



Research Journal of
**Environmental
Sciences**

ISSN 1819-3412



Academic
Journals Inc.

www.academicjournals.com

***Bombax ceiba* Linn.: As an Umbrella Tree Species in Forests of Southern Rajasthan, India**

¹V. Jain, ²S.K. Verma, ³S.K. Sharma and ¹S.S. Katewa

¹Laboratory of Ethnobotany and Agrostology, Department of Botany, Mohanlal Sukhadia University, Udaipur-313001, Rajasthan, India

²Indigenous Drug Research Center, Department of Medicine, RNT Medical College, Udaipur-313001, Rajasthan, India

³Assistant Conservator of Forests, Sajjangarh Wildlife Sanctuary, Udaipur (Raj.), India

Corresponding Author: S.K. Verma, Indigenous Drug Research Center, Department of Medicine, RNT Medical College, Udaipur-313001, Rajasthan, India

ABSTRACT

Bombax ceiba Linn. (Red Silk Cotton Tree) commonly known as Semal tree; is a multipurpose tree species of tropical forests; providing food, fodder, fibre, fuel and medicine besides many ecological benefits. It is a dominant plant species of tropical dry deciduous forests of Southern Rajasthan, India. The present work is an attempt to justify the role of *B. ceiba* as an umbrella or life support tree for many animal species in forest areas of Southern Rajasthan. During the study period, total 43 animal species were observed who visited *B. ceiba* either for food, shelter or roosting purposes. Out of these, 29 species were from Avian fauna, 11 species belonged to Mammalia, two species belonged to Arthropoda and one from Reptilia. The present study confirms use of *B. ceiba* for balancing forest ecosystems and further recommends that this drought tolerant, easily propagable plant species should be planted in dotted fashion in forests specially in protected areas and also in home gardens as a keystone resource for many animal species.

Key words: Red silk cotton tree, mammals, tropical forest, roosting, protected areas

INTRODUCTION

Trees form the major structural and functional basis of tropical forest ecosystems. There are many plant species such as *Ficus benghalensis*, *Ficus religiosa*, *Ziziphus nummularia* and *Phoenix sylvestris* etc., which play an important role in the lives of wild animals in forests and protected areas. They provide food, shelter, roosting and breeding sites to a large number of animals and therefore, these plant species can be aptly called as 'Life support plant species' or 'Umbrella tree species'.

Bombax ceiba Linn. (syn.: *Bombax malabaricum* DC.; *Salmalia malabarica* (DC.) Schott and Endl.); member of family Bombacaceae is one such tree species which also plays a major role in the lives of wild animals in tropical forest ecosystems. It is known as Red Silk Cotton tree, Indian Kapok, Semal, Bombax de Malabar, Shalmali etc., in different languages. This lofty tree species also designated as King of the Forests; is found in temperate and tropical Asia, Africa, America and Australia and is an important part of many tropical dry deciduous forest ecosystems (The Wealth of India, 2004).

The plant is well known for its beautiful crimson red flowers, which are used to make natural and eco-friendly color for Holi-the festival of colors in India. The flowers are major attractants during spring for many birds and insect eaters and therefore, this tree merits consideration as a keystone resource (Raju *et al.*, 2005). It is an important multipurpose tree having a long life span and provides many environmental benefits. It has been demonstrated that this plant possesses moderate SO₂ absorption efficacy and therefore, can be recommended for roadside plantations in polluted urban areas (Farooq *et al.*, 1988).

Bombax ceiba is considered to be a member of 'Panchwati' a place where five spiritual trees are planted together to do psycho-spiritual meditation (Sarkar, 1991). Almost every part of the plant is reported to be useful in a variety of disorders of human and animal health (Jain, 1991; Warriar *et al.*, 1994; Gupta *et al.*, 2004). Scientific researches worldwide have shown that it possess hypotensive, anti-inflammatory, antihyperglycemic, antihyperlipidaemic, antimicrobial, analgesic, antioxidant, fibrinolysis enhancing and anabolic properties (Gupta *et al.*, 2004; Jain *et al.*, 2011; Verma *et al.*, 2006; Verma *et al.*, 2011).

Being a dominant plant species of Southern Rajasthan with its multifarious uses, the present study attempts to evaluate the role of *B. ceiba* as a life support plant species for wildlife in dry deciduous forests of Southern Rajasthan.

MATERIALS AND METHODS

Botanical excursions were made in the forest areas of Southern Rajasthan every year during spring, summer, rainy and winter seasons from the year 2006-2011 in the area confined to 23 to 26° Northern latitude and 72 to 79° Eastern longitude. Total 12 Wildlife Sanctuaries situated in South and South-East Rajasthan and few villages namely Hawala, Chirwa and Desuri where also some patches of *B. ceiba* are present were visited for the study. Authors made two groups of two each. One group visited Wildlife Sanctuaries of South Rajasthan namely, Mount Abu, Phulwari, Kumbhalgarh, Sajjangarh, Todgarh-Raoli and Jaisamand and the other group visited six Wildlife Sanctuaries in South-East Rajasthan namely, Sitamata, Bassi, Bhainsrorgarh, Shergarh, Darrah and Jawahar Sagar. These sites were visited twice in spring season and once in summer, rainy and winter seasons.

Help of local forest officers and local tribal communities especially members of Eco-Development Committees (EDC) was also taken. As the night entry is not allowed in the Sanctuaries, early morning and late evening visits were made and help of pug marks was also taken to identify the nocturnal faunal species who visited *B. ceiba* trees. Sometimes night stays were arranged in the villages situated in the Sanctuary areas. Flying Squirrel was sighted with the help of bright search lights thrown on plants of *B. ceiba* situated on the periphery of Sanctuaries. Reddish colored reflection of eyes made identification of Flying Squirrel very easy. The *B. ceiba* trees in Sajjangarh Wildlife Sanctuary were in very young stages and therefore, this site was visited only during winter season. Presence of any animal species sighted even once, was noted down and added in the observations. Photographs and small video clippings were also prepared and animal species were identified with the help of standard reference books (Prater, 1980; Ali and Ripley, 1983; Roberts, 1997; Sharma, 2007) and further confirmation was authenticated at Department of Zoology, Mohanlal Sukhadia University, Udaipur.

RESULTS

Table 1 show that in the study area, there were 43 animal species who visited *B. ceiba* trees either for feeding, breeding or roosting purposes. Out of 43 animals observed, 29 species were birds,

Table 1: Uses of *Bombax ceiba* by various animal species

	Scientific name	English name	Utility of <i>Bombax ceiba</i>		Name of site where observed*	Remarks
			Plant part	Use		
Insects	<i>Oecophylla smaragdina</i> fabricius	Red weaver ants	Young pliable leaves	Incorporated into foliar nests	2,7	-
	<i>Apis dorsata</i> Fab.	Rock bee	Flowers	Nectar and pollens are taken as food	1,2,3,5,7,11	Also observed in hawala, chirwa and desuri villages
			Branches of huge sized trees	Used for making their hives		
Reptile	<i>Calotes versicolor</i> Daudin	Oriental garden lizard	Stem and branches	For dwelling	1,2	-
Birds	<i>Megalaima haemacephala</i> muller	Coppersmith barbet	Thick boughs	Nesting in self made holes	1,2,3,5,7	Bird is a primary hole nester. Also observed in hawala and desuri villages
	<i>Megalaima zeylanica</i> Gmelin	Brown headed Barbet	Thick boughs	Nesting in self made holes	2,7	Bird is a primary hole nester.
	<i>Ocyrceros birostris</i> Scopoli	Indian grey Hornbill	Thick boughs	Nesting in holes	3, 5, 7	Bird is a secondary hole nester
	<i>Butastur teesa</i> Franklin	White-eyed Buzzard	Leafless extremities	Used as perch station	1,2,3, 5-12	-
	<i>Dicrurus macrocercus</i> Vieillot	Black drongo	Flowers	Nectar is taken as food	1,2,3, 5-12	Also observed in hawala and chirwa villages
	<i>Bubulcus ibis</i> Linn.	Cattle egret	Top branches	Short-period day perch	2,8	Also observed in hawala and chirwa villages
			Flowers	Devours the insects hovering on flowers		
	<i>Pycnonotus cafer</i> Linn.	Red-vented bulbul	Flowers	Nectar is taken as food	1,2,3, 5-12	Also observed in hawala, chirwa and desuri villages
	<i>Pycnonotus jocosus</i> Linn.	Red-whiskered Bulbul	Flowers	Nectar is taken as food	5	Confined to semi-evergreen forests of high altitude
	<i>Acridotheres tristis</i> Linn.	Common myna	Flowers	Nectar is taken as food	1-3, 5-12	-
	<i>Passer domesticus</i> Linn.	House sparrow	Flowers	Nectar is taken as food	1,2,3,5,8,11	-
	<i>Sturnus roseus</i> Linn.	Rosy starling	Flowers	Nectar is taken as food	2,3,6,7,8,10,11,12	-
	<i>Petronia xanthocollis</i> Burton	Chestnut -shouldered petronia	Flowers	Nectar is taken as food	1-3, 5-12	-
	<i>Coracias benghalensis</i> Linn.	Indian roller	Flowers	Nectar is taken as food	1,2,3,5,6,7,9,11	-
	<i>Corvus splendens</i> Vieillot	House crow	Flowers	Nectar and petals are taken as food	1,2,3,5,6,8,9,11	-
	<i>Corvus macrorhynchos</i> Lesson	Large-billed Crow	Flowers	Nectar and petals are taken as food	2,3,5,7,10,11	-
	<i>Oriolus larvatus</i> Lichtenstein	Black-headed oriole	Flowers	Nectar is taken as food	2,7	-
	<i>Oriolus oriolus</i> Linn.	Eurasian golden oriole	Flowers	Nectar is taken as food	2,3,5,7,11,12	-
	<i>Dendrocitta vagabunda</i> latham	rufous treepie	Flowers	Nectar is taken as food	2,3,7,9,11,12	-

Table 1: Continued

Scientific name	English name	Utility of <i>Bombax ceiba</i>		Name of site where observed*	Remarks
		Plant part	Use		
<i>Copsychus saularis</i> Linn.	Oriental magpie robin	Flowers	Nectar is taken as food	2,7	-
<i>Zosterops palpebrosus</i> temminck	Oriental white eye	Flowers	Feeds on nectar and hovering on flowers	2,7	-
<i>Psittacula krameri</i> Scopoli	Rose-ringed parakeet	Flowers	Nectar and petals are taken as food	1,2,3,5,7,8	Also observed in hawala village
<i>Nectarinia zeylonica</i> Linn.	Indian purple-rumped sunbird	Flowers and fruits	Nectar is taken as food and soft fibres (Silk cotton) are used for lining the nests	1,2,3,5-12	Also observed in hawala, chirwa and desuri villages
<i>Nectarinia asiatica</i> latham	Purple sunbird	Flowers and fruits	Same as above	2,7	-
<i>Eudynamys scolopaceus</i> Linn.	Asian Koel	Branches	Used as perch station	2,5	Also observed in hawala village
<i>Carpodacus erysrinus</i> pallas	Rosefinch	Flowers	Nectar is taken as food	2,3,7	-
<i>Glaucidium radiatum</i> tickell	Jungle owlet	Top branches	Used as perch station during night	2	-
<i>Athene brama</i> Temmnick	Spotted owlet	Top branches	Used as perch station during night	1,2,11	-
<i>Pavo cristatus</i> Linn.	Blue Peafowl	Fallen flowers	Petals are nibbed as food	1,3,6,12	-
<i>Rhipidura aureola</i> Lesson	White-browed fantail flycatcher	Flowers	Devours the insects hovering on flowers	1,2,3,7	Flowers are indirectly useful for the bird.
Mammals <i>Semnopithecus entellus</i> dufresne	Hanuman or common Langur	Intact and fallen flowers Stem	Flowers are eaten as food Debarking of stem is done during summer to devour the bark as food	1,3,5,6,8,9	-
<i>Macaca mulatta zimmermann</i>	Rhesus macaque	Intact and fallen flowers	Flowers are eaten as food	10,11,12	-
<i>Boselaphus tragocamelus</i> pallas	Blue bull	Fallen flowers	Consumed as food	3,6,8,11,12	-
<i>Tetracerus quadricornis</i> de blainville	Four-horned antelope	Fallen flowers	Consumed as food	2,3,7	-
<i>Gazella bennettii</i> Sykes	Indian Gazelle/ chinkara	Fallen flowers	Consumed as food	1,3,11,12	-
<i>Rusa unicolor</i> Kerr.	Sambhar	Fallen flowers	Consumed as food	3,6,11	-
<i>Melursus ursinus</i> Shaw	Sloth Bear	Fallen flowers	Consumed as food	2,3,5,11	-
<i>Funambulus pennati</i> wroughton	Northern palm squirrel	Intact and fallen flowers	Nectar and petals are consumed as food	1,2,3,5-12	Also observed in Hawala and Chirwa villages
<i>Petaurista philippensis</i> elliot	Elliot's flying squirrel	Intact flowers	Nectar and petals are consumed as food	2,7	-
<i>Pteropus giganteus</i> brunnich	Flying fox	Intact flowers	Nectar and whole flower consumed as food	2	-

Table 1: Continued

Scientific name	English name	Utility of <i>Bombax ceiba</i>		Name of site where observed*	Remarks
		Plant part	Use		
<i>Hystrix indica</i> Kerr.	Indian crested porcupine	Fallen flowers	Consumed as food	1,2,3,6,11	-
		Fallen unripe and ripe fruits	Seeds are taken out and consumed as food		
		Roots of Seedlings	Excavated and eaten as food		

*1: Jaisamand wildlife sanctuary, 2: Phulwari wildlife sanctuary, 3: Kumbhalgarh wildlife sanctuary, 4: Sajjanganrh wildlife sanctuary, 5: Mount abu wildlife sanctuary, 6: Todgarh-raoli wildlife sanctuary, 7: Sitamata wildlife sanctuary, 8: Bassi wildlife sanctuary, 9: Bhainsrorgarh wildlife sanctuary, 10: Shergarh wildlife sanctuary, 11: Darrah wildlife sanctuary and 12: Jawahar sagar wildlife sanctuary

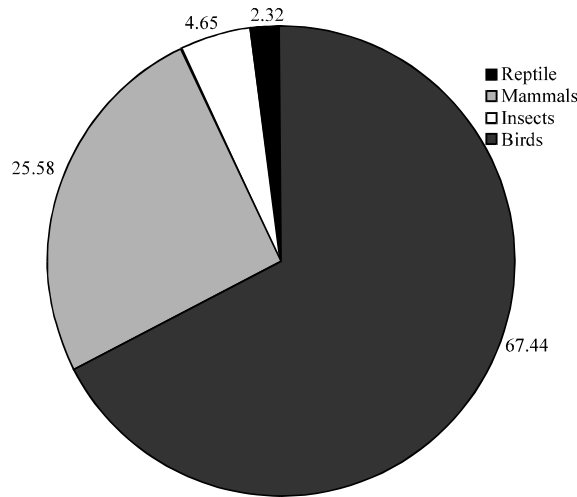


Fig. 1: Percent contribution of each faunal group who visited *Bombax ceiba* in the study area

11 species were mammals, 2 species were arthropods and one was a reptile. Figure 1 demonstrates that total 67% birds, 25% mammals, 4% arthropods and 2% reptiles visited Semal trees in the study area.

DISCUSSION

Tropical forests are often referred to as one of the most species diverse terrestrial ecosystems generating a variety of natural resources to help sustain the lives of wild animals and livelihood of local communities (Kumar *et al.*, 2011; Jain *et al.*, 2009). *B. ceiba* is an integral part of many tropical ecosystems. In the present study, maximum animals visited *B. ceiba* for feeding purpose. Nectar rich flowers were used as food by total 32 animal species followed by its roots, ripe and unripe fruits, bark and seeds. Four animal species used *B. ceiba* for breeding purpose and as a shelter provider (Table 1). Looking to its life supporting nature for many animal species, this plant can very well be termed as an ‘Umbrella tree’.

Large, attractive, nectar rich, odor-less, crimson red-colored flowers of *B. ceiba*, fascicled near the ends of leafless branches are produced during January to March. Being predominantly an ornithophilous plant species, *B. ceiba* is also designated as ‘Little bird’s cafeteria’. Figure 1 shows that out of total faunal species who visited *B. ceiba* trees; the maximum number obtained was of

birds (67%). Birds rapidly and frequently visit its flowers for collecting nectar and stored water within the cup shaped calyx and thus help in the process of pollination particularly geitonogamy and allogamy.

Large and tall Silk Cotton trees are among the most favorite roosting and nesting sites for many large birds especially Vultures, Eagles, Storks and mammals like Bats. In the present study, three bird species were observed, who used *B. ceiba* as a nesting site. A study on population status and breeding ecology of *Gyps bengalensis* (White-rumped Vulture) in Rampur valley, Nepal, has shown that 86% nests of *G. bengalensis* were built on *B. ceiba* trees. Commercial logging of *B. ceiba* trees in Nepal has limited its nest-site availability leading to drastic reduction in population of White-rumped Vultures which are nature's best scavengers (Baral *et al.*, 2005). Similarly, decline in population of an endangered bird *Leptoptilos dubius* (Greater Adjutant Stork) has also been observed in Assam, India which is due to continuous reduction in the availability of its nesting sites in general and over-exploitation of *B. ceiba* in particular as it is the most preferred nesting site of Greater Adjutant Stork (Singha *et al.*, 2002).

Bombax ceiba is also one of the preferred plant species used by Rock Bees for making their hives on it. In the year 2011, for the first time, a maximum of 13 Bee hives were observed on a single *B. ceiba* tree in Jaisamand Wildlife Sanctuary during continuous surveys since last five years. In Maradavally forest area of Western Ghats, India, *B. ceiba* has been the main shelter tree for honeybee colonies. But overexploitation of this plant species has put it into an endangered species and also resulted in reduction of honeybee populations which are the main pollinating agents. The loss of pollinators has further induced reduction in the seed set of *B. ceiba*. Therefore, depletion of such keystone resource species within a forest area can cause a deleterious impact on the whole ecosystem (Ramakrishnappa and Krell, 2006).

In many of the forest and non-forest areas, scarcity of food for wild animals has become a major problem nowadays. It is due to the loss of green plants which are primary producers of food chain. Pudyatmoko *et al.* (2009) has reported that diversity of birds were lower in urban environment than in forests of Java, Indonesia. This clearly indicates the loss of habitats for animals especially in urban environment. Looking to the status of *B. ceiba* as a life support tree for many animal species, availability of food can be improved by planting this species in dotted fashion in forests, wastelands, urban, peri-urban and rural areas. Good patches of Silk Cotton trees, raised outside or at the periphery of protected areas (Sanctuaries and National Parks) can support the spill over population of many wild animal species of the protected areas. This plant species can also be used to beautify cities by planting it along the roadsides where it can help to support a good number of city dweller birds and mammalian species.

The male Spotted Deer (*Axis axis*) and the Sambhar (*Rusa unicolor*) have a tendency to rub their antlers against stem of this tree during rutting period (Sharma, 2007). Sharp thorns present on the stem of *B. ceiba* provide it tolerance to browsing and debarking; making this species suitable for planting even in unfenced deer prone areas.

Bombax ceiba can be easily propagated through seeds and leafless branch cutting. It is considered as a reforestation pioneer plant species and survives easily in low rainfall and well drained conditions. To make its dispersal easy, nature has also provided flying ability to its light-weighted seeds which are embedded in soft silk. Being a less water and light demanding species, it can be easily grown in tropical dry forests and other non-forest areas and thus can help in balancing these ecosystems. Moreover, being a commercially important and a fast growing species, it can be planted in farms and used for agro-forestry which can economically benefit the farmers and simultaneously support the animal species living outside the forest areas.

Being a good coppicing species, it can be regenerated even after harvesting. Dry leaves and flowers of *B. ceiba* can be used to prepare vermi-compost (Sannigrahi, 2009). Protein rich leaves also make it one of the most preferred fodder species and thus it is used extensively in silvi-pastoral system of agroforestry (Chundawat and Gautam, 1993).

A network of 25 Wildlife Sanctuaries and 2 National Parks is present in the state of Rajasthan, India. Out of these 27 protected areas, besides Tal Chhapar Wildlife Sanctuary, *B. ceiba* can be easily planted in remaining 26 protected areas. This practice can also be followed in areas of similar nature in other parts of India and world. However, not only planting is important but the future protection of this plant species is also necessary. This plant species is under stress in many pockets of South Rajasthan due to some socio-cultural practices (Jain *et al.*, 2009) and therefore, both *in situ* and *ex-situ* conservation strategies should be urgently employed to get benefits of this plant in future too.

In a nutshell, *B. ceiba* is not only important for humans (Jain *et al.*, 2009; Jain *et al.*, 2011) but also equally important for wild fauna as indicated in Table 1. All parts of this plant especially, tuberous roots of juvenile plants, bright flowers, soft fibers, seeds and stem bark are useful for wild animals. *B. ceiba* is therefore, a good example of an umbrella tree species and should be recommended for plantation in tropical forests, protected areas as well as home gardens to further support lives of many animal species that are dependent on it.

ACKNOWLEDGMENTS

Authors are thankful to Society for Microvita Research and Integrated Medicine (SMRIM), Udaipur for sponsoring the project. Authors are also thankful to faculty members of Department of Zoology, Mohanlal Sukhadia University, Udaipur for helping in identification of animal species and members of Eco-Development Committees and forest officials of the study area for providing necessary facilities and information.

REFERENCES

- Ali, S. and S.D. Ripley, 1983. Handbook of the Birds of India and Pakistan Together With Those of Bangladesh, Nepal, Bhutan and Sri Lanka -compact edition. Oxford University Press, New York.
- Baral, N., R. Gautam and B. Tamang, 2005. Population status and breeding ecology of white-rumped vulture *Gyps bengalensis* in Rampur Valley, Nepal. Forktail, 21: 87-91.
- Chundawat, B.S. and S.K. Gautam, 1993. Textbook of Agroforestry. Oxford and IBH publishing Co. Pvt. Ltd, New Delhi.
- Farooq, M., R.P. Saxena and M.U. Beg, 1988. Sulfur dioxide resistance of Indian trees-I. experimental evaluation of visible symptoms and SO₂ sorption. Water Air Soil Pollut., 40: 307-316.
- Gupta, A.K., M. Sharma and N. Tandon, 2004. Reviews on Indian Medicinal Plants. Vol. 2, Indian Council of Medical Research, New Delhi.
- Jain, S.K., 1991. Dictionary of Indian Folk Medicine and Ethnobotany. Deep Publications, New Delhi.
- Jain, V., S.K. Verma and S.S. Katewa, 2009. Myths, traditions and fate of multipurpose *Bombax ceiba* L.: An appraisal. Indian J. Trad. Knowledge, 8: 638-644.
- Jain, V., S.K. Verma, S.S. Katewa, S. Anandjiwala and B. Singh, 2011. Free radical scavenging property of *Bombax ceiba* Linn. root. Res. J. Med. Plant, 5: 462-470.

- Kumar, N.J.I., K. Patel, R.N. Kumar and B.R. Kumar, 2011. Forest structure, diversity and soil properties in a dry tropical forest in Rajasthan, Western India. *Ann. For. Res.*, 54: 89-98.
- Prater, S.H., 1980. *The Book of Indian Animals*. Bombay Natural History Society, Mumbai, India, ISBN: 0195621697.
- Pudyatmoko, S., Kaharuddin and S. Nurvianto, 2009. Role of urban environment on conservation of birds diversity in Java, Indonesia. *J. Biol. Sci.*, 9: 345-350.
- Raju, A.J.S., S.P. Rao and K. Rangaiah, 2005. Pollination by bats and birds in the obligate outcrosser *Bombax ceiba* L. (Bombacaceae), a tropical dry season flowering tree species in the Eastern Ghats forests of India. *Ornith. Sci.*, 4: 81-87.
- Ramakrishnappa, A. and R. Krell, 2006. Case study No. 8. Impact of cultivation and gathering of medicinal plants on biodiversity: Case studies from India. FAO Corporate Document Repository. <http://www.fao.org/DOCREP/005/Y4586E/y4586e09.htm>.
- Roberts, T.J., 1997. *The Mammals of Pakistan*. Oxford University Press, Karachi, Pakistan.
- Sannigrahi, A.K., 2009. Biodegradation of leaf litter of tree species in presence of cow dung and earthworms. *Indian J. Biotechnol.*, 8: 335-338.
- Sarkar, P.R., 1991. *Microvitum in a Nutshell*. 3rd Edn., AMPS Publication, Tiljala, Calcutta.
- Sharma, S.K., 2007. Study of biodiversity and ethnobiology of Phulwari Wildlife Sanctuary, Udaipur (Rajasthan). Ph.D. Thesis, Mohanlal Sukhadia University, Udaipur.
- Singha, H., A.R. Rahmani, M.C. Coulter and S. Javed, 2002. Nesting ecology of the greater adjutant stork in assam, India. *Waterbirds*, 25: 214-220.
- The Wealth of India, 2004. I Supplement Series (Raw Materials) Vol I: A-Ci. NISCAIR, New Delhi, ISBN: 81-7236-208-0.
- Verma, S.K., V. Jain and S.S. Katewa, 2006. Fibrinolysis enhancement by *Bombax ceiba*: A new property of an old plant. *South Asian J. Prevent. Cardiol.*, 10: 212-219.
- Verma, S.K., V. Jain and S.S. Katewa, 2011. Anabolic effect of *Bombax ceiba* root in idiopathic involuntary weight loss a case study. *J. Herbal Med. Toxicol.*, 5: 1-5.
- Warrier, P.K., P.K. Nambiar and P.S. Warrier, 1994. *Indian Medicinal Plants- A Compendium of 500 Species*. Vol. 1, Orient Longman Publishing, Kottakkal, ISBN: 81-250-0301-0, pp: 289-292.