



Phenology and Floral Morphology of *Dipterocarpus Indicus* From Western Ghats of Karnataka

KEYWORDS

Dipterocarpus indicus, Phenology, floral morphology.

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ABSTRACT Phenology and floral biology of an endangered species, *Dipterocarpus indicus* Bedd. was studied in relation to leaf sprouting, flowering and anthesis, fruit setting, development and retention besides leaf and fruit drop during three successive years along with its floral morphology and morphometry. The emergence of new leaves started during the last week of November 2012 and maturation started along with the fall of stipule during last week of December, also similar observations were recorded during 2013. Floral initiation was started during November last week in 2011, whereas in 2013 flower initiation was observed during December and in 2012 there was no flowering at all. Fruit initiation started from the last week of January, continued till February and maturation of fruits started during March in 2011.

Introduction

The family Dipterocarpaceae is well known for their timber species; consist of 19 genera and around 580 or more species (Londono et al. 1995, Morton 1995). Most of this dipterocarps are distributed over the tropical belt of three continents of Asia, Africa and South America (Appanah & Turnbull, 1998).

Dipterocarpus indicus is found in the evergreen forests of Southern Western Ghats from North Kanara southwards all along the Western Ghats down to Kerala and Tirunelveli and Kanyakumari districts of Tamil Nadu. The tree is endemic in the West Coast tropical evergreen forests (Champion & Seth, 1968). In Karnataka, the tree species are abundant in the wet evergreen forest of Chikmagalooru, Dakshina Kannada, Hassan, Kodagu, Shivamogga and Uttara Kannada forests (Ravikumar & Ved, 2000). At present the Dipterocarp dominates the international tropical timber market because of its high wood quality. Its oleoresin is used in the preparation of spirit, oil varnishes and lithographic inks. It is also used as an adulterant of dammar and as an application for rheumatism (Appanah & Turnbull, 1998). The current threat status of *Dipterocarpus indicus* is endangered at global level (IUCN, 2013).

In recent years, phenology has become an essential input for many studies concerned with the global carbon and water cycles (Menzel, 2002; Sparks & Menzel, 2002). Information on flowering phenology is crucial to understand the reproductive ecology of a plant species (Ollerton & Lack, 1998), as the flowers represent the main resource in reproductive terms. So, the mechanism of reproductive isolation and speciation (Kearns & Ionuye, 1993). The foraging behavior of a pollinator in a particular floral array is a result of a set of behavioral and physiological mechanisms (Sharma et al., 1999). The information about flowers is scattered in scientific papers that are not readily accessible to the general public, providing a little scope for a broad overview of the flowering plants mainly in tropical canopy tree species (Louis, 2010). Study of floral parts, breeding system and reproductive phenomenon is much important for its conservation and improve its distribution to overcome its threat status (IUCN, 2013). Much of

the study on *Dipterocarpus indicus* is focused on its regeneration, seed dispersal and wood quality, whereas less effort are made on the study of its floral parts because of the tall nature and less accessibility of flowers.

Materials and Methods

The present study was carried out at Agumbe (Latitude 13°30'9.64", Longitude 75°5'25.15", Altitude 400-600 MSL), situated in the tropical region of Central Western Ghats at Shimoga district of Karnataka, South India. The phenological observations were made on phenophases, such as (1) leaf sprouting, (2) flowering and anthesis, (3) Fruit set, development and retention and (4) leaf, fruit drop, during three successive years of March 2011 to March 2013. The observations were made throughout the year at 15 days intervals to describe broad phenological changes. A particular phenophase was considered to have started when about 10% of selected individuals were observed in that phase and was considered to have completed the phase when only less than 10% individuals remained in that particular phase (Sharma & Khanduri, 2007; Prasanna Kumar et al., 2013).

Studies pertaining to floral biology started from the very beginning of the bud stage of the flower. The twigs were marked for counting various floral stages (i.e., from S_1 to S_5 stages) at different time intervals. The flowering was recorded by counting the average floral stages on different twigs and 10 replicates in each case were taken. The formation of first floral bud was considered as floral initiation, 50% flowering was recorded when nearly 50% flowers had opened and full bloom was taken as the stage when more than 90% flowers had opened (Semalty & Sharma, 1996).

Ten individuals from each location (500 m apart from each other) were selected randomly and permanently marked from each location for observation such as (1) sexual system, (2) breeding system, (3) mean flower size, (4) flower longevity (days) after anthesis, (5) fruit set to ripen (days), (6) flower Shape, (7) flower color, (8) reward, (9) anther and stigma maturation, (10) flower anthesis, Type of Inflorescence - a) Length, b) Average number of flowers per inflorescence, c) Number

of calyx, d) Number of corolla, e) Number of stamens.

For the fruit setting studies ten trees of *Dipterocarpus indicus* with two branches each were tagged and observations were recorded after 20 days and 50 days of pollination.

Results and Discussion

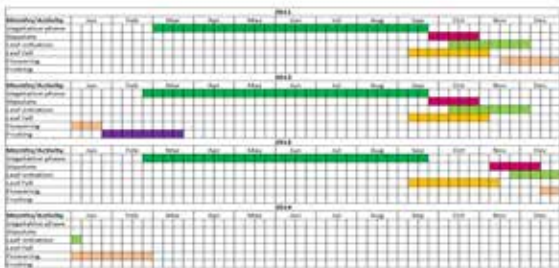
(a) **Phenology:** on the basis of phenological observations in *Dipterocarpus indicus* the various specified events in the phenophases are summarized as:

(1) **Leaf sprouting and development:** the leaf initiation in *Dipterocarpus indicus* started with the emergence of leaf buds in the last week of November in 2012. Peak stipule open and fall was observed in December first week, young leaves initiation starts after the fall of stipule. The colour of the stipule remained pink red and the initiated young leaves remained light green (Fig. 3c) during first week to mid of December then turned dark green till end December. Simultaneously leaves maturation started with the fall of stipule. A similar observation was recorded during 2013. The peak leaf fall was observed during September followed by the fresh leaf emergence during wet rainy season of October instead of the dry season as recorded earlier in the tropical forests of India and the La Selva (Rai & Proctor, 1986; Bawa et al., 2003).

(2) **Flowering and Anthesis:** The first floral buds were observed at the end of December and the flower initiation started from last week of December in 2013. In 2011 the flower initiation occurred during November last week and in 2012 there was no flowering. The peak flowering was observed during last week of December and first week of January in 2011 and mid-January to end of January in 2013. Among *Dipterocarp* trees it was often assumed that flowering does not occur annually but mass-flower once in every two to seven years with little or no flowering during the intervening years as reported by Kostermans (1992) and Curran and Leighton (2000).

(3) **Fruit setting, development and retention:** The fruit initiation started from the last week of January and continued till February the maturation of fruits started during March in 2012. In 2013 there was no fruit set.

Fig.1 Phenological events of *Dipterocarpus indicus* for the period of 2011 to 2013



Floral morphology

Inflorescence: The inflorescence are racemes, axillary with 8±3 flowers. It is a conspicuous drooping inflorescence with pendulous nature (Fig.3a). Similar nature of flowering was observed in *Shorea robusta* of *Dipterocarpaceae* (Atluri et al., 2004).

Flower: complete, bisexual, Actinomorphic, Pentamerous, fragrant, hermaphrodite (fig. 3d & e).

Calyx: green colour, five fused sepals with valvate aestivation.

Corolla: white with pink strip in the middle of the each petal.

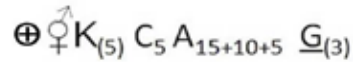
Five petals free with twisted aestivation.

Stamens: the stamens are 30 (15+10+5) arranged compactly in three whorls arising from the base of the petals.

Gynoecium: the pistil is tricarpellary syncarpus with six ovules. The ovary is superior with erect slender style and measures about 9 mm in length.

Floral formula and diagram

Floral formula is a symbolic representation of floral symmetry, presence or absence of floral whorls, their number cohesion and adhesion of various parts. The floral formula of *Dipterocarpus indicus* is,



Dipterocarpus indicus flowers are complete, actinomorphic, bisexual, calyx fused, valvate, corolla free twisted, androecium with 30 anthers arranged in three whorls (15+10+5), ovary superior with three carpels which are fused (syncarpus), Axile placentation with six ovules arranged as two in each locule.



Fig.2 Floral diagram of *Dipterocarpus indicus*

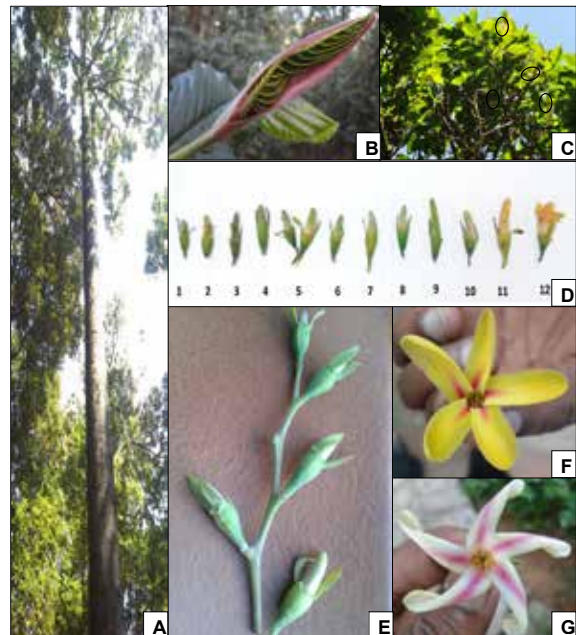


Fig 3. A) Mature *Dipterocarpus indicus*, B) Leaf initiation from stipule, C) Peak flowering stage, D) Floral stages of *Dipterocarpus indicus*, E) Inflorescence, F) Initial stage of a bloomed flower, G) Matured flower

Development of floral buds from S₁ to S₅ stages with their average length and diameter of the flowers were depicted as follows (Table.1).

Table.1 Size of floral buds at different stages of development

Stages	Length (mm)	Diameter (mm)
I	9.49±1.48	3.31±0.58
II	12.92±0.80	4.05±0.46
III	15.79±1.16	4.70±0.36
IV	20.37±2.13	5.21±0.74
V	27.35±2.70	5.94±0.57

The pollinators are determined by floral characters. The pollinators significantly related with flowering time, reward, and flower shape. Such relations among pollination systems and multiple floral characters can be called pollination syndromes (Faegri & van der Pijl, 1979). The study of pollination syndromes, floral characters are understood as mechanisms to attract appropriate pollinators to exclude low-efficiency visitors. The lower density of flowers and dull colour of *Dipterocarpus indicus* flowers attracts very few pollinators and as such it is mainly wind pollinated. The majority of flower buds and matured flowers are not retained for a longer period, due to floral abortion. In the present study no pollinator was found to be pollinating *Dipterocarpus indicus* flowers. Sharma et al. (1999) reported that dull colour flowers of *Boswellia serrate* attracted a few pollinators. Earlier studies of pollination mechanisms in tropical tree species documented wind-pollination in *Shorea robusta* (Atluri et al., 2004) *Madhuca indica* (Subba Reddi, 1976; Kuruvilla, 1989), *Mimusops elengi* (Subba Reddi & Atluri, 1981), *Cotoneaster distichus* and *Emblia officinalis* (Burd & Allen, 1988) from south India.

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