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PHENOLOGY AND REPRODUCTIVE BIOLOGY OF *Adansonia digitata* L: A THREATENED TREE SPECIES IN GWALIOR (MP) INDIA

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ABSTRACT

Adansonia digitata L. (Malvaceae) is a threatened tree of high medicinal and nutritional importance. It has numerous biological properties including antimicrobial, antiviral, anti-oxidant and anti-inflammatory activities amongst others. Over exploitation and poor attention paid by the conservationists, the tree species in under great threat and may disappear soon. In order to develop strategies to conserve this valuable tree species, present study was undertaken to investigate its phenology and reproductive biology. The trees were completely devoid of leaves till the end of April. First vegetative buds appeared in the first week of May, followed by the initiation of floral buds. Flowering was initiated in second week of May and continued up to end of June. Peak flowering was observed in second week of June and Fruiting started in the second week of September and continued up to the first week of October. Flowers open in the afternoon between 12.00-02.00 hours, anther dehiscence between 02.00- 3.00 hours and stigma fimbriate-papillose lobes and become receptive 03.30 hours and remains receptive for one day. Present communication deals with the phonological events and reproductive biology of this highly prized tree species.

Keywords: Baobab, Africa, phenology and reproductive biology.

INTRODUCTION

Adensonia (Malvaceae) is a genus of nine species of trees which are commonly known as Baobab. The generic name honours Michel Adanson, the French naturalist and explorer who described *Adansonia digitata*. Of the nine species, six are native to Madagascar, two are native to mainland Africa and the Arabian Peninsula, and one is native to Australia. This large gigantic tree, native to African continent has more than three hundred traditional uses (Buchmann *et al.* 2010). This has resulted in the over exploitation and destruction of this economically valuable tree species which is threatened to disappear. Studies on reproductive biology are essential for developing effective strategies for conservation of such species (Moza & Bhatnagar 2007). However, reproductive biology has been mostly studied in herbaceous crops and trees have not received the attention they deserve. This is largely due to several difficulties in conducting researches e.g. their large size, prolonged juvenility, long life cycles, in frequent flowering and inaccessible flowers, selection of plus trees, breeding, progeny testing and selection of elites (Tandon *et al*. 2005). Venter & Witkowski (2011) have examined fruit production in Baobab across five land-use types (nature reserves, rocky outcrops, plains, fields and villages) and over three consecutive years. Results showed that adult trees produced 8 times more fruit than sub-adult trees. Present communication deals with the phonological events and reproductive biology with special reference to its floral biology, pollination biology and breeding system for developing the conservation strategies of this threatened tree species.

MATERIALS AND METHODS

Study Site:

The study site is located (between 26º11'43.5" N and 078º 10'25.0" E), at Gwalior, northern Madhya Pradesh, India. The average elevation is about 197 m above the sea level and is spread over an area of

5214.00 sq km in the Chambal river valley. The annual temperature of Gwalior ranged between 17.7°C-32.7°C, annual average rainfall was 700 mm and Relative Humidity ranged between 60.54% and 65.89% during the study period (2012-2013).

Studies of some floral attributes like shedding of leaves, leaf emergence, flowering, fruiting were recorded over a period of flowering season. The average numbers of flowers present on an inflorescence were recorded from a randomly tagged flowering branches (n=50). Pollination efficiency of different insects was recorded by observing pollen load on their body parts under a microscope according to the procedure given by Kearns & Inouye (1993). Drop method was used for Pollen counts by counting the average ten drops (50% glycerine) in total volume of 50 ml (Jain *et al.* (1992). Pollen germination and pollen tube growth in the pistil were observed by adopting the methods of Shivanna & Rangaswamy (1992). Observations on Floral visitors/pollinators were conducted over 10–15 days at the sites during the growing season of *A. digitata* as per Dafni's method (1992).

OBSERVATIONS AND DISCUSSION

Habit:

Adansonia reach heights of 5 to 30 m (16 to 98 ft) and have trunk diameters of 7 to 11 m (23 to 36 ft). Trees reach to a height of 18-25 m and are produces a round crown of stiff branches. The trunk is swollen and stout, up to 10 m in diameter, usually tapering or cylindrical and abruptly bottle-shaped, often buttressed (Plate I). Giant individuals can attain a girth of up to 28 m. The shape of the trunk varies and in young trees, it is conical, while in mature individuals it may be cylindrical, bottle shaped or tapering with branching near the base (Yusha'u *et al.* 2010).

Branches are distributed irregularly and large and young branches are somewhat tomentose but rarely glabrous. The bark is smooth, reddish brown to grey, soft and fibrous. The bark of leaf-bearing branches is normally ashy on the last node.

Leaves are 2-3-foliate at the beginning of the season and exhibit early deciduous character, while mature ones are 5-7 (-9) - foliate. Leaves are alternate at the ends of branches or occur on short spurs on the trunk. Leaves of young trees are often simple. Leaflets are sessile to shortly petiolulate, with great variation in size. Overall mature leaf size may reach a diameter of 20cm and the medial leaflet can be 5-15 x 2-7cm, leaflet elliptic to obovate-elliptic with acuminate apex and decurrent base. Margins are entire and leaves are stellate-pubescent beneath when young becoming glabrescent or glabrous. Stipules are early caducous, subulate or narrowly triangular, 2-5mm long, glabrous except for ciliate margins.

Phenological events:

The study of phenological aspects of plants involves the observation, recording and interpretation of the timing of their life history events. The phenological data was sporadically collected on leaf fall, flowering and fruit formation. The seasonal loss of leaves brings about a period of dormancy during which photosynthesis is generally suspended.

Leaf fall started from the second week of February and continued up to the third week of April. The trees were completely devoid of leaves till the end of April. First vegetative buds appeared in the first week of May, followed by the initiation of floral buds. Flowering commences in the second week of May and reached its peak in the second week of June. This phase was maintained till the last week of the month

and then the flowering started declining in the second week of July. Fruiting started in the second week of September and continued up to the first week of October, it dehiscence took place in the second week of December and dispersal of seeds in the last week of December.

Plate I. Baobab tree at Govt. Science College, Gwalior (M.P.)

REPRODUCTIVE BIOLOGY

Floral biology:

The flowers are 4-5 in across and have waxy crinkled petals about 4 in long that surround dense clusters of purplish stamens that look like powder puffs. The flowers open only at night and are pollinated by bats feeding on the nectar. The pendant fruits are valvet covered, gray and gourd like, about a foot long and apparently look like dead rats hanging from the tree by their tails.

Flowers are pendulous, solitary or aired in leaf axils, large and showy and produced during both wet and dry seasons. Pedicels usually vary in length, 15-90cm, with 2 small, caducous bracteoles near the apex of the pedical. Flower bud is globose, sometimes somewhat ovoid with an apex conical to apiculate. Calyx 3-5 lobed, 5-9 x 3-7cm fused into a disc below but divided to half or more above, lobes triangular or oblong-triangular with apex acute or sub-acute, green and tomentose outside and cream and villous within, lobes reflexed. Corolla 5 partite, white, petals overlapping, obovate about as long as wide 4-10 x 3-12 cm, apex rounded, base shortly clawed, sparsely hairy or glabrous (except for the inside of the claw which is densely hairy).

Androecium bears a large number of stamens, 720-1600 forming a lower staminal tube 1.5-6 cm long, tube cylindrical or tapering, upper filaments of stamens free for about the same length as the tube and reflexed to form a ring. Anthers are reniform and *ca* 2 mm in length.

Gynoecium is syncarpous and differentiated into simple style, lobed stigma and an ovary. Ovary is usually 5-10 locular, with deeply intruded placentae, conical to globose, silky tomentose with upward-pointing hairs. Style is exserted about 15mm beyond the anthers, reflexed or erect, villous below and glabrous above and persists after floral abscission. The long style is usually bent over at approximately right angles in the globose bud. Baker (1985) suggested that the bent style of *A. digitata* might be an adaptation for bringing the stigma close to the base of the flower where it is more likely to be touched by a visiting bat. However, the possibility that this character is a developmental by-product of constraining a long style inside a bud needs to be considered. Stigma white with 5-10 irregular fimbriate-papillose lobes.

Fruits are variable, usually globose to ovoid but sometimes oblong-cylindrical, often irregular in shape, 7.5-54 cm long x 7.5-20 cm wide, apex pointed or obtuse, covered by velvety yellowish hairs (sometimes greenish). Pericarp 8-10 mm thick, woody, encloses a dry mealy pulp.

Seeds are reniform, embedded in the pulp, dark brown to reddish black with smooth testa and 10-13 x 8-10 x 4-5mm due to lateral flattening. Germination is phanerocotylar and seedlings have flattened hypocotyl *ca* 5 x 4 cm and shorter epicotyl. Some variations in seedling types have earlier been reported (Srivastava, 1959).

Pollen viability:

Pollen viability as tested by 1% acetocarmine mixed with 1% TTC (Tetrazolium Chloride) exhibited very less viability i.e. 6.2 to 27.27%. The viable pollen grains showed red color due to accumulation of formazan, whereas non-viable pollen grains remained colorless. Pollen production was 915.06 ± 34.07 grains/anther. Pollen grains are triporate or tetraporate and 50-60 µm in diameter.

Nectar:

So far searched, no much information on quantitative measurements of nectar

volume could be collected on *A. digitata* however, Baum (1995) observed large droplets of nectar on the inner surface of the calyx and estimated that at least 500 µl of nectar is produced by baobab.

Phenology:

Phenological studies are as important to our understanding of species interactions. The plant communities can be studied by dealing with particular life-history stages separately, such a leafing, flowering, fruiting and seed dispersal. Leaf shedding started from the second week of February and continued up to the third week of April. The trees were completely devoid of leaves till the end of April. First vegetative buds appeared in the first week of May, followed by the initiation of floral buds. The timing of flowering is one of the most widely investigated aspects of the phenology of plant life-cycles, and has been studied. Flowering started in the second week of May and reached its peak in the second week of June. This phase was maintained till the last week of the month and then the flowering started declining in the second week of July. Fruiting started in the second week of September and continued up to the first week of October, it dehiscence took place in the second week of December and dispersal of seeds in the last week of December.

Flowers open in the afternoon between 12.00-02.00 hours, anther dehiscence between 02.00- 3.00 hours and stigma fimbriate-papillose lobes and become receptive 03.30 hours and remains receptive for one day.

The flowering period of baobab tree varies in different eco-climatic zones. Flowering may occur anytime except during the peak of dry season. Flowers open in late afternoon and continue throughout the night. The number of flowers per tree varies from 1 or 2 to 10-50 (Baum, 1995) per day. Flowering period may continue up to 6 weeks. However, there are no data sets confirming this sequence for the wide range of baobab. In different parts of the world the flowering occurs in different months like, October-December in Southern Africa, November-December in Madagascar, sporadically throughout the year except January-March in Sudan and May-June in Western Africa. In India the flowering occurs during May to June, indicates high temperature and longer photoperiod as a possible cue for its flowering.

As soon as the flowers open, the calyx and corolla lobes curl back to expose the stamens. Later, the calyx and corolla straighten and re-cover the stamens. Flowers progressively wilt until late afternoon when the corolla is withered and falls off but the calyx persists. It was observed that pollination occurs over a 16-20 h period (Wickens, 1982), however anthesis may last only for less than 1 h (Baum, 1995). Fruits develop 5-6 months after flowering. No sufficient data are available on age of trees when first flowering begins. Wickens (1982) noted 16-17 years in South Africa and 22-23 years in Zimbabwe. Fruits tend to fall during the late rainy season onwards.

Pollination biology:

Pollination biology provides a tremendous opportunity to investigate various aspect of vigorous in terms of resource productivity. The species were all fruit bats like, *Eidolon helvum*, *Epomorphorus gambiensis* and *Rousettus aegyptiacus*. Its flowers produce a specific scent that attracts the bats and certain other flies and nocturnal moths as well as several species of bollworms that might affect some pollination. However, the pendulous nature of the flowers and phenology favours the action of fruit bats. The scent is described as resembling carrion (i.e. a sour smell). While

working in Bogor, Indonesia, Porsch (1935), first time observed the pollination of African baobab, done by a bat which was later confirmed by Pijl (1936) at the same location. A fruit bat (*Eidolon helvum*) was recorded pollinating baobab in West Africa by Jaeger (1945, 1954) and Harris & Baker (1959). Other evidences by bat pollination came from East Africa (Start, 1972). Bats swoop down on the flowers to seek the nectar secreted on the inner basal part of the sepals from secretary hairs. Visits are for seconds only and bat claws cling to and damage both corolla and staminal tube of the flowers. Bats have also been thought to eat some pollen (Wickens, 1982).

Pettersson *et al.* (2004) while studying the floral scent of bat-pollinated species of West Africa reported that *Adansonia digitata* was the only African species found to have a substantial proportion of sulphur compounds in its floral scent. Its dominant sulphur compound, dimethyl disulphide, is also the most commonly occurring sulphur component of Neotropical bat-pollinated species.

Some views regarding wind and ant pollination of the baobab tree were given by some authors (Jaeger, 1945; Wickens, 1982 and Humphries, 1982), but discounted by Baum (1995), although the observations on bush babies (*Otolemur crussicaudatus* and *Galago senegalensis*), known to feed on the flowers, play a pollinating role (Coe and Isaac, 1965) is not discounted. They probably play only a minor role in its pollination. Baum observed the visits of different pollinators on *A. digitata* and found that frequency of bats was maximum i.e. more than 10 visits per flower per hour, followed by bees, flies and butterflies (1-10 visits/flower/hr). Less visits were made by settling moths and hawk moths (Maximum one visit/flower/hr). No visits made by birds were observed.

Seed dispersal and tree regeneration:

After falling on the ground the outer woody part of the fruits fractures and termites enter to eat the sweet pulp, thus freeing the seeds. Wickens (1982) recorded a wide range of animals like monkeys, squirrels and rats that carries seeds away from the trees. Further, these fruits are widely eaten by humans and a number of large animals such as elephants and elands as well as birds, resulting in the dispersal of seeds. Fruits can also be dispersed through water and this is important when considering the disjunct distribution patterns of *A. digitata*. Dormancy is broken when the seeds pass through the digestive tract of animals which consume the fruit. Esenowo (1991) found that the most effective method to break the dormancy is scarification. Seeds generally take three to five weeks to germinate (Diop *et al.*, 2005), while plants grown from seed start flowering after eight to twenty-three years. The longer flowering period of baobab can be reduced to less than five years by grafting (Sidibe and Williams, 2002). Young trees grafted from elite trees with desirable characteristics develop faster than grown from seeds. Such methods may provide good possibilities for future vegetative cultivation and commercialization of baobab products.

Sporadic information is available about the natural regeneration rates of baobab, but to a large extent this could be because seedlings are not readily recognized since they lack the obvious palmately digitate leaves and swollen trunks.

Baobabs are traditionally propagated by transplanting naturally regenerated seedlings. However, seedlings are rare due to intensive browsing by livestock. In the field, seedlings do not emerge immediately after seeds are released from fruits due to hard seed coats, which appear to be non-

permeable. Cutting and grafting methods are also applied in some countries of Africa.

In the past Dogon, Kagolo and Bambara tribes in Mali (West Africa) used cuttings from the wild and transplanted them around their villages. The Dogon people used to transplant them next to their toilets where they could use wastewater to enable better growth of baobab. This practice originated from the shortage of water at certain times of the year and also a scarcity of wild seedlings. Germination rate of the hard seeds of baobab is usually less than 20% (Danthu *et al.,* 1995).

Conclusion:

Due to over exploitation and slow regeneration rate the baobab population is declining. It is time now that immediate action should be taken for its conservation. More efforts should be conducted for the multiplication of individuals through tissue culture techniques by developing a standard protocol. New cultivars with a short maturation period can also be developed. Looking to its specific pollination behavior by bats congenial environment should be provided for bats. Specific sites near bats inhabited areas like old buildings/ monuments/ caves etc. can be selected for its plantation. More public awareness is required for its conservation. In addition, the regenerated plants must be protected from wandering animals especially during the dry season.

References:

Baker, H.G. and Baker, I. (1973). Amino acids in nectar and their evolutionary significance. Nature 241:543-545.

Baker, M. (1985). The Mirror Principle and morphosyntactic explanation. Linguistic Inquiry 16(3):373-415.

Baum, D.A. (1995). The comparative pollination and floral biology of baobabs (*Adansonia* - Bombacaceae). Annals of Missouri Botanical Gardens 82:322-348.

Buchmann, C., Prehsler, S., Hartl, A. and Vogl, C.R. (2010). The importance of baobab (*Adansonia digitata* L.) in rural West African subsistence-suggestion of a cautionary approach to international market export of baobab fruits. Ecology of Food and Nutrition 49:145-172.

Chidumayo, E.N. (1994). Phenology and nutrition of Miombo woodland trees in Zambia. Trees Structure and Function 9:67-72

Coe, M.J. and Isaac, F.M. (1965) Pollination of the baobab, *Adansonia digitata L.* by the lesser bush-baby*, Galago crassicaudatus.* East African Wildlife Journal 3:123-124.

Dafni, A. (1992). Pollination Ecology. Oxford University Press, New York 1-250.

Danthu, P., Roussel, J., Gaye, A. and El Mazzoudi, E.H. (1995). Baobab (*Adansonia digitata* L.) seed pre-treatments for germination improvement. Seed Science and Technology 23:469-475.

Delarco, J.M., Escudero, A. and Garrido, M.V. (1991). Effects of site characteristics on nitrogen retranslocation from senescing leaves. Ecology 72:701-708.

Diop, A.G., Sakho, M., Dornier, M., Cisse, M. and Reynes, M. (2005). Le baobab africain (*Adansonia digitata* L.): principales caractéristiques et utilisations. Fruits 61(1):55-69.

Esenowo, G.J. (1991). Studies on germination of *Adansonia digitata s*eeds. Journal of Agricultural Science 117(1):81-84.

Fenner, M. (1998). The phenology of growth and reproduction in plants. Perspectives in Plant Ecology, Evolution and Systematics 1(1):78-91.

Harris, B.J. and Baker, H.G. (1959). Pollination of flowers by bats in Ghana. Nigerian Field 24:151-159.

Humphries, C.J. (1982). Bombacaceae. *In* VH (editor*),* Flowering Plants of the World. Prentice Hall, New Jersey USA pp.93-94.

Jaeger, P. (1945). Épanouissement et pollinisation de la fleur du Baobab [in French]. Comptes Rendus de l' Academie des Sciences, (Paris), 220:369-371.

Jain, A.K., Patel, P. and Datta, T.R. (1992). Production, dispersion & sensitivity of some allergenic pollen grains at Gwalior. J. Aerobiol. Special Vol. 95-98.

Kearns, C.A. and Inouye, D.W. (1993). Techniques for pollination biologists. University Press of Colorado Nivyot Colorado.

Moza, M.K. and Bhatnagar, A.K. (2007). Plant reproductive studies crucial for conservation. Current Science 92(9):1207.

Pettersson, S., Ervik, F. and Knudsen, J.T. (2004). Floral scent of bat-pollinated species: West Africa vs. the New World. Biological Journal of the Linnean Society 82:161-168.

Pijl, L. vander. (1936). Fledermoüse und Blumen Flora 13:146.

Porsch, O. (1935). Zur Blutenbiologie des Affenbrot-baumes Oesterr. Bot Zeit 84:219-224.

Rusch, V.E. (1993). Altitude variation in the phenology of Nothofagus pumilio in Argentina. Revista Chilena de Historia Natural 66:131-141.

Shivanna, K.R. and Rangaswamy, N.S. (1992). Pollen biology-A laboratory manual. Springer Verlag, Berlin.

Sidibe, M. and Williams, J.T. (2002). Baobab *Adansonia digitata*. Southampton, UK: International Centre for Under-utilised Crops.

Srivastava, G.S. (1959). Schizocotyly and polycotyly in *Adansonia digitata*. Linn Soc and Cult 25:218-219.

Start, A.N. (1972). Pollination of the Baobab (*Adansonia digitata*) by the fruit bat (*Rousethus agyptiacus*). East African Wildlife Journal 10:71-72.

Tandon, V., Chakravarty, R. and Das, B. (2005). Four new species of the genus *Lytocestus* (Caryophyllidea: Lytocestidae) from Edible Cat fishes in Assam and Meghalaya, India. J. Parasit. Dis 29(2):131-142.

Venter, S.M. and Witkowski, Ed T.F. (2011). Baobab (*Adansonia digitata* L.) fruit production in communal and conservation land-use types in Southern Africa. Forest Ecology and Management 261(3):630-639.

Wickens, G.E. (1982). The baobab: Africa's upside-down tree. Kew Bull 37:173-209.

Williams, R.J., Myers, B.A., Muller, W.J., Duff, G.A. and Eamus, D. (1997). Leaf phenology of woody species in a North Australian tropical savanna. Ecology 78:2542-2558.

Yusha'u, M., Hamza, M.M. and Abdullahi, N. (2010). Antibacterial activity of *Adansonia digitata* stem bark extracts on some clinical bacterial isolates Int. J. of Biomedical and Health Sci 6(3):129-135.