Journal of Asia-Pacific Biodiversity 10 (2017) 127–131

Contents lists available at ScienceDirect

Journal of Asia-Pacific Biodiversity

journal homepage: http://www.elsevier.com/locate/japb

Short communication

Rediscovery of *Magnolia rabaniana* (Magnoliaceae): A threatened tree species of Meghalaya, northeast India

Aabid Hussain Mir [a], Krishna Upadhaya [b,*], Nripemo Odyuo [c], Brajesh Kumar Tiwari [a]

[a] *Department of Environmental Studies, North-Eastern Hill University, Shillong, Meghalaya, India*
[b] *Department of Basic Sciences and Social Sciences, North-Eastern Hill University, Shillong, Meghalaya, India*
[c] *Botanical Survey of India, Eastern Regional Centre, Shillong, Meghalaya, India*

ARTICLE INFO

Article history:
Received 7 June 2016
Received in revised form
14 September 2016
Accepted 26 October 2016
Available online 20 January 2017

Keywords:
community forest
conservation
data deficient
recollection

ABSTRACT

Magnolia rabaniana (Hook.f. & Th.) D.C.S. Raju & M.P. Nayar, a threatened and endemic tree species of northeast India, has been rediscovered after a lapse of almost 100 years from Khasi Hills of Meghalaya. A total of 65 individuals that includes 38 mature (≥ 5 cm diameter at breast height) and 27 young individuals (≤ 5 cm diameter at breast height) were recorded from five sites. The existing populations of the species are under severe threats due to a number of human disturbances and therefore warrant immediate conservation initiatives.

Introduction

The family Magnoliaceae is one of the most important primitive families belonging to the order Magnoliales. Globally, about 245 species (Cicuzza et al 2007) of the family have been recorded. In the Indian subcontinent, the family is represented by 46 species and five subspecies, distributed in seven genera (Kundu 2009), of which 24 species are found in northeast India and 15 species have been reported from Meghalaya (Balakrishnan 1981; Haridasan and Rao 1985). The genus *Magnolia* (including *Elmerrillia*, *Kmeria*, *Manglietia*, *Michelia*, *Pachylarnax*, and *Talauma*), is one of the important genus of the family represented by about 219 species. The genus is distributed in the Himalayas to Japan and West Malaysia, and Eastern North America to tropical America (Mabberley 2008).

Magnolia rabaniana (Hook.f. & Th.) D.C.S. Raju & M.P. Nayar (synonym: *Talauma rabaniana* Hook.f. & Th.) is a threatened tree species considered as endemic to northeast India (Khela 2014). It is distributed in the states of Assam, Arunachal Pradesh, Mizoram, Sikkim, and Meghalaya. The habitat of the species is represented by subtropical, temperate, as well as subalpine coniferous forests (Khela 2014) and occurs at an elevation ranging from 1,300 m to 2,400 m above sea level (asl) (Kundu 2009). However, there is a lack of information on the distribution, existing population size, and the threats operating on the species (Khela 2014). A study in the Subansiri area of the eastern Himalayas over 4.88 ha counted 14 individuals (Behera et al 2002) of the species. However, in Meghalaya, although there were reports of the species from Khasi (Barapani) and Garo hills, the species could not be collected from the state during the past 100 years. The last collection of the species was in 1916 from Barapani by U. Kanjilal (200 ASSAM).

The population of *M. rabaniana* has been continuously declining over the past few decades as a result of deforestation, forest fragmentation, shifting cultivation, and agricultural expansion in the region (Khela 2014). It has been assessed as “regionally extinct” in Meghalaya by the Forest and Environment Department, Government of Meghalaya, signifying that it may have reduced its range of occurrence in the state (FED 2016). The species has been classified as “data deficient” by the International Union for Conservation of Nature (Khela 2014). Haridasan and Rao (1985) classified it under the “rare” category. So far, there are no conservation measures for the species (Khela 2014). While carrying out floristic studies in Khasi hills, one of the species was identified as *M. rabaniana*. The identity of the species was confirmed by comparing with the herbarium specimens housed at the Botanical Survey of India, Eastern Regional Centre, Shillong (ASSAM). It was a recollection after a lapse of almost 100 years from the state. Therefore, a detailed study was conducted with the following objectives: (1) to

* Corresponding author. Tel.: +(91) 9436119857.
E-mail address: upkri@yahoo.com (K. Upadhaya).
Peer review under responsibility of National Science Museum of Korea (NSMK) and Korea National Arboretum (KNA).

http://dx.doi.org/10.1016/j.japb.2016.10.004
pISSN2287-884X eISSN2287-9544

assess the distribution of the species in Meghalaya; (2) to estimate the population structure and regeneration status; (3) to study the phenological pattern of the species; (4) to examine the threat operating on the species; and (5) to suggest measures for its conservation.

Materials and methods

Study sites

Extensive field surveys were carried out in different parts of the state during January 2014 to May 2016 to locate the species with the help of available literature, herbarium information, and local people. The species could be collected from five sites including, Mawsmai (25°14.355' N; 91°43.841' E, alt 1112 m asl), Cherrapunjee-Nongthymmai (25°14.777' N; 91°43.998' E, alt 1131 m asl), Mawkyrwat (25°25.106' N; 91°25.908' E, alt 1590 m asl), Sangriang (25°14.355' N; 91°43.841' E, alt 1112 m asl), and Laikynsew (25°13.138' N; 91°40.385' E, alt 901 m asl), hereafter referred to as Site I, Site II, Site III, Site IV, and Site V, respectively.

Study species

M. rabaniana is a tall tree with a height of 20–25 m and with a dense crown. Young parts fugaciously tawny-tomentose. Bark dark gray in color and 1.27–1.77 cm thick. Leaves alternately arranged, elliptic or oblanceolate, shortly acuminate at apex, gradually attenuate to the base and measure 15–50 cm × 4–12 cm. Petioles ca 2.5 cm long and leaf blade coriaceous, glabrous, dark green, and shiny above, light green underneath, midrib stout, lateral nerves 12–24 pairs nearly straight, reticulation fine and close, very distinct underneath. Flowers terminal and solitary, white, pedicels ca 2.5 cm long and 1.2 cm thick. Bracts densely adpressed tomentose. Sepals three, suborbicular, rough outside, caducous. Petals nine, in three whorls, broadly elliptic obovate, outer whorl reflexed, inner ones concave, smaller. Stamens numerous, filaments short, anthers oblong, ca 1.5 cm long. Gynoecium sessile, carpels ca 20. Fruiting carpels woody, dehiscent by ventral suture, axis woody, pits rhomboidal, and shallow.

Specimen examined

India: Meghalaya: Cherrapunjee, East Khasi Hills, 19 March 2015, A. H. Mir 88685 (ASSAM); 2nd mile sanitarium hall, Garo hills, 15 March 1915, U. Kanjilal 197 (ASSAM); Haflong, N.C. Hilss, 17 January 1915, U. Kanjilal 198 (ASSAM); Barapani, Khasi Hills, 20 March 1916, U. Kanjilal 200 (ASSAM).

Field survey and data analysis

The forests where the species occurred were thoroughly surveyed. Based on the presence of the species a plot of 20 m × 20 m was laid to enumerate the species and its associates. The species occurred in two, four, three, seven, and 12 plots at Site I, Site II, Site III, Site IV, and Site V, respectively. The population structure and regeneration status of the species was studied by classifying the species into: (1) adult individuals (≥ 5 cm diameter at breast height: dbh) measured at 1.37 m from the ground level); and (2) regenerating individuals that include saplings (< 5 cm dbh and > 1 m height) and seedlings (< 1 m height). The adult individuals were assigned to four diameter at breast height (dbh) classes (5–15 cm, 16–25 cm, 26–35 cm, and > 35 cm) to analyze the population structure. Regeneration status of the species was assessed based on the density of seedling, sapling, and adult (Sukumar et al 1992). To record the phenological events such as leaf flush, leaf fall, flowering, and fruiting, 10 mature individuals were marked with aluminum tags and observations were made for a period of 2 years (from January 2014 to December 2015).

For each site, the disturbance index was computed following Mir et al (2016) with modifications. A score of 0–10 was assigned to each disturbance factor viz., extraction of timber, fuel wood, non-timber forest products (NTFPs) collection, encroachment of forest land for agriculture, grazing, building roads, and fire. Depending on the intensity of the disturbance, a score of 0 was considered to be negligible, 1 as low, 5 as intermediate, and 10 as high. All the scores were summed up to get the total disturbance score. The forest having all the disturbances at the highest degree will have a total score of 70.

Results and discussion

Distribution and site characteristics

The Mawsmai forest patch (Site I) was a highly disturbed site and represents subtropical broad leaved forest. The dominant species in the forest include *Syzygium cuneatum* (Duthie) Balak., *Ligustrum robustum* (Roxb.) Bl., *Litsea elongata* (Nees) Hk.f., *Ilex excelsa* Hk.f., and *Camellia cauduca* Cl. ex Brandis. The forest patches at Cherrapunjee- Nongthymmai (Site II) which symbolized the sacred forests, was also degraded and the dominant species include *Engelhardtia spicata* Leschn. ex Bl., *Cinnamomum tamala* Fr. Nees, *Lithocarpus dealbatus* (Hk.f. & Th. ex Miq.) Rehder and *Castanopsis tribuloides* (Sm.) DC. Site III at Mawkyrwat was also highly disturbed, represented by mixed pine forest, and dominated by *Schima khasiana* Dyer., *Schima wallichii* (DC.) Korth, *Rhus acuminate* DC., and *Litsea citrate* Blume. Site IV at Sangriang and Site V at Laikynsew representing sacred forests were least disturbed. These sites were dominated by *C. tribuloides*, *Helicia nilagirica* Bedd., *Dysoxylum gobara* (Buch.-Ham.) Merr., *Eriobotrya bengalensis* Hk.f. *Ostodes paniculata* Blume, and *Alseodaphne khasyana* (Meisn.) Kosterm. In terms of disturbance index, the sites can be arranged in the order: Site IV < Site V < Site II < Site I = Site III (Table 1).

Population structure and regeneration status

There was a variation in the total population of *M. rabaniana* between the sites. Site V had highest population (26 individuals) including seedling, sapling, and adult trees. This was followed by Site IV (19), Site II (10), and Site I and Site III (5 individuals each). The greater number of individuals at Site V and Site IV may be attributed to favorable habitat and least disturbances in comparison to other forests. Of all the sites, Site V had the highest population of adult individuals (14), followed by Site IV (10), Site II (6), Site III (5), and Site I (3).

The density-diameter distribution of the species depicted that the number of individuals were highest in the smallest diameter class (5–15 cm), which sharply declined with the increase in the diameter class (Figure 1). Although literature states that individuals of the species have diameters of approximately 60 cm (IBP 2016), during the present study the highest diameter recorded was 40 cm. The low density of the species in greater diameter classes could be attributed to selective felling of bigger trees. Similar results have been observed in the case of *Magnolia lanuginosa* (Wall.) Figlar & Noot, a rare tree species of northeast India (Mir et al 2016) and *Alphonsea sclerocarpa* Thwaites, an endemic plant species of Eastern Ghats (Kadaval and Parthasarathy 2001).

The age structures of the population based on the density of seedling, sapling, and adult individuals varied between the sites. The highest seedling density (7 individuals) was recorded at Site V, followed by five individuals at Site IV and one individual each at

Table 1. Site characteristics and population of *Magnolia rabaniana*.

Site	Forest type	Number of individuals			Disturbances	Disturbance index
		Seedling	Sapling	Adult		
I	Broad leaved forest	1	1	3	Timber extraction, fuel wood harvesting, NTFP collection, clearing forest land for agriculture, grazing, building roads, & fire	55
II	Broad leaved forest	1	3	6	Timber extraction, fuel wood harvesting, NTFP collection, grazing, building roads, & fire	40
III	Mixed pine forest	0	0	5	Timber extraction, fuel wood harvesting, NTFP collection, clearing forest land for agriculture, grazing, building roads, & fire	55
IV	Broad leaved forest	5	4	10	Fuel wood harvesting, grazing, & building roads	15
V	Broad leaved forest	7	5	14	Timber extraction, fuel wood harvesting, NTFP collection, & building roads	20

NTFP = non-timber forest product.

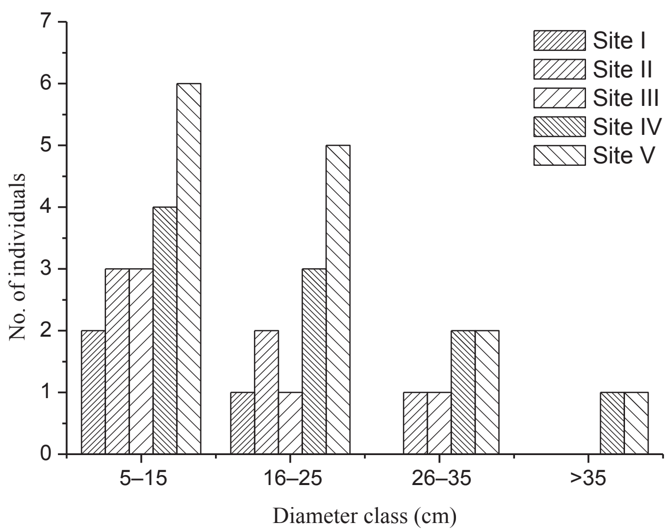

Figure 1. Population structure of *Magnolia rabaniana* at different sites.

Site I and Site II. Similarly, the sapling density was highest at Site V (5 individuals), followed by Site IV (4), Site II (3), and Site I (1). There was a complete absence of seedlings and saplings at Site III (Table 1). Based on the number of seedlings, saplings, and adult trees, the regeneration status was "fair" at Site IV and Site V, "poor" at Site I and Site II, while there was no regeneration at Site III (Table 1). The absence of regenerating individuals in the latter site could be attributed to forest fire.

Phenological patterns

Leaf initiation occurs during the 1st week of March and lasts until the end of April (Figure 2). This period is characterized by the advent of rainfall and an increase in temperature. Leaf fall was observed from January to March, with a peak in February, coinciding with the dry season (Figure 2). The dropping of leaves during the dry season and regaining them during the rainy season is considered as a defense mechanism to tolerate dry weather, as has been observed in the case of *Senegalia senegal* (L.) Britton (Omondi et al 2016).

Flower bud initiates during December and continues until January. Peak flowering was observed in the 1st week of April. The process of flowering relates with the onset of the rainy season and the pollination was mainly done by insects (beetles). Pollination of this family by beetles is considered an important character from an evolutionary viewpoint, because the members of the family evolved during the time when winged insects have not evolved (Rivers et al 2016). Maximum flowering during the spring season coincides with high insect population that acts as pollen vectors (Janzen 1967). Fruit development occurs during the rainy season (from mid-April to May) with follicle initiation that matures in mid-September and continues until the end of November. This timing of fruit initiation during the rainy season is to allow for fruit growth and proper development, since this stage requires a lot of photosynthates (Lieberman 1982). The fruits open for dispersal mainly in the middle of September and follows a zoochoric mode. Rapid underdeveloped fruit fall was observed in May (Figure 3).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Leaf fall	***************											
Leaf initiation			ᴥᴥᴥᴥᴥᴥᴥᴥᴥ									
Flower budding	ΞΞΞ											ΞΞΞ
Flowering			××××××××									
Fruit initiation				¤¤¤¤¤¤¤¤¤¤¤								
Fruit maturation									▫▫▫▫▫▫▫▫▫▫▫▫▫▫▫▫▫▫▫▫▫▫▫			

ᴥᴥᴥ = Leaf initiation; *** = Leaf fall; ΞΞΞ = Flower bud initiation; ××× = Flowering;, ¤¤¤ = Fruit initiation; ▫▫▫▫▫ = Fruit maturation.

Figure 2. Phenological calendar of *Magnolia rabaniana.*

Figure 3. *Magnolia rabaniana*. A, Dormant flower bud; B, Initiating flower bud; C, Flower about to bloom; D, Flower; E, Immature fruit; F, Dehisced mature fruit; G, Aborted flower; H, Twig with aborted fruit; I, Aborted fruits at various growth stages.

Threat status and conservation implications

The major threat to the species is human disturbances, as evidenced by a significant negative correlation between population size and disturbance index ($y = 29.81 - 0.45x$, $R = -0.92$, $n = 5$, $p < 0.02$). The low population of the species could be attributed to repeated disturbance caused by a number of factors including timber and NTFP extraction, agricultural expansion, forest fires, and grazing. All these factors have been identified as the causes of decline in the population of a species (Lin and Cao 2009; Noble and Dirzo 1997). This may lead to extinction of the species in the state. The processes including selective tree felling, extraction of NTFPs, including pole cuttings and fire wood, also interrupt the population structure of a plant species (Cannon et al 1998). The plant is of great economic value, and is a useful wood for making boxes, musical instruments, and yields an excellent commercial timber called “white wood” or “yellow poplar” (Pandey and Misra 2009). This could be the reason for its selective extraction and low density in higher dbh class. Such a disturbance-linked decline in population size of the species has also been observed in *A. sclerocarpa* from Eastern Ghats (Kadaval and Parthasarathy 2001), *Ilex khasiana* Purk. (Upadhaya et al 2009), and *M. lanuginosa* (Mir et al 2016) from Northeast India.

Along with human disturbances, environmental factors also seem to affect the population and regeneration of the species, as the majority of the fruits fall down before reaching maturation stage (Aker 1982). The constant rains soften the pedicle, and make the heavy fruits vulnerable to gushes of wind, which then fall easily. Several workers have suggested lack of successful pollination as a major cause of fruit abortions (Gross and Werner 1983; Kikuzawa and Mizui 1990). In addition, uncertainties in florivores and predation mechanisms also determine the rates of fruit development (Bawa and WebbFlower 1984).

Conclusion

It may be concluded that the species is under sever threat due to a number of human activities and warrants urgent conservation initiatives to prevent it from extinction in the state. The habitat of the species needs to be strictly protected and the population to be monitored. Forest fires, illegal timber extraction, and agricultural expansion, which are rapidly contributing to the forest degradation and fragmentation, need to be checked in and around the population of this species. In order to reduce the pressure on the species, local people should be encouraged to grow the species in their home gardens and agroforestry. Moreover, the species needs to be brought under *in situ* and *ex situ* conservation programs. Such studies would contribute to the Global Strategy for Plant Conservation goals and assist biologists, conservationists, and land managers in monitoring and protecting the species from extinction.

Conflicts of interest

The authors confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

Acknowledgments

The authors are thankful to the State Forest Department, Government of Meghalaya (No. MFD/ThFC/2012–13/8289), and the Ministry of Environment, Forests and Climate Change, Government of India (No. 14/25/2011–ERS/RE) for financial assistance. We are also thankful to the Botanical Survey of India, Eastern Circle, Shillong, India for permission to consult the herbaria. The help and cooperation received from the Headmen and local people during the study is also acknowledged.

References

Aker CL. 1982. Regulation of flower, fruit and seed production by a monocarpic perennial, Yucca whipplei. *Journal of Ecology* 70:357–372.
Balakrishnan NP. 1981. *Flora of Jowai*, Vol. 1. Howrah, India: Botanical Survey of India. pp. 1–305.
Bawa KS, WebbFlower CJ. 1984. Fruit and seed abortion in tropical forest trees: implications for the evolution of paternal and maternal reproductive patterns. *American Journal of Botany* 71:736–751.
Behera MD, Kushwaha SPS, Roy PS, Srivastava S, Singh TP, Dubey RC. 2002. Comparing structure and composition of coniferous forests in Subansiri district, Arunachal Pradesh. *Current Science* 82:70–76.
Cannon CH, Peart DR, Leighton M. 1998. Tree species diversity in commercially logged Bornean rainforest. *Science* 281:1366–1368.
Cicuzza D, Newton A, Oldfield S. 2007. *The Red List of Magnoliaceae*. Cambridge, UK: Lavenham Press.
FED (Forest and Environment Department). 2016. *General Description of Meghalaya. Forest and Environment Department Government of Meghalaya*. Available at: http://megforest.gov.in [Date accessed: 2 March 2016].
Gross RS, Werner PA. 1983. Relationships among flowering phenology, insect visitors, and seed set of individuals: experimental studies on four co-occurring species of goldenrod (Solidago: Compositae). *Ecological Monographs* 53:95–117.
Haridasan K, Rao RR. 1985. *Forest Flora of Meghalaya*, Vol I. Dehra Dun: Bishen Singh and Mahendrapal Singh. pp. 1–450.
IBP (India Biodiversity Portal). 2016. *Magnolia rabaniana (Hook.f. & Thomson) D.C.S. Raju & M.P. Nayar*. Available at: http://indiabiodiversity.org/biodiv/species/show/246479 [Date accessed: 3 May 2016].
Janzen DH. 1967. Synchronization of sexual reproduction of trees within dry season in Central America. *Society for the Study of Evolution* 21:620–637.
Kadaval KN, Parthasarathy N. 2001. Population analysis of *Alphonsea sclerocarpa* Thw. (Annonaceae) in the Kalyaran Hills of Eastern Ghats India. *International Journal of Ecology and Environmental Science* 27:51–54.
Khela S. 2014. Magnolia rabaniana. The IUCN Red List of Threatened Species 2014. Available at: http://dx.doi.org/10.2305/IUCN.UK.20141 [Date accessed: 03 May 2016].
Kikuzawa K, Mizui N. 1990. Flowering and fruiting phenology of *Magnolia hypoleuca*. *Plant Species Biology* 5:255–261.
Kundu SR. 2009. A synopsis on distribution and endemism of Magnoliaceaes in Indian Subcontinent. *Thaiszia Journal of Botany* 19:47–60.
Lieberman D. 1982. Seasonality and phenology in a dry tropical forest in Ghana. *Journal of Ecology* 70:791–806.
Lin LX, Cao M. 2009. Edge effects on soil seed banks and understory vegetation in subtropical and tropical forests in Yunnan, SW China. *Forest Ecology and Management* 257:1344–1352.
Mabberley DJ. 2008. *Mabberley's plant-book: a portable dictionary of the vascular plants: their classification and uses: utilizing Kubitzki's the families and genera of vascular plants*. 3rd revised ed. Cambridge, UK: Cambridge University Press.
Mir AH, Iralu V, Pao NT, Chaudhury G, Khonglah CG, Chaudhary KL, Tiwari BK, Upadhaya K. 2016. *Magnolia lanuginosa* (Wall.) Figlar & Noot. in West Khasi Hills of Meghalaya, northeastern India: Re-collection and implications for conservation. *Journal of Threatened Taxa* 8:8398–8402.
Noble IR, Dirzo R. 1997. Forests as human-dominated ecosystems. *Science* 277:522–525.
Omondi SF, Odee DW, Ongamo GO, James I, Kanya I, Khasa DP. 2016. Synchrony in leafing, flowering, and fruiting phenology of *Senegalia senegal* within Lake Baringo woodland, Kenya: Implication for conservation and tree improvement. *International Journal of Forestry Research* 2016:1–11.
Pandey SN, Misra SP. 2009. *Taxonomy of Angiosperms*. New Delhi: Ane Books Pvt. Ltd. pp. 341–342.
Rivers M, Beech E, Murphy L, Oldfield S. 2016. *The Red List of Magnoliaceae - revised and extended*. Richmond, UK: BGCI.
Sukumar R, Dattaraja HS, Suresh HS, Radhakrishnan J, Vasudeva R, Nirmala S, Joshi NV. 1992. Long-term monitoring of vegetation in a tropical deciduous forest in Mudumalai, Southern India. *Current Science* 62:608–616.
Upadhaya K, Barik SK, Adhikari D, Baishya R, Lakadong NJ. 2009. Regeneration ecology and population status of a critically endangered and endemic tree species (*Ilex khasiana* Purk.) in north-eastern India. *Journal of Forestry Research* 20:223–228.