Mass flowering and pollinators of *Strobilanthes consanguinea* in the Western Ghats, South India

Mass flowering is an intense phenomenon and has got ecological significance[1–4]. Plant species that exhibit this flowering pattern take several years to produce flowers characterizing monocarpy and they usually die after seed set[5]. Such plants with massive floral displays over a brief period recruit pollinators successfully by providing abundant pollen and nectar as floral rewards. In the Western Ghats, the best known example of mass flowering is *Strobilanthes kunthianus*, which flowers at regular intervals of 12 years. Apart from the flowering reports of the species[6,7], information on the ecological importance of mass flowering has not been addressed. Matthew[6] observed the migration of *Apis dorsata* and *A. cerana indica* when *S. kunthianus* is in a mass bloom to concentrate on its flowers for food and in effect, an increase in honey yield. Gamble[8] reported that the mass blooming *Strobilanthes* species grow so densely that the seedlings of the forest trees could hardly survive under them. With this background, we carried out a study on mass flowering and pollination in *S. consanguinea* (*Nees*) T. Anderson[9] (Acanthaceae) (Figure 1 *a*) occurring in the low-land deciduous forests of Nilgiri Biosphere Reserve, Western Ghats, South India.

S. consanguinea is a shrub that occurs on hill slopes and often forms dense undergrowth along roadsides of the Western Ghats, especially in the moist and dry deciduous forests of Kerala and Tamil Nadu[9]. It is abundant in Anaikatty Reserve Forest, Coimbatore Forest Division, Tamil Nadu. Gamble[10] reported that *S. consanguinea* flowers once in a 12 years. Venu (pers. commun.) observed that it flowers at an interval of 4–6 years. Our interaction with the local elders revealed that it flowered in 1996 and again in 2000. We observed the flowering season and flower visitors of this plant species during November 2005–January 2006. It shows mass flowering during which the flowers attract different insect species such as bees (*A. cerana indica*, *A. florea* and *Amegilla* sp.; Figure 1 *b*) ants, flies and butterflies (*Junonia iphita*, *Ypthima ceylonica*, *Y. huebneri*, *Cepora nerissa*, *Psuedozizeeria maha*, *Junonia lemonias*, *Neptis hylas*, *Pachliopta hector*, *Hebomoia glaucippe*, *Ixias pyrene*, *Graphium sarpedon*, *Euploea core*, *Pantoporia hordonia*, *Hypolimnas bolina*, *Colotis eucharis* and *Danaus genutia*). Among these, bees and ants are common foragers, while others forage occasionally. The flowers with broad tube and prominent bifid stigma at the throat facilitate bees to collect nectar and pollen, and butterflies to collect nectar. In this process, these foragers contact the stigma and effect pollination. Butterflies assume less importance in pollination because of their occasional visit to the flowers. The flowers with the characteristics mentioned above and other characteristics such as blue colour, concealed nectar and landing platform provided by the corolla throat according to Faegri and van der Prijl[11], suggest that *S. consanguinea* is melittophilous and that bees are the primary pollinators. Ants are resident nectar foragers and rarely contact the stigma, and hence their role in pollination is negligible. Further, flies usually do not contact the stigma and freely move into the corolla tube to access nectar; they have no role in pollination.

Mass flowering plants in general and *Strobilanthes* species in particular, may end up with little amount or no seed set in bloom when environmental parameters are not favourable and pollinators are not available. In this context, further studies are needed on *S. consanguinea* and on all mass flowering species for which there is no reproductive information in order to understand the ecological significance of their flowering pattern in relation to their local climate and pollinators, and also in relation to the reproductive ecology of other co-existing plant species in the forests.

Figure 1. ***a***, *Strobilanthes consanguinea* in mass flowering. ***b***, Pollinator visiting the flower of *S. consanguinea.* (Photo: K. Anitha.)

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Developing multiple natural dyes from flower parts of Gulmohur

Recently, interest in the use of natural dyes has been growing rapidly due to the result of stringent environmental standards imposed by many countries in response to toxic and allergic reactions associated with synthetic dyes[1]. Until about 150 years ago all dyes were natural substances, derived mainly from plants and animals. The natural dyes present in plants and animals are pigmentary molecules[2,3], which impart colour to the materials. Pigmentary molecules containing aromatic ring structure coupled with a side chain are usually required for resonance and thus to impart colour. There is a correlation of chemical structure with colour, and chromogen-chromophore with auxochrome. Chromogen is the aromatic structure containing benzene, naphthalene or anthracene rings. The chromogen-chromophore structure is often not sufficient to impart solubility and cause adherence of the dye to the fibre, but the presence of auxochrome or bonding affinity groups enhances adherence properties of the dye to the fabrics. With the world becoming more conscious towards ecology and environment, there is greater need today to revive the tradition of natural dye and dyeing techniques as an alternative of hazardous synthetic dyes. The traditional method of dyeing is extremely crude. It is well known that the rural folk dye the yarn by heating chopped leaves or flowers of the plant in water. The process lacks proper shade calculation and reproducibility of shade for subsequent dyeing processes. It is also laborious and time-consuming.

There are several plants/plant parts that provide natural dyes[4–9] which are used in the textile industry. The literature reveals[10–15] the chemical composition and biological study of the different parts of *Delonix regia* 'Gulmohur', but no reports exist so far on the extraction of natural dyes from *D. regia* and their applications. The present investigation deals with the extraction of natural dyes from different flower parts of *D. regia* and their applications on textiles. *D. regia* grows in all warm and damp parts of India, and is considered to be one of the most beautiful trees in the world. The tree produces striking flame-like scarlet and yellow flowers during spring before the leaves emerge. Flowers are brilliant red, the uppermost petal streaked with tallow or yellow-and-white, petals stalked, their distal part abruptly expanded, orbicular, with wavy-crinkled edges, each about 4–6 cm long. Stamens decline together, curving out and down. It has been reported[16] that the Gulmohur flower contains flavonoids such as leucoanthocyanin and carotenoids such as lutein, zeaxanthin, violoxanthin, neoxanthin, auroxanthin, 5,6-monoepoxylutein, antheraxanthin and flavoxanthin, which are responsible for dyeing. Work has been carried out to prepare eco-friendly natural dyes from different parts of Gulmohur flower and application of colouring materials on cotton and silk yarns. Different parts such as petal, calyx, petal with reproductive organ and whole flowers were extracted separately with methanol as solvent at room temperature. Different parts of the flower were extracted in different time intervals such as 3 h (part I) and subsequently 6 h (part II).

The plant parts (100 g) were taken in pure methanol (500 ml) as solvent for extraction. The organic solvent was then distilled-off to get a brownish-black coloured pasty mass. Total yield of the mass was 8%. The pasty mass (1 g) was used in 20 ml of 0.5% sodium hydroxide solution to make a dye solution for different fabrics such as cotton and silk. The dyeing bath temperature was maintained at 60°C and time of dyeing was 45 min for every procedure at pH range 7–8. Light fastness study of the dyed yarn was carried out by washing with water, soap, rubbing, drying at room temperature and then direct sunlight and exposing the dry yarn to Digi-light for its fastness properties. Silk fabrics showed attractive shades with the dye materials, but cotton fabrics offered dull shades which do not give light fastness properties. Some of the findings are reported in Table 1.

In case of Sl.-1 and Sl.-2, the dye concentrations are the same at the time of dyeing with different dyeing conditions. The Sl.-1 offers golden yellow shades in presence of turmeric on silk fabrics whereas Sl.-2 offers olive green in presence of alum as mordant. The result of dyeing depends upon the concentration of dye after extraction as well as the dyeing condition. However, the dye concentration in Sl.-4 and Sl.-6 is the same as the result for both the cases are similar under the same dyeing conditions. Sl.-4 and Sl.-6 both give olive green shade using alum as mordant. Sl.-3 gave dark tan shade with turmeric powder and Sl.-5 gave saddle brown shades without mordant with different dyeing conditions. Colouring material extracted from the petal along with reproductive organ (Sl.-7) offers dark brown shades without mordant on silk fabrics, whereas Sl.-8 gave brown shades with alum as mordant. Sl.-9 gave brown shades on silk fabrics without using any mordant. The shades are compared with the nearest equivalent shades