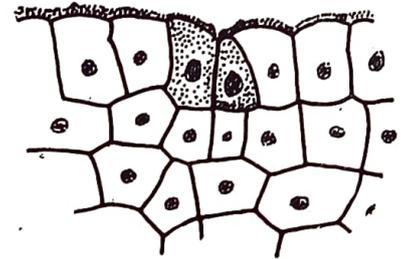
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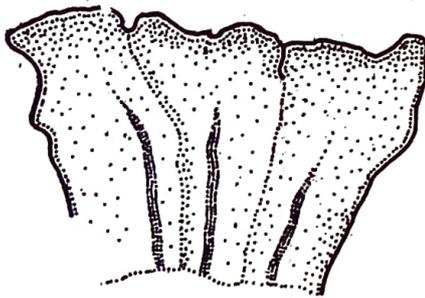
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17



15



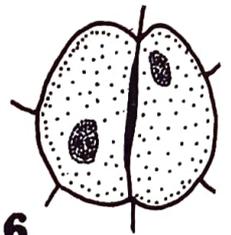
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28 μ 21

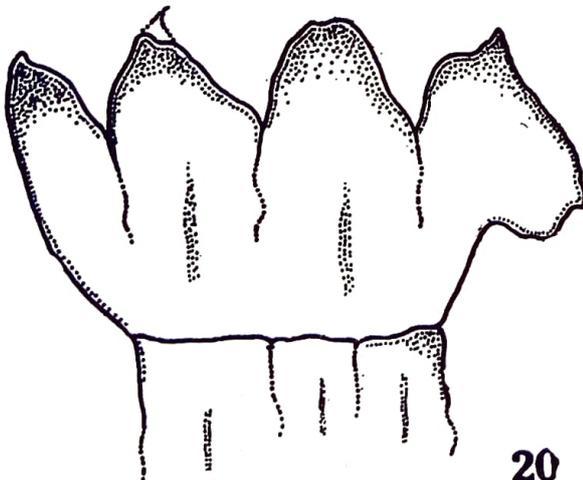
30 μ 12, 14, 16-18

55 μ 13

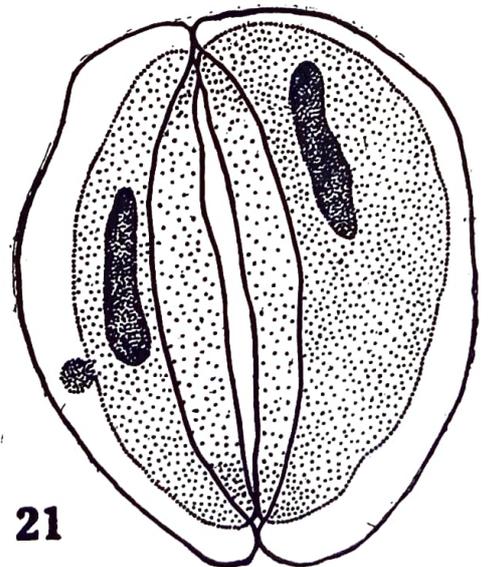
20 μ 15
15X 19, 20



16



20



21

In the annulus (Figs. 1 & 2), however, the stomata are scattered and not distributed in vertical rows. They may be two or more than two in number, very close to or touching each other (Figs. 3, 4) or obliquely placed (Fig. 1). Stomata are not present near the tip of annulus but distributed in 3/4 part of annulus from the base.

SIZE AND SHAPE

In *Equisetum* stomata, the guard cells are overarched by a pair of subsidiary cells (Fig. 21) and their size ranges from 40 μ to 55 μ . The stomata of annulus are clearly distinguishable from the stomata found in aerial branches and leaves by their smaller size. The stomatal size in annulus ranges from 15 μ to 35 μ . Stomatal cavity, in a cross section (Figs. 5, 6) or in surface view (Figs. 7, 8) is found suppressed. Subsidiary cells are generally absent (Figs. 9 & 10) and can hardly be seen. If they are present, their structure is almost similar to that of the guard cells (Fig. 17). In a few cases one of the guard cells is smaller in size than the other (Figs. 11, 12 & 18), while in others, guard cells are triangular in the surface view (Fig. 14). A few stomata are found in closed condition even during day time (Figs. 1, 15 & 16), while in some the nucleus is not clearly visible. It seems that the annulus stomata tend to become highly reduced structures, are more or less functionless and represent vestigial organs.

SILICA DEPOSITION

The presence of silica bands in the stomata of *Equisetum* leaf and aerial branch is another interesting feature. Silica bands are present on the upper surface of guard cells. SAXENA (1976) who studied the stomata from annulus showed that guard cells either did not bear the silica bands (Figs. 16 & 18) or if the silica bands were present, they were incomplete (Fig. 9). In some stomata of annulus, silica bands are present only in one of the two guard cells (Fig. 12) or may be totally absent (Figs. 8 & 13). It is rare to find a complete silica band. In most of the stomata silica is impregnated as dot-like small silica bodies on guard cells (Figs. 14 & 17).

The above observations on the stomata of the annulus show the peculiarities which differentiate them from the stomata found in leaves and aerial branches.

The following specimens have been examined and the same results were obtained by the author**.

**Details printed on herbarium sheets are given as such.

Fig. 1. Stomata from annulus, present in scattered fashion.

Fig. 2. A portion of annulus peel with stomata showing the outer silicious margin of annulus.

Figs. 3 & 4. Stomata are closely arranged and without subsidiary cells. Guard cells are covered with dot-like silica bodies.

Figs. 5 & 6. Stomata, in cross section of annulus in fig. 5 showing two subsidiary cells having one small guard cell on right side. Fig. 6 shows two guard cells with dense cytoplasmic contents.

Figs. 7 & 8. Surface view of stomata showing reduced stoma.

Fig. 9. Stomata without pair of subsidiary cells and incomplete silica ribs are seen.

Fig. 10. Surface view of stomata showing triangular outline of guard cells. Overarching subsidiary cells are absent.

Fig. 11. Stomata with unequal guard cells. Subsidiary cells are absent. Only one side of guard cell is having silica ribs.

1. S. F. JARDIM BOTANICO DO RIO DE JANEIRO. Herb. No. 102883. Fam. Equisetaceae—*Equisetum ramosissimum*. Nom. Vulg.—. Proced. Escola Superior de Agricultura "Leuiz de chueiroz" Piracicaba. Obs.—. Col. Walter Radames Accorsi. Data 2.10.22 Det. p—.
2. S. F. JARDIM BOTANICO DO RIO DE JANEIRO. Herb. No. 67742. Fam. Equisetaceae—*Equisetum ramosissimum* Desf.
3. The Hebrew University, Jerusalem, 33/3, Southern Turkey. *Equisetum ramosissimum* Desf. Env. of Mersine. Ditsches. 12.8.31. Leg. A. Eig and M. Zohary.
4. The Hebrew University, Jerusalem, 33/4, Cyprus, *Equisetum ramosissimum* Desf. Mts. Troodos, Platres. Banks of a stream. 1300 m. 9 VIII, 1939. Leg. N. Feinbrun.
5. The Hebrew University, Jerusalem, 33/6, Herbarium Universitatis Hebraicae Hierosolymitanae. Flora Palaestinae. 20190. *Equisetum ramosissimum* Desf. var. *altissimum* A. Br. ex Milde. Loc. Acre Plain, env. of Nahariya. Hab.—. Alt.—. 1 Date 23.8.1939. Leg. N. Feinbrun and M. Zohary.
6. The Hebrew University, Jerusalem, 33/7, Herbarium Universitatis Hebraicae Hierosolymitanae. *Equisetum ramosissimum* Desf. var. *altissimum* A. Br. ex Milde. Syria, Mt. Hermon. Hatsbani bank near Paradis. 19.7.1924. Leg. A. Eig.
7. The Hebrew University, Jerusalem, 33/8, Herbarium Universitatis Hebraicae Hierosolymitanae. No. 20173. *Equisetum ramosissimum* Desf. var. *altissimum* A. Br. ex Milde. Loc. and Hab. Sharon Plain, banks of Yarkon River, betw. Ir. Ganim and Petah Tiqva Alt.—. Leg. A. Eig. Date 19.9.1924.
8. The Hebrew University, Jerusalem, 33/11, Iraq, No. Releve 4. Zawita plain, ca. 880m Reddish-Compact soil 20.4.1933. Leg. A. Eig. and M. Zohary.
9. The Hebrew University, Jerusalem, 33/12, Syria. *Equisetum ramosissimum* Desf. var. *procerum* (Poll.) Asch. Env. of Sorsikol (near Alexandretta) Bushy roadsides. Leg. A. Eig. and M. Zohary. 10.8.1931.
10. The Hebrew University, Jerusalem, 33/13, Herbarium Universitatis Hebraicae Hierosolymitanae. 20191. *Equisetum ramosissimum* Desf. var. *procerum* (poll.) Asch., Loc. Acre Plain, env. of Nahariya. Hab.—. Alt.—. Date 25.8.1939. Leg. M. Zohary and Feinbrun.
11. The Hebrew University, Jerusalem, 33/14, Herbarium Universitatis Hebraicae Hierosolymitanae. No. 20202. *Equisetum ramosissimum* Desf. var. *procerum* (Poll.) Asch. Loc. and Hab. Philistaeon Plain, Wadi Rubin, swamps. Alt.—. Leg. M. Zohary and Y. Waisel. Date 26.4.1958.
12. Birbal Sahni Institute of Palaeobotany Herbarium. S. No. 9819. Natural Order. Name—*Equisetum ramosissimum*. Local Name—Habit.—Herb. Habitat—Paddy fields. Locality (U.P.) Lucknow. Altitude—Remarks—Growing Chinhut with the grasses. Coll. J. C. Srivastava. Date 12 Dec. 1958. Det. Hafiz Ahmed Khan.
13. Specimen borrowed from Plant Research Institute, Ottawa, Canada. Dept. of Agriculture (DAO) Ottawa, Canada. Accessioned 1978. H. N. 96849. *Equisetum ramosissimum* Desf. Com. Pest. In uliginose praedii Rakos prope Budapestinum. 1904. Oct. 4. Gyujtotte. Kocsis Tstrom. Hungary.
14. Vascular Cryptogamic Collection (D. K.) Herb. No. 15. Name—*Equisetum ramosissimum* sub. sps. *ramosissimum*. Fam. Equisetaceae. Place Nainital. Alt. 3000 ft. Col. D. K. Saxena, Botany Department, Bareilly College, Bareilly, India.

DISCUSSION

The presence of stomata in the annulus of *E. ramosissimum* cone has never been reported before. The study of epidermis of annulus shows the presence of stomata as found in leaf sheath, and the epidermal cells of annulus are more or less similar to leaf sheath. The presence of lobed annulus (Fig. 20) in some cone, and number of lobes are equal to the

Fig. 12. Guard cells are unequal in size and only in one guard cell incomplete silica ribs are present.

Fig. 13. Normal arrangement of stomata in leaf sheath of *Equisetum*, stomata are arranged in rows.

Figs. 14 & 17. Guard cells of stomata are covered with crystal like silica bodies and guard cells are also peculiar in outline in Fig. 14.

Figs. 15 & 16. Stomata in closed condition in day time, same in cross section in Fig. 15.

Fig. 18. A stomata with unequal guard cells.

Fig. 19. Peel of annulus showing vascular supply.

Fig. 20. An annulus with lobe like projections.

Fig. 21. Normal stomata from the leaf sheath. Silica bands are not drawn.

teeth of leaf sheath. The above characteristics of annulus irresistably lead to the conclusion that these two distinct types of appendages are similar in nature and are homologous structures, and annulus is the last whorl of sterile leaves before fertile strobilus starts. It is also significant to note that the stomata are confined to the annulus only and not below or above it. It is also clear from the above studies, that irregular shape of stomata of annulus, their smaller size and the absence of silica bands show that these are vestigial stomata. The above observation is in agreement with those of BROWNE (1920), KASHYAP (1930), EAMES (1936), TSCHUDY (1939) and FOSTER AND GIFFORD (1967) that annulus is a reduced leaf or leafy in nature.

BARRATT (1920) states that the lack of vascular supply to the annulus, or even to abnormal fertile annuli, is an argument against the foliar nature of annulus. Several examples have been observed by the author that annulus bear vascular strands (Fig. 19) which are continuous with the vascular supply. This supports the foliar nature of annulus.

ACKNOWLEDGEMENT

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