ON THE INTERNAL BUNDLES IN THE STEM OF *RUMEX PATIENTIA* L.

BY P. MAHESHWARI AND BALWANT SINGH
(*Dacca University, Dacca*)

(Received November 18, 1941)

1. *Introduction and Previous Work*

A FEW years ago, one of us (Maheshwari, 1929) investigated the anatomy of *Rumex crispus* and found that the inflorescence axis of this plant possesses a number of internal and inverted bundles in addition to the normal outer ring of vascular bundles. A detailed study of their origin and development revealed that they are not formed by the division of pith cells as was previously supposed (Hérail, 1885) but from the inner portions of the same procambial strands which produce the normal bundles. It was also demonstrated that the bundles are not merely inverted or obcollateral but actually become concentric (amphivasal) due to the extension of the cambium all round the phloem. The xylem in the internal bundles is entirely secondary in origin, while the phloem is both primary and secondary. A maximum of five internal bundles was found in association with a single normal vascular bundle.

Since then Joshi (1931), in a brief note on the anatomy of *Rumex dentatus*, mentions that while the stem is normal in structure and devoid of any internal bundles, there arises occasionally in the basal internodes a pericyclic cambium, which forms an accessory ring of bundles between the cortex and the pıimary vascular ring.

Würke (1933), in a work dealing with the anatomy of the rhizome of *Rheum*, also makes some casual remarks on the anatomy of a few species of *Rumex*. *R. patientia*,[1] *R. crispus* and *R. domesticus* were found to have bicollateral bundles, whose internal phloems later on give rise to inverted bundles. Further details are not mentioned and after a general discussion and confirmation of Maheshwari's work on *R. crispus*, the author passes on to *Rheum*, which forms the main part of his contribution.

2. *Observations*

The material used in the present study was collected by one of us[2] in 1936, from the suburbs of Kiel, during an excursion with Prof. G. Tischler, and consisted of a few pieces of the inflorescence axis preserved in formalin-

[1] According to Hérail the internal bundles of *R. patientia* consist of phloem only.

[2] I am grateful to Drs. W. Gauger and H. D. Wulff of the Botanical Institute, Kiel, who were present in the excursion and helped me in the collection (P. Maheshwari).

acetic-alcohol. Sections were cut freehand and stained in Safranin and Fast Green.

A cross-section of an internode shows a hollow pith and a single ring of vascular bundles which at first appear to be quite normal. A closer examination reveals, however, the presence of internal phloem in many of the bundles which are thus truly bicollateral. The external surface is provided with ridges and furrows, with collenchyma occurring underneath the former (Fig. 1).

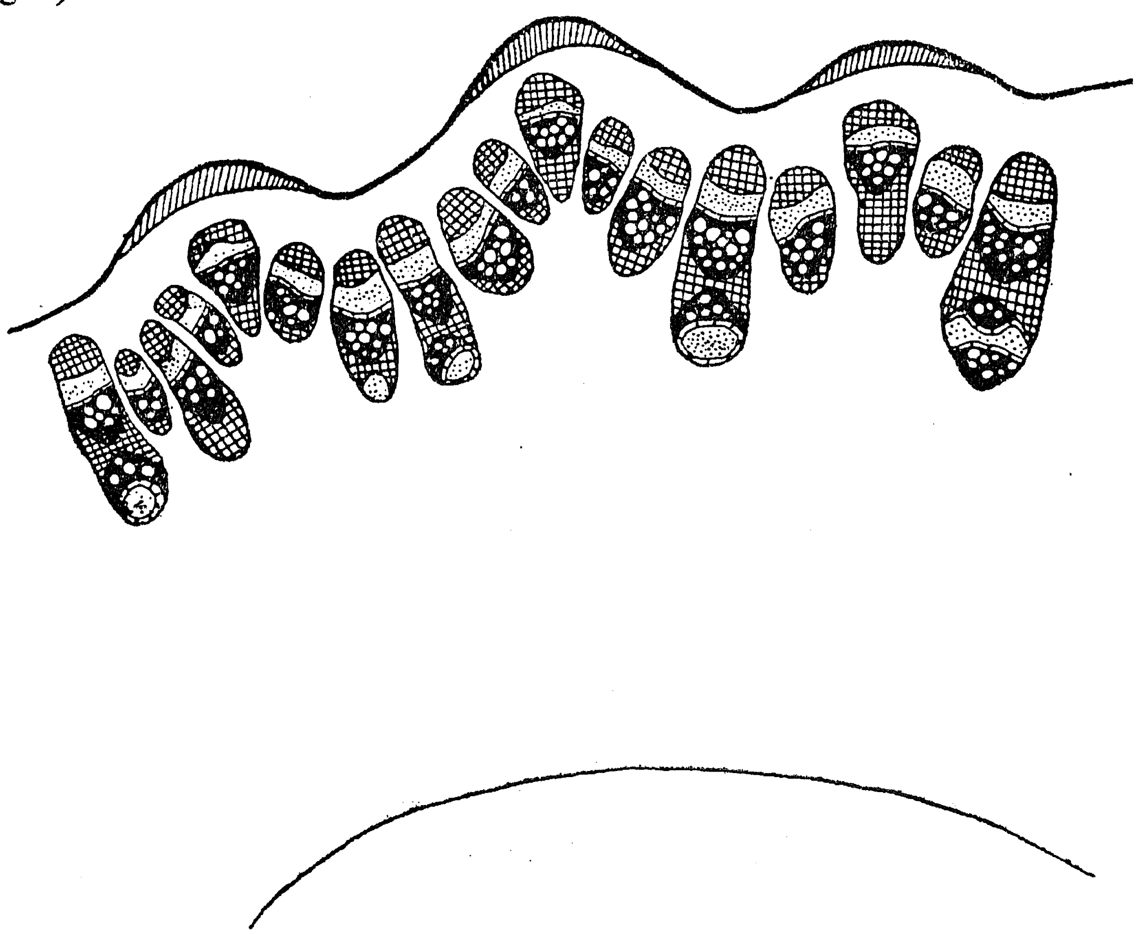
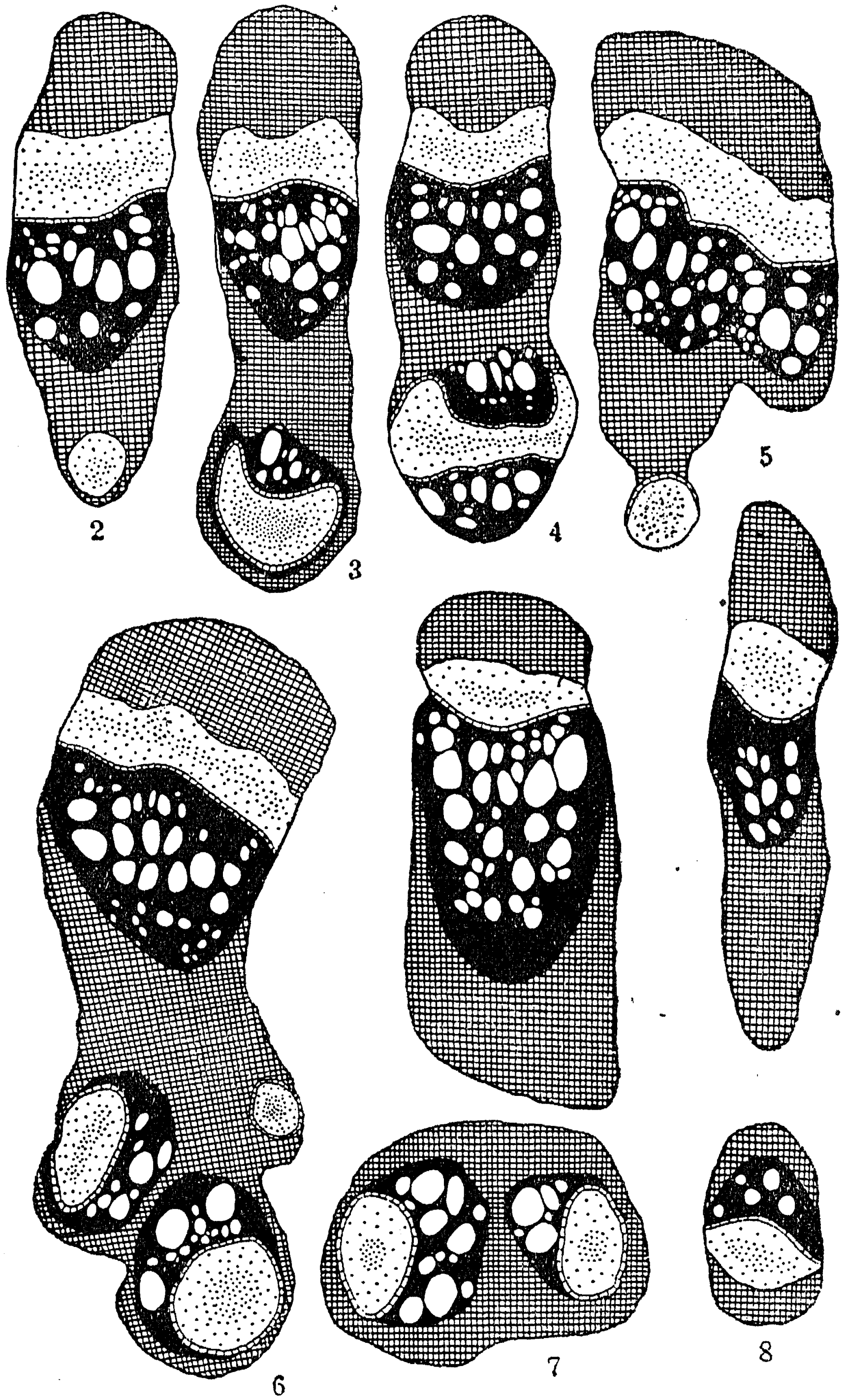


FIG. 1. Diagram of a portion of a t.s. of the inflorescence axis of *Rumex patientia*. In this and the subsequent figures the sclerenchymatous sheath is represented by cross lines, phloem by dots, cambium by a single layer of cells, xylem parenchyma in black, and xylem vessels by empty spaces. × 33.

Sections of the older internodes presented a still larger number of bicollateral bundles, the internal phloem lying completely within the sclerenchymatous sheath of the outer bundle (Fig. 2) and not scattered in patches at the periphery of the pith as is the case in the Convolvulaceæ, Solanaceæ, Apocynaceæ, Asclepiadaceæ, etc. The older of the phloem groups showed a distinct cambium on their outer side, just facing the protoxylem (Fig. 5). This cambium has a clear tendency towards lateral extension and later completely surrounds the phloem (cf. *Rumex crispus*). Most of its activity is however confined to the outer side only, resulting in the formation of obcollateral or inverted bundles. The xylem in this bundle is obviously all secondary but the phloem is partly primary and partly secondary. The central region of the phloem, which is primary, is particularly rich in sieve tubes. In a few cases the internal bundles were ob-bicollateral with phloem in the centre and xylem on both sides (Fig. 4) or amphivasal (Fig. 3) with xylem vessels or xylem parenchyma completely surrounding the phloem.



FIGS. 2–8. Figs. 2–6. Vascular bundles of the inflorescence axis of *Rumex patientia* showing various stages in the development of internal bundles. × 173. Fig. 7. A normal bundle of *Rumex crispus* with two adjacent internal bundles. × 173. Fig. 8. A normal and an internal bundle of *Rheum rhaponticum* L. × 173.

The oldest pieces of the stem, available to us, showed conspicuous internal bundles. In some sections, 3 such bundles were found to be associated with a single outer bundle, all enclosed in a common sheath of sclerenchyma and forming a distinct unit (Fig. 6). In rare cases a single internal bundle lies in association with 2 partially anastomosed normal bundles (Fig. 5).

For comparison, we examined some previously prepared slides of *Rumex crispus* and found that there is no essential difference in the stem anatomy of the two species. In one case, in *R. crispus*, we found two internal bundles detached from the sheath and lying at some distance inward in the pith (Fig. 7). Their deeper position does not mean, however, that such bundles actually arise through a division of pith cells. It is more likely that a sclerification of the cells between the outer and inner bundles was probably delayed for some time and when it did take place, each side formed its own sheath, leaving some unlignified parenchyma between.

Such a separation of the internal bundles which is rare in *Rumex*, is common in the allied genus *Rheum* (Fig. 8). According to Würke the conditions in the two genera are closely similar in the earlier stages but later on the internal bundles of *Rheum* get detached from the normal vascular ring due to a division of the intervening cells.

We do not deny the possibility of the formation of internal bundles from pith cells in other plants. Indeed, this has been conclusively demonstrated in the case of tobacco (Esau, 1938), where pith cells resume a meristematic character and give rise to groups of sieve tubes irregularly arranged in the perimedullary zone.

3. Conclusion

The phylogenetic or physiological significance of the internal bundle has been discussed by several authors. Worsdell (1915, 1919) considers the medullary phloem to represent a vestigial structure, the remnant of a former system of medullary vascular bundles, in which the xylem has disappeared and adds that " the morphological origin of this internal phloem bundle is from an amphivasal bundle, for the latter is the typical and more primitive form of the medullary phloem bundles, wherever they occur ". The inversely oriented internal bundles are explained by supposing that only the outer portion of the originally amphivasal bundle is retained.

Maheshwari (1929), in his study of *Rumex*, adduced evidence to show that the presence of internal bundles is an advanced character, the species with higher chromosomes being generally found to possess them and those with the lower numbers lacking them. Würke (1933) is in complete agreement with this view. Alexandrov and Alexandrova (1926) and Hartwich

(1936), working on the internal bundles of the inflorescence axis of *Ricinus communis*, also regard their presence as derived.

In order to test the hypothesis that the species of *Rumex* with higher chromosomes are likely to be provided with internal bundles while those with lower numbers are likely to be without them, it is necessary to examine more material belonging to a variety of forms. With an instrument like colchicine in hand, it may also be possible to induce polyploidy either in the same species or its hybrids and then examine them anatomically to see if this change is associated with the appearance of the internal bundles. This would open up a new field of experimental anatomy, that would probably lead to the solution of other problems.

4. *Summary*

The inflorescence axis of *Rumex patientia* has bicollateral bundles whose internal phloems give rise to obcollateral, ob-bicollateral and amphivasal bundles. Sometimes two or three internal bundles lie in association with a single outer bundle. It is concluded that the presence of such bundles is an advanced character. Further, the condition in *Rheum*, where the internal bundles lie detached from the outer ones, is easily derived from that in *Rumex*.

5. LITERATURE CITED

1. Alexandrov, W. G., and Alexandrova, O. G. "Über Koncentrische Gefässbündel in Stengel von *Ricinu communis*," *Bot. Arch.*, 1926, **14**, 455–60.
2. Esau, K. .. "Ontogeny and structure of the phloem of tobacco," *Hilgardia*, 1938, **11**, 343–99.
3. Hartwich, W. .. "Über die Entstehung der leptozentrischen Leitbündel in der Infloreszenz-Achse von *Ricinus communis*," *Diss. Berlin*, 1936, 40.
4. Hérail, H. J. .. "Recherches sur l'anatomie comparée de la tige des Dicotyledones," *Ann. Sci. Nat. Bot.*, 1885, VII, **2**, 203–314.
5. Joshi, A. C. .. "Anomalous secondary thickening in the stem of *Rumes dentatus* L.," *Jour. Ind. Bot. Soc.*, 1931, **10**, 209–12.
6. Maheshwari, P. .. "Origin and development of internal bundles in the stem of *Rumex crispus*," *ibid.*, 1929, **7**, 89–177.
7. Worsdell, W. C. .. "The origin and meaning of medullary (intraxylary) phloem in the stems of Dicotyledons. I. Cucurbitaceæ," *Ann. Bot.*, 1915, **29**, 567–90.
8. ———— .. "The origin and meaning of medullary (intraxylary) phloem in the stems of Dicotyledons. II. Compositæ," *ibid.*, 1919, **33**, 412–58.
9. Würke, H. .. "Untersuchungen über die Maserbildung beim Rhabarberrhizom," *Diss. Berlin*, 1933, 40.