INTRODUCTION

The surge of interest in structure and function of phloem with the advent of electron microscopy has brought, renaissance in this field, not only adding new insights to the problem but also some misconceptions too. Nonetheless, the comprehension of structure of phloem cells has deepened and the discussions of its functional significance at subcellular level have become more meaningful. Despite the widened frontiers of phloem unravelling many of its details, the light microscopic investigations are indispensable as they contribute to the basic understanding of some of the
Phloem being a close counterpart of xylem in the vascular system, has received the attention of numerous botanists. Because xylem, particularly the secondary xylem has provided a gamut of interpretable data for evolutionary and taxonomic purposes, secondary phloem has also been investigated in this direction as both the tissues owe common origin. Certain features of secondary phloem parallel those in secondary xylem and show promise of service in taxonomic and phylogenetic investigations (Esau 1979). Hence, the study of phloem in general and secondary phloem in particular needs no elaborate justification.

The data accumulated on phloem, since its discovery has been periodically reviewed (Kollmann, 1964, 1968; Esau and Cheadle, 1965; Evert et al., 1966; Clowes and Junipers, 1968; Weatherley and Johnson, 1968; Esau, 1969, 1971b; Behnke, 1972; Zimmermann and Milburn, 1975). The comprehensive review of literature on structure and development of phloem by Esau (1969) is monumental.

Inspite of the accumulation of these data on phloem, little attention has been paid regarding structure, distribution, dimensional relationships and phylogenetic
trends of components of secondary phloem in woody and herbaceous dicotyledons. Though Metcalfe and Chalk (1972, 1979) covered major aspects of anatomical features, information available on secondary phloem is meagre. Only a few have attempted a comparative approach to the study of phloem among dicotyledons (Hemenway, 1911, 1913; Huber, 1939; Holdheide, 1951; Esau and Cheadle, 1958, 1959; Cheadle and Esau, 1958; Zahur, 1959; Wilson, 1965). A comparative study on secondary phloem of tropical dicotyledonous taxa is totally lacking, which prompted me to take up this endeavour on gamopetalous and monochlamydeous groups, along with Karnik (1981) who has studied 101 polypetalous taxa.

The present investigation deals with the structure, distribution, dimensional analysis, their interrelationships and evolutionary aspects of secondary phloem components in 125 tropical herbaceous and woody dicotyledons belonging to 43 gamopetalous and monochlamydeous families. Thirty two parameters of secondary phloem enlisted in “Materials and Methods” have been studied in each of the taxa involving standard statistical techniques, to test the current concepts of specialization of phloem components and to project their variability and specialization involved among the individual taxon as well as the entire group.
Sieve tube elements have been dimensionally analysed where length and width variations have been indicated (Cheadle and Whitford, 1941; Cheadle, 1948; Zahur, 1959; Wilson, 1965; Behnke, 1965; Parthasarathy, 1966, 1968; Parthasarathy and Tomlinson, 1967). Esau and Cheadle, (1955) Zahur (1959) and Wilson (1965) recorded divisions among the precursors of sieve tube elements. Zahur (1959) concludes that phylogenetic decrease in length of sieve tube elements among most of the gamopetalae and in some polypetalae has come about by frequent secondary septation of sieve tube mother cells. Carlquist (1961) questioned Zahur's (1959) generalization regarding the phylogenetic value of divisions of phloem initials, because such divisions occur also in families that are not advanced in many other respects. Zahur (1959) believes that length of the sieve tube element is not a dependable marker for phylogeny. But how frequent these septations disturb the symmetry of a large population of sieve tube elements has not been looked into. Hence, a statistical attempt has been made by subjecting sieve tube element length to normal distribution analysis. To project behaviour of parameters of simple sieve plates and compound sieve plates occurring separately or together in a population regarding their normal distribution, seven features of sieve plates have been tested similarly.
Sieve tube element length bears definite spatial relations with sieve plate length, number of sieve areas on a sieve plate, transverse cell area, and inclination of end walls (Cheadle and Whitford, 1941; Esau and Cheadle, 1959; Zańur, 1959; Wilson, 1965). However, Parthasarathy (1966) found no correlation between the degree of inclination of the end wall and length and width of sieve tube elements among some monocotyledons. These aspects have been studied both by nonparametric and statistical methods.

As no attempt to understand the relations of sieve tube element length with various features like simple sieve plate length, compound sieve plate length, frequency of transverse simple sieve plate, frequency of very oblique simple sieve plate, companion cell length, average number of companion cell and maximum diameter of lateral sieve area has been done, these aspects have also been taken up in this study.

Sieve tube element width is reduced because of longitudinal divisions in the precursors of sieve tube elements (Esau, 1969; Philipson et al., 1971). Though, sieve tube elements with simple sieve plates tend to narrow (Esau, 1969), the sieve tube element width has no correlation
with sieve tube element length (Karnik, 1981). This conclusion is based on nonparametric methods. In this investigation, the spatial relation of length and width of sieve tube elements is statistically analysed.

The relationship between sieve tube element width, with different features like transverse cell area, sieve plate length, area of the sieve plate, maximum diameter of lateral area, frequency of transverse end wall, have been analysed statistically so as to add an additional dimension in the understanding of aspects of specialization in phloem.

Slenderness ratio representing the interaction of parameters has been tested for its relation with sieve tube element length, width, frequency of simple sieve plate, sieve plate pore diameter and also with the ratio of sieve plate pore diameter to lateral sieve area pore diameter.

The degree of disparity between pores of lateral sieve area and that of sieve plates - a significant feature among angiosperms, has been recorded in all the 125 taxa. The relationship of frequency of the types of sieve plates with associated frequency of different inclination of end walls has been analysed statistically to know how the current concepts (Esau, 1969) withstand to their exercise.
Inspite of established phylogenetic concepts on sieve plates, there seems to be paucity of information regarding statistical analysis of dimensional values of sieve plates in secondary phloem, their components and their interrelationships. The present knowledge of some correlation of length of sieve plate and size of sieve pores with number of sieve areas on a sieve plate is based on evolutionary concepts in phloem (Esau et al., 1953; Esau and Cheadle, 1959; Zahur, 1959; Esau, 1969). The mathematical relationship between the diameter of sieve pores and the number of sieve pores in a particular sieve area has been reported in <span>gyathea niligirensis</span> by Nair and Shah (1981). The type of sieve plate is one of the major criteria, among many others, in the evaluation of a taxon for the specialization of secondary phloem. When a taxon has both simple and compound sieve plates, their frequency and degree of compoundness make the task of evaluation difficult. Moreover, consideration of simple sieve plate as an advanced structure is mainly based on their frequent association with taxonomically advanced taxa. But a detailed statistical analysis, as an additional evidence to support and elaborate this concept has not been attempted. In the present investigation this analysis has been done with a few randomly selected genera of Asteraceae that showed maximum variations in features of sieve plates.
According to Esau and Cheadle (1959) the mean area of sieve plate increases from simple to scalariform compound sieve plates. This aspect has been studied in detail involving the relationship of average number of sieve area(s) on a sieve plate with sieve plate length and area of sieve plate; and also of average number of sieve areas on a compound sieve plate with length and area of a compound sieve plate. Behaviour of sieve plate pores with several parameters has been investigated.

Zahur (1959) categorized the lateral sieve areas among woody dicotyledons. Meanwhile among vascular cryptogams lateral sieve areas have been typified on the basis of their morphology and distribution (Nair, 1978; Nair, 1979; Nair and Shah, 1981). Based on their study, four categories of the distribution have been recognised in this investigation. The dimensional behaviour of lateral sieve area with its pores, sieve plate pores; and of lateral sieve area pores with sieve plate pores and their ratio, have been statistically analysed.

In this investigation the occurrences of P-Protein, starch and necrotic nucleus in sieve tube elements have been recorded.
Companion cell types and their association with different sieve tube element types have been recorded. As no dimensional interrelationships of companion cells with that of sieve tube elements have been studied, a detailed analysis has been presented here.

Phloem parenchyma cells other than the companion cells and albuminous cells vary in their form and function. Many of them, either of axial system or the ray system are concerned with storage of starch, phenolics or crystals as ergastic substances (Esau, 1969). Some specialised type of parenchyma cells are reported by Shah and Jacob (1969a). Zahur (1959) recognised two major types of parenchyma cells. In this investigation an attempt has been made to study the distribution and abundance of phloem parenchyma along with its ergastic contents.

Phloem sclerenchyma the characteristic elements, particularly of secondary phloem has profound taxonomic significance (Bamber, 1962; Esau, 1969; Bamber and Summerville, 1979). Zahur (1959) attributed phylogenetic significance to its distribution and recorded the dimensions of fibres attempting to find out correlation between the sieve tube element type and fibre dimensions. Among the taxa surveyed, the distribution of fibres and sclereids and dimensions of fibres have been recorded.
Broad morphological features and cell types of periderm and anomalous structure of secondary phloem have been recorded.

The characters of phloem are potentially of taxonomic significance. Features of phloem that show promise of service in taxonomic and phylogenetic investigations have been discussed by Esau (1979). However, the variations that occur in the natural system magnify the problem. Though, most of the phylogenetic trends of secondary phloem components are known, a scheme that attempts to express confidently the phylogenetic status of the components in a taxon is lacking, due to which the assessment of relative level of specialization of secondary phloem has not been possible. Hence, a mathematical model has been proposed to assess the relative advancement levels of secondary phloem in a taxon, as well as various dicotyledonous groups, with a degree of certainty.