DISCUSSION

Kerala is one of the widely studied regions with respect to flora, fauna and ecology. Though there are numerous investigations at macro and micro levels, many of them fall short of providing a comprehensive picture of biodiversity. Of the several methods for assessing floristic diversity of Kerala, habitat level approaches have primary importance (Remesh et al., 2003). Situated between $8^\circ$ 8' to $18^\circ$ 48' N and $74^\circ$ 4' to $77^\circ$ 50' E lying in the windward side of the Western Ghats, Kerala enjoys a tropical climate. Modern evolutionists believe that in all probability, angiosperms have originated in the mountains under the most diverse and variable environmental conditions and look for their origin within the tropics (Takhtajan, 1969). According to Whiffin (1978) the tropical rainforests are the richest of all communities and differ from other communities.

It is well established that the rich diversity observed in the flora of Kerala is attributed to geographical diversity. Reports of Sasidharan (1997) shows that there are over 3872 flowering plants in Kerala, of which 1272 are endemic and 159 species have been classified under different threat categories. Of these about
three fourths of the flowering plants constitute a potential resource base and 900 species are reported to be medicinal.

As far as the strategic plans of conservation of biodiversity of Kerala Forest and Wild Life Department are concerned much emphasis is given to the gene pool conservation (Remesh et al., 2003). The action plan includes:

a. Identification of gene pools based on genetic variability of resource species. Emphasis is given to the conservation of such habitat with high priority.

b. Demarcation of identified areas and preparation of specific conservation plans. Ecological studies should be conducted on those selected resource species to determine the habitat preference, population structure, reproductive biology etc. Based on the information, these areas need to be demarcated and specific conservation plans are to be prepared.

Nair (2000) lists out medicinal plants providing important research leads. Of these, *Sida rhombifolia* is widely accepted for its biological properties such as immunomodulatory, antitumour, anti-HIV, anti-inflammatory, hepatoprotective and antimicrobial (Khare et al., 2002). *Sida cordifolia* is widely accepted for its rejuvenative properties (Ramanathan 2000). It also falls under the group of plants used as preventive drugs. Thus in the present study emphasis is given to the phytographic as well as phytochemical aspects of *Sida* and allied species with special emphasis on their genetic resource management.
Habitats are generally defined as the space used by an organism together with other organisms with which it co-exists. Plants growing together have mutual relationships among themselves and with the environment. A group of plants growing in one area forms a community. Thus data on analytic as well as synthetic characters provide a better understanding on the structure of a community. Parameters such as basal area refers to the ground actually penetrated by the stems and is readily seen when the leaves and stems are clipped at the ground surface (Hanson & Churchill, 1961; Hanson, 1950; Braun, 1932). The area of coverage is used to express the dominance of the plants.

5.1. Vegetation analysis

All the taxa under study are getting established in house fields, wastelands and roadsides as weeds. Selected taxa showed dominance along roadsides rather than house fields. Inamdar & Choudhary (1984) indicated that polluted leaves of *Peristorphe bicalyculata* showed high Stomatal Index, increase in trichome length and increase in size of cystolith. Roadside flora is resistant to stress of pollutants, which are emitted from the automobiles. Phenotypic plasticity (Stace, 2000) is observed in all the selected taxa. Plants growing in fertile soil and shade grow tall; however, dwarfing is due to poor, dry soil conditions.

The sites where the species of *Sida* are not available their substitutes can be used (Nair, 2004). Available information revealed that root drug vendors collect the roots of substitutes and adulterants and give them to the root drug market. The selected taxa grow as weeds without much care so these plants spread naturally with in the ecosystem.
In site I (Table 3) *S. cordifolia* is dominating. Relative frequency, relative density, relative dominance and Importance Value Index of *S. cordifolia* are high compared to the other taxa (Text fig. 2). Very low value is obtained for *S. retusa* shows the scarcity of the plant (Text fig. 1).

In site II (Table 5, 6 and Text fig. 25) relative frequency, relative density, relative dominance and Importance Value Index are high in *S. rhombifolia* (Text fig. 6) when compared to other genera. The values are very low in *U. sinuata*. In *S. retusa* the IVI is 16.62 (Text fig. 5).

In site III *S. acuta* is dominating (Text fig. 12). Relative frequency, relative density, relative dominance and Importance Value Index are high in *S. acuta*. In *T. rhomboidea* and *U. sinuata* the values are very low (Text fig. 26, Table 7 and 8) In *S. retusa* the IVI is 34.84 (Text fig. 11).

Quadrat study at Site IV (Aluva) shows that *S. cordifolia* is dominating (Table 9 and 10). In *S. cordifolia* relative frequency, relative density, relative dominance and Importance Value Index are high (Text fig. 17). The values are low in *S. retusa* (Text fig. 16), *U. sinuata* and *T. rhomboidea* (Text fig. 27).

Of the four sites studied, *S. cordifolia* shows dominance in Aluva and Karimughal, *S. rhombifolia* shows dominance in Kolenchery and *S. acuta* shows dominance in Kothamangalam. Aluva is considered as species-rich site because eight taxa under study are established there. Such an area has to be permanently demarcated for future reference and conserved. In all sites *S. retusa* shows less
dominance, low density and low frequency revealing the threats of extinction of
the particular species. In the absence of particular species its substitutes can be
used.

5.2. Soil analysis

Soil moisture directly influences the growth rate of species. It also
determines the osmotic pressure of plant sap. Osmotic pressure increases with
decrease in soil moisture. pH of the soil during vegetative growth varies from 5.7
to 6.1. In all the cases the soil is slightly acidic (Table 12). pH of the soil depends
upon the relative amounts of adsorbed hydrogen and adsorbed metallic cations.
When hydrogen ion predominates the reaction becomes acidic. Soil pH is also
correlated with amount of Calcium and Magnesium, solubility of Iron, Aluminium
management, Phosphorous and activity of micro-organism.

Electrical conductivity of the soil solution gives a clear idea of the total
soluble salts. It ranges from 0.50 dSm⁻¹ to 0.60 dSm⁻¹. In all the sites the amount
of total soluble salt is medium. Percentage of organic Carbon is high at
Karimughal and medium at Aluva, Kolenchery and Kothamangalam (Table 12).
The highest value of organic Carbon in the least disturbed sites may be due to the
addition of large quantity of organic matter through leaf fall.

Presence of Phosphorous is low at site I (Karimughal) and high at the other
three sites. Phosphorous affects the root system of plants and encourages the
formation of lateral and fibrous roots, which increase the absorbing surface for
nutrients (Rai, 1995). The root system of the taxa under study collected from
Karimughal is comparatively poor in development than those of other three sites emphasizing this fact.

At Aluva and Karimughal Potassium content is low, however, at Kothamangalam and Kolenchery it is medium. Potassium is essential for photosynthetic activity of leaves and it helps in translocation of manufactured food from leaves to roots (Pandeya, 1968).

5.3. Seed germination

Davis & Heywood (1963) pointed out that seed characters are neglected in floras; however, seeds are relatively stable in external morphology and especially in internal organization. This was re-emphasized by Sivarajan et al. (1992) by studying mericarp morphology of species of *Sida*.

Dormancy in seeds may be defined as their temporary suspension of growth activity. It is an ecological adaptation. It delays the occurrence of the species in the ecosystem till suitable environmental conditions for growth are available. Dormancy may be due to different reasons. The present study indicates that seeds are photosensitive in all species. They do not show any germination when placed in dark. Light may activate some enzyme system necessary for germination, destroy germination inhibitors and may also produce germination promoters (Toole et al., 1956).

In the seeds of *G. microcos* the embryo remains dormant in all the pre-treatments done for germination. Seeds kept under laboratory conditions also
showed poor germination in all the other taxa. Under this category, the highest percentage of germination (10%) was observed in *U. lobata* and *U. sinuata* (Table 14).

Vernalization of the seeds at freezing temperature may also bring about physiological changes for germination. Cold treatment for 48 hours showed an increase in percentage of germination (80% & 70%) in *U. lobata* and *U. sinuata* respectively (Table 14).

For removal of inhibitors, seeds were washed in running water for 24 hours and were placed for germination. 60% germination was observed in *U. lobata*. Germination percentage is low in all the other taxa (Table 14).

Hard seed coat is another reason for seed dormancy. Seed coat of the seeds were punctured and placed for germination. It has shown favourable changes in percentage of germination (Table 14).

Seeds of all the taxa when treated with concentrated Sulphuric acid showed significant result. Seed coats are hard enough to withstand the adverse climatic conditions. After 30 minutes of treatment, the seeds placed for germination showed favourable result in *S. rhombifolia*, *S. retusa*, *S. cordifolia*, *A. indicum*, *U. lobata*, *U. sinuata* and *T. rhomboidea*. Thus, of the various treatments, treatment with conc. *H_2SO_4* proved to be the most effective in enhancing seed germination except in *G. microcos* (Table 15). The increased
effect on seed germination due to concentrated H$_2$SO$_4$ treatment in species of *Sida* is in line with the earlier reports (Seal & Gupta, 1999).

The failure in germination or the phase of dormancy may be caused by several factors resulting in delay of the whole life cycle of plants (Harper, 1957 & Purohit *et al.*, 1998). The relevance of different seed treatments for breaking dormancy, improving seed germination and seedling establishment is well known (Thomas, 1981). The treatments such as pre-sowing soaking, seed-coat puncturing, acid treatment, chilling treatment, hot water treatment, alternate high and moderate temperature treatment and gibberllic acid treatment have been found to induce and enhance germination of dormant seeds (Bradbeer, 1968; Basu & Sur, 1988; Boss & Sarma, 2000). Beigh *et al.* (2002) studied seed germination and seedling survival in *Aconitum heterophyllum*. Lata *et al.* (1993) and Uniyal *et al.* (2000) observed the effect of hot water treatment in the seed germination of *Grewia optiva* Durmmond. and *G. oppositifolia* Roxb. respectively.

5.4. Seed output and reproductive capacity

Plants always produce larger numbers of seeds than the habitat can sustain. The number of seeds produced (seed output) is of considerable autecological significance. It is the potential capacity of a species to reproduce itself. Seed output of a plant is dependent upon a number of environmental factors. Of the ten taxa studied, the highest seed output is observed in *A. indicum* and lowest in *S. veronicaefolia*. However, the reproductive capacity is 123.95 in *A. indicum* and 7.75 in *S. veronicaefolia*. Results are shown in Table 16. When comparing the mean reproductive capacity and percentage of germination, the percentage of
germination was low under laboratory conditions (Text fig.28), however, pre-treatments of seeds showed significant increase in percentage of germination (Text fig. 29).

Seed viability was found to be satisfactory in all the taxa studied when compared to percentage of germination under laboratory conditions (Text fig. 30). In *S. retusa* mean reproductive capacity was 18.18, and the percentage of germination under laboratory conditions was 6. However, pretreatment of seeds with conc. H$_2$SO$_4$ shows 53% germination and tetrazolium test reveals that 60% of the embryos were viable. Even though the percentage of germination was low, it is found to be sufficient to spread the species within the ecosystem.

As far as the ecological studies are concerned, considerable seed output and embryo viability are a positive factors for the establishment of the population. The substitutes of *Sida* also show high seed viability (Table 13). However, the percentage of germination under laboratory conditions is low. Pre-treatment of the seeds enhanced germination. Seeds of *G. microcos* do not germinate under any conditions of pre-treatments. The present study reveals that the seeds of *G. microcos* seeds do not respond to any of the pretreatments. Further studies are suggested for the cultivation aspects of such medicinal plants.

5.5. Root system

In all the taxa studied, the plants possess taproot system. When the base of the stem shows trailing habit adventitious roots are produced from the base of the stem. Root system of *S. retusa* is harder than the other taxa (Fig.2.A, B, and C). In
S. retusa the root system possess large number of thin and wavy laterals. The stem also shows early branching due to the prostrate habit of the plant In S. cordifolia and S. rhombifolia the lateral roots are limited in number. In all the species of Sida the root system is pale yellow in colour.

The root system of U. lobata and U. sinuata are brownish black with large quantity of mucilage. Root system of T. rhomboidea is also brownish black but lacks mucilage. The taproot system of G. microcos consists of long stout taproot with limited number of laterals. The root is light brown in colour. The morphological nature of the roots is much significant in the identification of crude drugs.

5.6. Foliar features

Cellular morphology of the epidermis of angiosperms has features of taxonomic and phylogenetic importance (Stebbins & Khush, 1961). Carlquist (1961) states that leaf epidermis is one of the anatomical characters of both systematic and phylogenetic value. Histomorphology of the foliar epidermis, including stomata, is now employed as any other anatomical character of vegetative organs in the identification of fragmentary materials in the pharmacognostic studies (Krishnamurthy & Sundaram, 1967; Krishnamurthy & Kannabiran, 1970). The present study shows that factors such as leaf architecture, Stomatal Index and Palisade ratio are of taxonomic value.
5.6.1. Leaf architecture

Dicotyledonous leaves possess consistent and recognizable patterns of leaf architectural organization at all levels from the subclass to the species (Hickey & Wolfe, 1975). Studies of Jesudass et al. (2003); Chunari & Mukhopadhyay (2003) re-emphasized the significance of leaf architecture in identification and systematic position of several taxa. Shehgal & Paliwal (1974) have classified leaves as uni-, bi- and tri-veined on the basis of the number of strands entering the base of the petiole. In the present group of species, the leaves are mostly tri-veined; however, in G. microcos a single midrib enters the base of the petiole and serves as the origin for the higher order of venation. The major venation pattern is mostly of the actinodromous type in all the species of Sida, Abutilon, Urena and Triumfetta. However, in Grewia they are of semicraspedodromous type (Fig.5A).

Marginal ultimate venation is incomplete in all the taxa except in G. microcos where it is looped. The venation pattern is perfect in all the cases. Nature of primary vein is weak in all the taxa except in G. microcos.

The shape of the leaf varies within the same species. Variation was observed in various stages of the growth viz., seedling, vegetative and flowering. However, in majority of the cases, the shape of the leaf is ovate. In most of the cases, the shape of leaf apex is acute. The nature of leaf margin is serrate or crenate; however, in G. microcos, it is entire. The texture of the leaf is either chartaceous or coriaceous. In S. rhombifolia, S. retusa and S. acuta the veins are prominent up to the secondaries. In the other two species of Sida the veins are prominent up to the teritiaries. In G. microcos, U. lobata, U. sinuata,
T. rhomboidea and A. indicum the veins are prominent up to the veinlets. The shape of the aerole is either pentagonal or quadrangular.

5.6.2. Stomatal Index

Weiss (1865) and Baranova (1992) have pointed out that size, number and distribution of stomata can be used as a diagnostic features. Wilkinson (1979) has reported that the Stomatal Index is a useful taxonomic character when comparable leaf areas are used. Among the investigated taxa, the lowest value for Stomatal Index is noticed for A. indicum (Table 18). The present findings show that the Stomatal Index cannot be taken as an independent taxonomic criterion, but may be reliable along with other conservative characters. The Stomatal Index value has already been calculated for S. acuta (Mohideen et al., 2002). The reinvestigation showed an increase in the Stomatal Index values. These changes may be either due to various external as well as internal environmental stresses to which the plant is subjected or due to the difference in locality.

Statistical analysis was done to check whether the selected taxa has equal mean for Stomatal Index and the significance value was less than 0.05 (Table 19). Since the significance value is less than 0.05 the hypothesis (selected taxa have same value for Stomatal Index) is rejected. Further analysis was done to find out the similarity between various pairs of taxa (Table 20). S. rhombifolia differs significantly from the other nine taxa. S. retusa and S. veronicaefolia do not differ significantly. S. acuta, U. lobata, S. cordifolia and A. indicum also do not vary significantly. A similar case is also met with S. veronicaefolia and S. retusa. U.
sinuata, T. rhomboidea and G. microcos differ significantly from all the other taxa (Table 19 & 20).

5.6.3. Size of the stomata

Similar statistical analysis was also done in stomatal size (Table 22). Since the significance value is less than 0.05 the hypothesis (selected taxa have equal value for stomatal size) is rejected. Here also multiple pair wise analyses were done to find out the similarity (Table 23). Multiple pair wise comparisons show that S. rhombifolia, S. veronicaefolia, U. lobata and U. sinuata do not differ significantly. Even though S. retusa is a sub species of S. rhombifolia these two taxa show significant variation in stomatal size. The values of S. acuta, S. cordifolia, A. indicum and T. rhomboidea do not differ from each other (Table 23). G. microcos remains as an odd taxon for this parameter.

5.6.4. Palisade ratio

Metcalfe & Chalk (1979) have pointed out that palisade ratio is a reliable taxonomic character. The present study based on ten taxa shows that the palisade ratio varies from taxon to taxon; however, it is constant for particular taxon (Table 24 and Text fig. 32). Findings of the investigator emphasize the fact that palisade ratio is constant for a particular taxon. This is in keeping with Zorning & Weiss (1925). Statistical analysis was done to check whether the ten taxa had equal mean for palisade ratio (Table 25). Since the significance value is less than 0.05 the hypothesis (ten plants have equal palisade ratio) is rejected ie. the mean value of palisade ratios varies with taxa. Multiple pair wise comparisons were done for the dependent variable palisade ratio to find out the similarity of various pairs of
plants (Table 26). *S. rhombifolia* and *G. microcos* do not differ significantly, even though these two taxa belong to different families. *S. retusa* shows much variation from the other nine taxa. This can be used as a criterion to identify *S. retusa* from its adulterants. *S. acuta*, *A. indicum*, *U. lobata* and *U. sinuata* do not differ significantly. Further, no significant difference is met within the palisade ratio values of *S. cordifolia*, *A. indicum* and *U. sinuata*, *S. veronicaefolia* and *T. rhomboidea*.

World attention has focused on India’s rich biodiversity and ancient knowledge systems in medicare together with qualified human resources. This emphasises the necessity for conservation, cultivation and commercialisation of our medicinal plant wealth (Nair, 2000). Plants are the sources of medicinal preparation, both preventive and curative. Non-availability of some taxa needed for the manufacture of drug products leads to adulteration in the form of substitutes or adulterants.

The present investigation on the ecogeographical and ethnomedicinal aspects of *Sida* and allied species reveals the endless vistas and immense scope of phytographic parameters in medicinal plant systematics. The therapeutic efficacy of Ayurvedic medicines depends on the quality and purity of its ingredients. The botanical identity of the raw drugs mentioned in ancient Sanskrit texts is difficult, as there are no definite rules of nomenclature in Ayurveda (Nair, 2004). Moreover lack of precision in identifying the plant source of raw drugs make Ayurveda appear unscientific and unacceptable to many. Hence based on the present observations a taxonomic key is also prepared.
Tex Figure 33. Bar chart showing Stomatal Index of selected taxa