ECOLOGICAL FEATURES OF CULTIVATED STANDS OF AQUILARIA MALACCENSIS LAM. (THYMELAEACEAE), A VULNERABLE TROPICAL TREE SPECIES IN ASSAMESE HOMEGARDENS

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Abstract

Research was conducted in twenty-seven selected villages located in some of the districts of upper Assam, northeast India, for population estimation, quantitative ecological analysis, and evaluation of Aquilaria malaccensis (Thymelaeaceae). Vegetation sampling was done by quadrat method and A. malaccensis is the most dominant tree species in all twenty-seven different study sites of upper Assam contributing 10–54% of the total tree density with a mean of . Density of the species varied from 6,236 individuals ha−1 to 429 individuals ha−1 with a mean of 1,609 individuals , whereas frequency of occurrence is very high ranging from 93% to 100% with a mean of in different study sites. Distribution of A. malaccensis is found contagious in all twenty-six study sites on the basis of abundance to frequency ratio except in KBG, Golaghat, where its distribution is random with 0.04 abundance to frequency ratio. The widespread cultivation of A. malaccensis in upper Assam, northeast India, offers a potential ex situ reservoir for the future conservation and management of this threatened tree.

1. Introduction

Aquilaria malaccensis (Thymelaeaceae), locally known as “Sanchi” or “Agaru” in Assamese, is an evergreen tropical forest tree highly priced for its resin or agarwood. The species is valued in many cultures for centuries because of its distinctive fragrance and used extensively in incense, perfume, and traditional medicine. Natural populations of Agaru are distributed in south and southeast Asia and in India; it occurs mostly in foothills of northeastern region (Assam, Arunachal Pradesh, Nagaland, Meghalaya, Mizoram, Manipur, and Tripura) as well as West Bengal [1]. However, large scale harvesting of the species from natural population caused rapid depletion in the wild and is listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1994 [2]. The species is “vulnerable” globally according to the current IUCN red list [3]. On the other hand, Agaru is extensively cultivated in homegardens of upper Assam and contributes significantly up to 20% of the total annual income of the family with a mean of to the economy of the local people [4]. A good population stock of Agaru with highest density and frequency in homegardens of upper Assam was also reported by Saikia et al. [5]. Two distinct morphs of Agaru (Bhola Sanchi and Jati Sanchi) are cultivated in homegardens of upper Assam with different life form characteristics [6]. Bhola Sanchi is fast growing and less agarwood yielding than the other variant Jati Sanchi which is slow growing but high agarwood yielding and preferred for commercial cultivation. Nath and Saikia [7] also reported similar variations among the population of Agaru growing in homegarden and they identified three “races” from different areas of Assam. According to them, “variant I (RRLJ 2729)” is a medium sized tree with slender trunk, oblong-lanceolate leaves known as Bhola Sanchi; “variant II (RRLJ 2726)” is a large sized tree with obovate lanceolate leaves known as Sanchi; “variant III (RRLJ 2730)” is a much branched small to medium sized tree with lanceolate leaves known as Jati Sanchi.

Quantitative inventories help in identifying species that are in different stages of vulnerability as well as various factors that influence the existing vegetation in any region [8, 9]. Considering the scarcity of information on Agaru cultivation in homegardens of upper Assam, we attempted to study the ecological features, mainly, the quantitative characteristics of A. malaccensis Lam. in homegardens of upper Assam, northeast India.

2. Materials and Methods

2.1. Study Sites

The study was conducted in twenty-seven selected villages located in Jorhat and Golaghat districts of upper Assam, northeast India (25°48′ to 27°10′N and 93°17′ to 94°36′E) (Figure 1). The site is surrounded by Sibsagar and Dibrugarh districts on the east, Nagaon and Karbi Anglong districts on the west, Lakhimpur and Sonitpur districts on the north, and the bordering state of Nagaland on the south. The total numbers of villages of Jorhat and Golaghat districts are 855 and 1089 with population density of 354 and 236 individuals per square kilometer, respectively [10]. The climate of the study area is classified as tropical type having distinct hot and humid summer (34.0°C during June-July) and cool winter (10.0°C during December-January). The mean annual rainfall of Golaghat and Jorhat districts ranges between 1200 mm and 1900 mm. The relative humidity remains very high throughout the year [11].

2.2. Vegetation Analysis

A total of twenty-seven different sites (16 from Golaghat and 11 from Jorhat district) of Jorhat and Golaghat districts of upper Assam, northeast India, were selected randomly from the pool of Agaru cultivating areas based on informal knowledge which roughly represented about 30% of all Agaru growing areas in the site. A total of 135 homegardens (with a mean of 5 homegardens per site) were selected randomly and studied during 2007–2010 (Table 1). Vegetation was studied using quadrat method covering a minimum of 30% of the area in each homegarden. Random quadrats of 10 m × 10 m size were used for trees and, within the same 10 m × 10 m quadrat, one 5 m × 5 m quadrat for shrubs and two 1 m × 1 m quadrats for herbs were used in the studied homegardens. Diameter at breast height (DBH) of all the individual trees was recorded during the study at 1.37 m above ground. Plant species were identified on the basis of vernacular names, published field inventories, floras, and consulting available herbaria of the region. Herbarium specimens were collected and deposited in the Department of Forestry, North Eastern Regional Institute of Science and Technology (Deemed University), Arunachal Pradesh.

2.3. Data Analysis

Quantitative analysis of vegetation was done following Misra [12]. Importance value index (IVI) was computed by summing up relative density, relative frequency, and relative dominance. The species richness was calculated by using the method “Margalef’s index of richness” (Dmg) [13]: where = total number of species and = total number of individuals.

- The Shannon-Wiener Diversity Index [14] was calculated from the IVI values using the formula given by Magurran [13]: where is the proportion of the IVI of th species and the IVI of all the species.

- Concentration of dominance was assessed by Simpson's Index [15]: where is the same as for the Shannon-Wiener information function.
- Evenness index was calculated from Shannon-Wiener Diversity Index using the formula where is Shannon-Wiener Diversity Index and (where = total number of species).
- Srensen's similarity index was calculated using the formula given by Sorenson [16]: where is the number of species common to two sites, is the total number of species in site , and is the total number of species in site .
- The ratio of abundance to frequency was used to interpret the distribution pattern of the species [17]. The ratio of abundance to frequency indicates regular distribution if below 0.025, random distribution if between 0.025 and 0.05, and contagious distribution if >0.05
- Statistical analysis (Standard error and -test) has been done using statistical software like MS-Excel and ORIGIN.

3. Results

3.1. Ecological Features of A. malaccensis

A. malaccensis is the most dominant tree species in twenty-seven different study sites of upper Assam contributing 10–54% of total tree density with a mean of . Density of the species varied from 429 individuals ha−1 to 6,236 individuals ha−1 with a mean of 1,609 individuals . Areca catechu L. is the most dominant tree associate in twenty-six different study sites, whereas Mesua ferrea L. was the most dominant tree associate in BMG, Jorhat (Table 1). Similarly, A. malaccensis is the most frequent species followed by A. catechu and Bambusa pallida L. and frequency of occurrence of A. malaccensis ranged from 93% to 100% with a mean of in different study sites. 100% frequency was recorded at most of the study sites including BS, BMG, DG, DK, ETG, HK, HCG, JTG, KWG, KNG, KG, KBG, NG, NMG, PS, PFG, SMG, and SNG. Total basal cover was the highest (1.25 cm2 ha−1) in NG, Jorhat, and the lowest (0.34 cm2 ha−1) in JN, Golaghat. Among different sites, IVI of A. malaccensis ranged between 17.94 and 72.63 with a mean of . On the other hand, abundance of the species in different study sites ranged from 4 to 62 with a mean of and it was the highest in NMG, Golaghat, and the lowest in KBG, Golaghat. Distribution of A. malaccensis is found contagious in all twenty-six study sites on the basis of abundance to frequency ratio except in KBG, Golaghat, where its distribution is random.

A total of 323 plant species belonging to 241 genera under 95 families consisting of 106 (33%) herbs, 61 (19%) shrubs, and 156 (48%) trees were recorded from twenty-seven study sites of upper Assam (Table 5). Although the number of documented trees was higher than that of herbs and shrubs, differences were not statistically significant. Overall data showed that family Euphorbiaceae had the highest number of species (15) followed by Moraceae (13) and Poaceae (12). Species richness was very high at all study sites ranging from 63 to 188 species with a mean of , but the highest richness was recorded from GG, Jorhat, and the lowest from BMG, Jorhat (Table 3). A high variability in density of plant species was also noticed in different study sites. Tree density was the highest in NMG, Golaghat (13,418 individuals ha−1), and the lowest in BMG, Jorhat (1,400 individuals ha−1). On the other hand, basal area of tree species was the highest in SMG, Golaghat (4.40 m2 ha−1), and the lowest in NG, Jorhat (0.54 m2 ha−1).

Peak richness index of tree species of 10.54 was recorded in KWG, Golaghat, whereas it was the lowest in DG, Jorhat (3.53). Concentration of dominance (Simpson's Index) and diversity (Shannon-Wiener Diversity Index) of tree species were showing reverse trend in study sites. Concentration of dominance (Simpson's Index) of tree species was the highest in DG, Jorhat (0.12), and the lowest in KBG, Golaghat (0.03); on the other hand, the highest diversity of tree species (Shannon-Wiener Diversity Index) was found in KBG, Golaghat (3.78,) and it was the lowest in DG, Jorhat (2.52). However, species evenness index of tree species ranged from 0.77 to 0.93 with a mean of and it was peak in KBG, Golaghat, and the lowest in KNG, Golaghat. Sørensen's similarity indices showed a high degree of similarity with a range from 34.25% to 75.38% among different study sites (Table 4).

4. Discussion

Floristic inventory, survey, and diversity studies help us to understand the species composition and diversity status of any community [19]. A. malaccensis is one of the most dominant tree species in study sites of upper Assam representing 10–54% of the total tree density (with a mean of) showing a trend towards monoculture. In general, monoculture has a great impact on species diversity. Introduction of rubber (Hevea brasiliensis) into homegardens resulted in a reduction of species diversity in homegardens of Kerela [20]. But this is not evident in the present study and may be due to the fact that owners tried to produce all the possible species of common household utilities in their homegarden itself.

Density of a species provides an index to competition between individuals of the species. Higher densities can cause greater competitive stresses, leading to poor growth and lower reproductive capacity. We recorded A. malaccensis with high density (429 to 6,236 individuals ha^{-1} with a mean of 1,609 individuals), frequency (93% to 100% with a mean of), and abundance (4 to 62 with a mean of). One potential explanation of higher density, frequency, and abundance could be extensive cultivation of the species in study sites because of its high commercial value. Total basal cover of trees (>3.18 cm DBH) is very low and ranged from 0.34 cm^2 ha^{-1} to 1.25 cm^2 ha^{-1} with a mean of 0.67 cm^2 , may be because of the highest density of lower diameter class individuals of A. malaccensis. Importance value index (IVI) of the species represents the ecological success of any species in a community and it gives an excellent idea about varying environmental factors [21]. It provides a complete picture of sociological structure of a species, because the frequency provides information about the dispersal of a species in an area, density gives numerical strength of the species, and dominance represents the basal area. In almost all study sites, the highest IVI is contributed by A. malaccensis which is ranged from 17.94 to 72.63 with a mean of . Dispersal limitation is an important ecological factor for controlling species distribution pattern [22]. Contagious distribution has been accepted as a characteristic pattern of plant occurrence in nature [23] and it is an indication of clusteredness. Contagious distribution of A. malaccensis is found in all study sites except in KBG, Golaghat, where its distribution is random with abundance to frequency ratio of 0.04. Contagious distribution of all the species irrespective of their habit in homegardens of northeast India is also reported by Sahoo et al. [24].

Ecological and socioeconomic factors including geographic location, climate, water availability, garden size and history, agricultural policy, market needs, food culture, and household preferences influence the species diversity of traditional homegardens [25–27]. Needs and interest of homegarden owners may also play a vital role in regulating floristic compositions of homegardens apart from edaphic, cultural, and socioeconomic factors [5]. Species richness provides an easily comprehensible expression of diversity which is affected by long term factors like community stability and evolutionary time as the heterogeneity of micro- and macroenvironments impact on the diversification of different communities [28]. Our investigation recorded 323 plant species (156 trees, 61 shrubs, and 106 herbs) indicating a high species richness of the study site. It is much higher than the earlier reports from Assam [29] as well as other parts of the world [30, 31]. This may be due to the diverse cultural practices of the region and prevailing microclimatic conditions which provide suitable growing conditions for different plant species. Constituent of high floristic diversity is perhaps the potential of homegardens to serve as repositories of genetic diversity [5]. Very high species richness at all study sites is recorded in the present study ranging from 63 to 188 species with a mean of which is much higher than the earlier report from other parts of the world [25, 32]. Although tree density (1,400 to 13,418 individuals ha−1) in different study sites was much higher than the recorded tree density in homegardens of other parts of India [29, 31], the basal cover of tree species (0.54 to 4.40 m2 ha−1) was much lesser than earlier report from Assam [29]. This may be due to the dominance of narrow range diameter class species in the study sites of upper Assam, northeast India.

Higher species richness indices (3.53 to 10.54) and species evenness indices (0.77 to 0.93) represent the floristic richness of all the study sites of upper Assam, northeast India. Shannon-Wiener diversity index is generally high for tropical forests of Indian subcontinent and ranged from 0.81 to 4.1 [33–36]. Shannon-Wiener diversity indices ranging from 2.52 to 3.78 represent the same structure of study sites of upper Assam and tropical forests of Indian subcontinent. Differences in species diversity between communities generally resulted from variations in site specificity [37]. Moreover, it is often correlated with rainfall and nutrient status of the site [38]. Although species diversity was high, the high similarity indices (34.25% to 75.38%) among different study sites indicate that floristic composition is characteristically similar in the region, may be because of common cultural interest of household owners. High diversity and low concentration dominance in study sites may be due to different levels of anthropogenic pressure in different sites.

5. Conclusions

The widespread cultivation of A. malaccensis in upper Assam, northeast India, offers a potential ex situ reservoir for the future conservation and management of this threatened tree. However, genetic diversity of such rare species of forest origin may be affected in managed ecosystems due to limited gene flow, inbreeding, and selection pressure. A thorough investigation of the genetic variation of the A. malaccensis cultivations investigated here is needed before their potential value to the ex situ conservation of this species can be confirmed.

References

- P. Saikia and M. L. Khan, “Agar (Aquilaria malaccensis Lam.): a promising crop in the homegardens of Upper Assam, Northeastern India,” Journal of Tropical Agriculture, vol. 50, pp. 8–14, 2011. View at Scopus
- P. Saikia, B. I. Choudhury, and M. L. Khan, “Floristic composition and plant utilization pattern in homegardens of Upper Assam, India,” Tropical Ecology, vol. 53, no. 1, pp. 105–118, 2012. View at Scopus
- P. Saikia and M. L. Khan, “Aquilaria malaccensis Lam., a Red-listed and highly exploited tree species in the Assamese home garden,” Current Science, vol. 102, no. 4, pp. 546–547, 2012. View at Scopus

- S. C. Nath and N. Saikia, "Indigenous knowledge on utility and utilitarian aspects of Aquilaria malaccensis Lamk. in northeast India," Indian Journal of Traditional Knowledge, vol. 1, no. 1, pp. 47–58, 2002.
- N. Parthasarathy, "Tree diversity and distribution in undisturbed and human-impacted sites of tropical wet evergreen forest in southern Western Ghats, India," Biodiversity and Conservation, vol. 8, no. 10, pp. 1365–1381, 1999. View at Publisher · View at Google Scholar · View at Scopus
- H. Padalia, N. Chauhan, M. C. Porwal, and P. S. Roy, "Phytosociological observations on tree species diversity of Andaman Islands, India," Current Science, vol. 87, no. 6, pp. 799–806, 2004. View at Scopus
- Census of India, Census Report, Ministry of Home Affairs, Government of India, 2001.
- P. Saikia, Population structure and conservation practices of Aquilaria malaccensis Lam. in homegardens of upper Assam and its prospects in socio-economic development [Ph.D. thesis], Department of Forestry, NERIST (Deemed University), Arunachal Pradesh, India, 2011.
- R. Misra, Ecology Workbook, Oxford & IBH Publishing Company, Calcutta, India, 1968.
- F. Magurran, Ecological Diversity and Its Measurement, Princeton University Press, Princeton, NJ, USA, 1988.
- E. Shannon and W. Wiener, The Mathematical Theory of Communities, University of Illinois Press, Urbana, Ill, USA, 1963.
- E. H. Simpson, "Measurement of diversity," Nature, vol. 163, article 688, 1949. View at Publisher · View at Google Scholar · View at Scopus.

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