Hindawi Publishing Corporation
International Journal of Forestry Research
Volume 2014, Article ID 140926, 16 pages
http://dx.doi.org/10.1155/2014/140926

Research Article

Ecological Features of Cultivated Stands of *Aquilaria malaccensis* Lam. (Thymelaeaceae), a Vulnerable Tropical Tree Species in Assamese Homegardens

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Received 10 February 2014; Accepted 22 June 2014; Published 8 July 2014

Academic Editor: Sunil Nautiyal

Research was conducted in twenty-seven selected villages located in Jorhat and Golaghat 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 34% ± 2. Density of the species varied from 6,236 individuals ha^{-1} to 429 individuals ha^{-1} with a mean of 1,609 individuals ha^{-1} ± 217, whereas frequency of occurrence is very high ranging from 93% to 100% with a mean of 98% ± 0.53 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 4% ± 0.46 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]:

$$\text{Dmg} = \frac{(S-1)}{\ln n}, \tag{1}$$

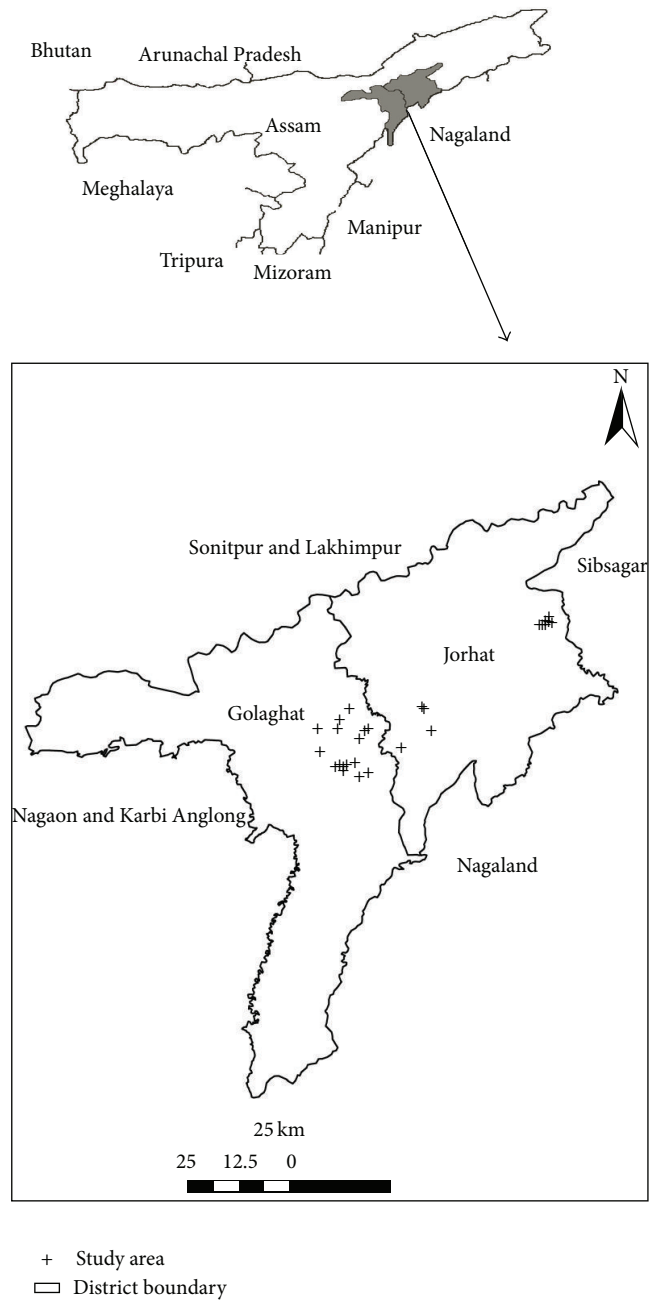

Figure 1: Map of Golaghat and Jorhat districts of upper Assam, NE India, showing the locations of the study sites.

where S = total number of species and n = total number of individuals.

The Shannon-Wiener Diversity Index [14] was calculated from the IVI values using the formula given by Magurran [13]:

$$H = -\sum_{i=1}^{s} p_i \ln p_i, \tag{2}$$

where p_i is the proportion of the IVI of ith species and the IVI of all the species (n_i/N).

Table 1: Number of studied homegardens and their mean size and number of associated species and dominant tree associate of different studied villages.

Study sites (villages)	HG studied (number)	Mean HG area in ha (±SE)	Associated species (numbers)	Dominant tree associate
Buralikson (BS)	2	0.17 ± 0.04	63	*Areca catechu* L.
Bhumuraguri Missing Gaon (BMG)	2	0.13 ± 0.00	62	*Mesua ferrea* L.
Doloigaon (DG)	2	0.11 ± 0.02	70	*Areca catechu* L.
Dulakhariya (DK)	2	0.16 ± 0.11	74	*Areca catechu* L.
Elengi Thekela Gaon (ETG)	5	0.24 ± 0.03	140	*Areca catechu* L.
Ganakpukhuri (GP)	5	0.16 ± 0.03	99	*Areca catechu* L.
Gayan Gaon (GG)	17	0.17 ± 0.02	187	*Areca catechu* L.
Habungia Bamun Gaon (HBG)	6	0.15 ± 0.04	117	*Areca catechu* L.
Hatiyekhuwa (HK)	2	0.09 ± 0.01	68	*Areca catechu* L.
Hensowa Chengkola Gaon (HCG)	4	0.23 ± 0.06	163	*Areca catechu* L.
Jalukonibari Thengal Gaon (JTG)	6	0.21 ± 0.03	138	*Areca catechu* L.
Junakinagar (JN)	5	0.13 ± 0.04	110	*Areca catechu* L.
Kabarugaon (KWG)	14	0.16 ± 0.01	168	*Areca catechu* L.
Kakati Gaon (KG)	4	0.15 ± 0.03	95	*Areca catechu* L.
Kamarbandha Bamun Gaon (KBG)	8	0.22 ± 0.02	159	*Areca catechu* L.
Kamarbandha Namsonia Gaon (KNG)	8	0.17 ± 0.02	135	*Areca catechu* L.
Khumtai (KH)	3	0.18 ± 0.02	120	*Areca catechu* L.
Konhar Gaon (KHG)	2	0.23 ± 0.04	67	*Areca catechu* L.
Natun Gaon (NG)	3	0.11 ± 0.01	91	*Areca catechu* L.
Naharani Maj Gaon (NMG)	2	0.17 ± 0.10	85	*Areca catechu* L.
Pohusora (PS)	4	0.12 ± 0.01	115	*Areca catechu* L.
Pulibor (PB)	8	0.21 ± 0.02	138	*Areca catechu* L.
Puronimati Fatagaon (PFG)	2	0.22 ± 0.01	90	*Areca catechu* L.
Sapani (SP)	3	0.16 ± 0.02	108	*Areca catechu* L.
Sialekhati (SK)	3	0.18 ± 0.02	85	*Areca catechu* L.
Sumoni Gaon (SMG)	9	0.21 ± 0.03	163	*Areca catechu* L.
Sunari Gaon (SNG)	4	0.09 ± 0.02	106	*Areca catechu* L.

Concentration of dominance was assessed by Simpson's Index [15]:

$$\mathrm{CD} = \sum_{i=1}^{s} (p_i)^2, \tag{3}$$

where p_i is the same as for the Shannon-Wiener information function.

Evenness index was calculated from Shannon-Wiener Diversity Index using the formula

$$E = \frac{H'}{H' \max}, \tag{4}$$

where H' is Shannon-Wiener Diversity Index and H' max = ln S (where S = total number of species).

Sørensen's similarity index was calculated using the formula given by Sorenson [16]:

$$\text{Sørensen's similarity index} = \frac{2C}{A+B} \times 100, \tag{5}$$

where C is the number of species common to two sites, A is the total number of species in site A, and B is the total number of species in site B.

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 [18].

Statistical analysis (Standard error and t-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 34% ± 2. Density of the species varied from 429 individuals ha^{-1} to 6,236 individuals ha^{-1} with a mean of 1,609 individuals ha^{-1} ± 217. *Areca catechu* L. is the most dominant tree associate in twenty-six different study sites,

Table 2: Community characteristics of different study sites of upper Assam, northeast India.

Study sites	Number of families	Number of genera	Species richness	Species richness index	Density (individuals ha^{-1})	Basal area (m^2ha^{-1})	Diversity (Shannon's H')	CD	Evenness index
BS	39	57	64	4.27	4,410	1.08	3.01	0.06	0.91
BMG	39	54	63	5.16	1,400	0.78	2.89	0.09	0.88
DG	43	63	71	3.53	3,100	0.65	2.52	0.12	0.84
DK	41	64	75	4.13	8,000	1.25	2.97	0.07	0.88
ETG	64	113	141	8.22	3,625	2.48	3.37	0.07	0.82
GP	52	85	100	7.72	3,197	1.74	3.44	0.05	0.86
GG	73	150	188	9.49	3,332	2.11	3.58	0.06	0.82
HBG	53	99	118	7.78	3,239	2.14	3.41	0.05	0.86
HK	44	63	69	4.15	6,100	0.76	2.94	0.07	0.91
HCG	67	136	164	8.30	5,341	3.09	3.56	0.05	0.86
JTG	67	122	139	6.86	7,947	2.23	3.37	0.07	0.84
JN	52	96	111	9.39	2,384	0.99	3.62	0.05	0.87
KWG	71	141	169	10.54	4,370	2.29	3.66	0.06	0.82
KG	53	83	96	6.20	3,710	0.93	3.22	0.06	0.86
KBG	64	135	160	7.69	4,133	2.58	3.78	0.03	0.93
KNG	60	116	136	7.60	3,531	3.81	3.10	0.10	0.77
KH	52	103	121	6.47	10,381	1.63	3.26	0.08	0.84
KHG	38	58	68	4.58	4,043	0.59	3.11	0.06	0.92
NG	52	82	92	5.49	4,455	0.54	3.21	0.05	0.90
NMG	52	78	86	5.21	13,418	0.99	3.22	0.07	0.88
PS	58	95	116	5.27	6,200	1.05	3.10	0.08	0.86
PB	67	119	139	9.23	2,731	2.19	3.50	0.07	0.83
PFG	49	82	91	6.10	3,885	1.79	3.27	0.06	0.89
SP	63	97	109	5.62	4,033	2.37	3.07	0.07	0.85
SK	52	79	86	7.14	2,380	0.71	3.28	0.06	0.86
SMG	65	132	164	7.77	5,205	4.40	3.29	0.07	0.79
SNG	59	94	107	5.47	5,577	0.78	3.22	0.06	0.89

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 98% ± 0.53 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 cm^2 ha^{-1}) in NG, Jorhat, and the lowest (0.34 cm^2 ha^{-1}) in JN, Golaghat. Among different sites, IVI of *A. malaccensis* ranged between 17.94 and 72.63 with a mean of 49.36 ± 2.64. On the other hand, abundance of the species in different study sites ranged from 4 to 62 with a mean of 16 ± 2 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 with 0.04 abundance to frequency ratio (Table 2).

3.2. Floristic Composition of Study Sites. 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 113 ± 7, 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 m^2 ha^{-1}), and the lowest in NG, Jorhat (0.54 m^2 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

Table 3: Ecological parameters of different populations of *A. malaccensis* (>3.18 cm DBH).

Study sites	Frequency (%)	Density (individuals ha^{-1})	TBC (cm^2ha^{-1})	Abundance	IVI	Density share (%)	A/F ratio
BS	100	1,140	0.63	11	39.26	25.85	0.11
BMG	100	709	0.64	7	72.63	50.65	0.07
DG	100	1,686	0.65	17	72.45	54.38	0.17
DK	100	3,273	0.93	33	59.12	40.91	0.33
ETG	100	1,792	0.53	18	66.46	49.43	0.18
GP	93	647	0.48	7	34.57	20.23	0.07
GG	97	1,261	0.77	13	55.71	37.85	0.13
HBG	96	896	0.50	9	42.42	27.67	0.10
HK	100	1,700	0.57	17	37.19	27.87	0.17
HCG	100	1,972	0.69	20	50.45	36.92	0.20
JTG	100	1,700	0.57	17	35.07	21.39	0.17
JN	94	858	0.34	9	50.56	35.99	0.10
KWG	100	1,563	0.69	16	52.26	35.77	0.16
KNG	100	1,793	0.70	18	68.41	50.79	0.18
KG	100	965	0.75	10	42.44	26.01	0.10
KBG	100	429	0.64	4	17.94	10.37	0.04
KHG	93	1,121	0.77	12	43.50	27.74	0.13
KH	94	1,756	0.68	19	30.05	16.92	0.20
NG	100	927	1.25	9	35.22	20.82	0.09
NMG	100	6,236	0.40	62	58.46	46.48	0.62
PS	100	3,080	0.61	31	63.78	49.68	0.31
PB	96	1,275	0.72	13	65.47	46.69	0.14
PFG	100	1,254	0.69	13	46.64	32.28	0.13
SP	93	1,467	1.08	16	50.54	36.36	0.17
SK	95	905	0.42	10	55.42	38.03	0.10
SMG	100	1,425	0.78	14	43.02	27.08	0.14
SNG	100	1,623	0.68	16	43.66	29.10	0.16

(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 0.86 ± 0.01 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 34% ± 2) 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 ha^{-1} ± 217), frequency (93% to 100% with a mean of 98% ± 0.53), and abundance (4 to 62 with a mean of 16 ± 2). 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 $cm^2\,ha^{-1}$ ± 0.04, 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

Table 4: Sørensen's similarity index (%) for different study sites of upper Assam, northeast India.

	BS	BMG	DG	DK	ETG	GP	GG	HBG	HK	HCG	JTG	JN	KWG	KNG	KG	KBG	KHG	KH	NG	NMG	PS	PB	PFG	SP	SK	SMG
BS	0.00																									
BMG	47.24	0.00																								
DG	56.3	49.25	0.00																							
DK	41.73	34.78	49.32	0.00																						
ETG	47.80	46.08	53.77	48.15	0.00																					
GP	48.78	49.08	52.63	46.86	57.26	0.00																				
GG	43.65	49.40	49.42	45.63	60.79	75.06	0.00																			
HBG	45.05	34.25	48.68	51.81	61.78	83.87	54.90	0.00																		
HK	52.63	45.45	54.29	45.83	51.43	89.12	44.36	48.13	0.00																	
HCG	44.74	38.77	43.40	46.03	62.95	73.11	60.80	65.25	46.35	0.00																
JTG	51.23	44.55	51.43	43.93	63.57	69.10	67.28	56.03	53.85	66.01	0.00															
JN	50.29	48.28	53.85	47.31	60.32	78.44	55.52	49.78	53.33	54.55	64.80	0.00														
KWG	46.35	44.83	50.00	41.80	69.68	60.00	66.67	57.14	47.90	62.46	66.23	70.00	0.00													
KNG	51.00	44.22	52.17	50.24	64.98	77.31	60.49	66.14	51.71	62.67	65.45	63.97	71.48	0.00												
KG	47.50	55.35	57.49	46.78	59.07	79.20	61.97	52.34	50.91	53.08	55.32	62.80	62.64	60.34	0.00											
KBG	51.79	41.26	49.35	43.40	67.11	64.68	63.79	57.55	54.15	67.90	71.57	61.25	68.09	69.59	57.03	0.00										
KHG	51.52	36.64	74.82	46.15	46.89	98.43	46.09	46.24	45.26	37.93	46.38	45.81	47.26	48.04	51.22	40.35	0.00									
KH	46.49	43.478	56.25	51.02	64.12	79.57	58.25	61.09	61.05	61.75	57.69	60.34	61.38	62.26	56.22	61.92	49.74	0.00								
NG	55.13	54.19	61.35	47.90	57.51	83.30	54.29	54.29	54.66	52.34	58.01	59.11	57.47	58.77	59.57	53.97	51.25	55.40	0.00							
NMG	52.00	41.61	48.41	45.96	47.58	96.61	47.45	51.96	56.77	50.40	51.56	56.85	55.69	50.45	54.95	53.66	44.16	56.04	51.69	0.00						
PS	52.22	39.11	52.41	48.17	60.70	79.35	56.58	58.12	51.89	58.57	61.96	57.27	58.95	58.73	56.60	61.59	48.91	58.23	51.92	47.52	0.00					
PB	49.26	43.56	51.43	44.86	62.86	71.37	61.77	63.81	51.92	66.01	69.78	68.80	70.13	68.36	62.98	66.89	45.41	61.54	55.41	56.89	61.18	0.00				
PFG	54.19	45.45	51.85	48.19	58.62	82.21	54.48	49.76	53.75	47.06	60.87	53.47	58.46	56.39	58.82	55.78	57.86	53.77	57.92	53.11	57.97	55.65	0.00			
SP	49.71	52.33	57.78	44.57	61.60	72.35	62.63	52.86	55.06	56.41	61.29	58.18	61.15	59.59	67.32	62.45	49.72	56.52	61.69	55.38	55.11	61.29	55.00	0.00		
SK	50.67	46.98	48.41	47.20	50.22	94.00	48.91	47.06	55.48	53.60	51.56	65.99	55.69	53.15	58.24	55.28	40.26	50.24	53.93	52.33	49.50	59.56	49.72	58.46	0.00	
SMG	47.37	46.70	50.21	50.21	67.54	74.34	65.91	62.41	50.64	40.24	66.67	61.09	65.47	66.67	53.85	68.52	44.83	67.37	57.81	54.40	61.43	64.69	54.12	58.61	50.40	0.00
SNG	53.80	50.59	59.55	41.76	62.10	67.25	56.27	56.89	59.09	57.56	61.79	62.39	63.77	61.73	64.04	64.42	49.14	57.02	75.38	53.89	55.61	61.79	59.60	66.67	53.89	61.25

Table 5: Density (individuals ha^{-1}), frequency (%), abundance, and IVI of tree (>3.18 cm DBH), shrub, and herb species in studied homegardens of upper Assam, northeast India.

Species	Family	Density (individuals ha^{-1})	Frequency (%)	Abundance	IVI
		Trees			
Acacia auriculiformis Cunn. ex Benth.	Mimosaceae	1.06	0.66	2	1.76
Adenanthera pavonina L.	Mimosaceae	2.38	2.11	1	0.94
Aegle marmelos Corr.	Rutaceae	2.64	2.51	1	1.00
Ailanthus grandis Prain	Simaroubaceae	0.13	0.13	1	0.87
Albizia lebbeck (L.) Benth.	Mimosaceae	2.11	1.32	2	2.30
Albizia lucida (Roxb.) Benth.	Mimosaceae	7.53	5.28	1	1.68
Albizia procera (Roxb.) Benth.	Mimosaceae	0.66	0.66	1	0.68
Alstonia scholaris (L.) R. Br.	Apocynaceae	15.85	11.89	1	2.90
Amoora wallichii King	Meliaceae	0.66	0.53	1	0.42
Anacardium occidentale L.	Anacardiaceae	0.26	0.26	1	0.71
Annona reticulata L.	Annonaceae	1.06	1.06	1	0.39
Anthocephalus chinensis (Lam.) Rich. ex Walp.	Rubiaceae	5.81	4.49	1	2.22
Antidesma ghaesembilla Gaert.	Euphorbiaceae	0.40	0.40	1	0.21
Aquilaria malaccensis Lam.	Thymelaeaceae	1442.67	98.02	15	49.50
Arabongali*		0.26	0.26	1	0.21
Araucaria heterophylla (Salisb.) Franco	Araucariaceae	0.53	0.53	1	0.32
Areca catechu L.	Arecaceae	554.29	74.37	7	24.94
Artocarpus chaplasha Roxb.	Moraceae	2.25	1.59	1	1.46
Artocarpus heterophyllus Lam.	Moraceae	34.87	24.57	1	5.49
Artocarpus lakoocha Roxb.	Moraceae	3.04	2.77	1	1.83
Averrhoa carambola L.	Averrhoaceae	4.49	4.23	1	1.19
Azadirachta indica Juss.	Meliaceae	1.19	1.19	1	0.43
Baccaurea sapida (Roxb.) Mull. Arg.	Euphorbiaceae	1.32	1.19	1	0.36
Bambusa balcooa Roxb.	Poaceae	214.93	3.04	71	5.53
Bambusa nutans G. C. Wall. ex Munro	Poaceae	2.25	0.13	17	0.07
Bambusa pallida Munro.	Poaceae	1157.60	11.23	103	28.96
Bambusa tulda Roxb.	Poaceae	50.99	0.53	97	1.28
Bauhinia purpurea L.	Caesalpiniaceae	0.26	0.26	1	0.46
Beilschmiedia brandisii Hook. f.	Lauraceae	1.45	0.79	2	0.48
Bixa orellana L.	Bixaceae	2.38	1.72	1	0.54
Bombax ceiba L.	Malvaceae	3.83	3.43	1	1.75
Borassus flabellifer L.	Arecaceae	0.13	0.13	1	1.74
Bridelia retusa (L.) A. Juss.	Euphorbiaceae	0.66	0.40	2	0.66
Butea monosperma (Lam.) Taubert	Papilionaceae	0.40	0.26	2	0.95
Callistemon lanceolatus D.C.	Myrtaceae	0.53	0.40	1	0.29
Canarium strictum Roxb.	Burseraceae	0.53	0.53	1	1.07
Carallia lucida Roxb. ex Kurz.	Rhizophoraceae	1.72	1.59	1	0.52
Carica papaya L.	Caricaceae	34.48	18.63	2	3.95
Caryota urens L.	Arecaceae	1.98	1.59	1	1.13
Cassia fistula L.	Caesalpiniaceae	12.15	7.79	2	2.04
Cassia siamea Lam.	Caesalpiniaceae	1.85	1.72	1	0.86
Castanopsis indica (Roxb. ex Lindl.) A. D.C.	Fagaceae	1.19	0.66	2	0.44
Chukrasia tabularis Juss.	Meliaceae	1.06	0.79	1	0.92
Cinnamomum glanduliferum (Wall.) Meisn.	Lauraceae	0.26	0.26	1	1.10
Cinnamomum tamala (Buch.-Ham.) Nees and Eberm.	Lauraceae	5.28	4.36	1	1.05

Table 5: Continued.

Species	Family	Density (individuals ha^{-1})	Frequency (%)	Abundance	IVI
Citrus limon (L.) Burm.f.	Rutaceae	7.79	4.76	2	0.97
Citrus maxima (Merr.)	Rutaceae	10.44	9.25	1	1.91
Citrus medica L.	Rutaceae	0.92	0.53	2	0.13
Citrus reticulata Blanco.	Rutaceae	7.13	4.76	2	0.97
Citrus sinensis (L.) Osbeck	Rutaceae	1.06	0.66	2	0.18
Citrus sp.	Rutaceae	2.38	1.85	1	0.38
Cocos nucifera L.	Arecaceae	25.76	17.83	1	4.38
Cordia grandis Roxb.	Boraginaceae	2.64	2.11	1	0.82
Crataeva nurvala Ham.	Capparidaceae	1.32	1.19	1	0.53
Dalhousiea bracteata (Roxb.) Baker	Papilionaceae	0.13	0.13	1	0.30
Delonix regia (Boj. ex Hook.) Raf.	Caesalpinaceae	2.38	1.85	1	0.87
Dillenia indica L.	Dilleniaceae	0.66	0.66	1	3.00
Diospyros embryopteris Pers.	Ebenaceae	0.53	0.40	1	1.24
Dysoxylum binectariferum (Roxb.) Hook. f. ex Bedd.	Meliaceae	2.64	1.98	1	1.08
Ehretia acuminata R.Br.	Boraginaceae	1.06	1.06	1	0.71
Elaeocarpus floribundus Blume.	Elaeocarpaceae	5.55	5.02	1	1.56
Elaeocarpus ganitrus Roxb.	Elaeocarpaceae	0.13	0.13	1	1.29
Erythrina stricta Roxb.	Papilionaceae	2.51	1.59	2	0.67
Eucalyptus citriodora Hook.	Myrtaceae	0.79	0.79	1	0.95
Eugenia fruticosa Roxb.	Myrtaceae	1.59	1.32	1	0.57
Eugenia jambolana Lam.	Myrtaceae	5.55	4.49	1	1.39
Eugenia jambolana Lam. var. *caryophyllifolia* Duthie.	Myrtaceae	0.40	0.40	1	0.63
Eugenia jambos L.	Myrtaceae	3.04	2.91	1	0.73
Evodia meliaefolia Benth.	Rutaceae	2.77	2.38	1	1.13
Ficus benghalensis L.	Moraceae	0.26	0.26	1	9.66
Ficus cyrtophylla	Moraceae	0.53	0.13	1	0.03
Ficus fistulosa Reinw. ex Blume	Moraceae	0.53	0.53	2	9.66
Ficus hirta Vahl.	Moraceae	1.06	0.13	1	0.04
Ficus hispida L.	Moraceae	5.28	3.96	25	0.89
Ficus racemosa L.	Moraceae	0.40	0.40	3	0.39
Ficus religiosa L.	Moraceae	0.53	0.53	4	6.56
Garcinia lanceaefolia Roxb.	Clusiaceae	0.26	0.26	1	0.43
Garcinia morella (Gaertn.) Desr.	Clusiaceae	1.45	1.06	7	0.44
Garcinia paniculata Roxb.	Clusiaceae	0.26	0.26	2	0.2
Garcinia pedunculata Roxb. Engl.	Clusiaceae	0.79	0.79	6	0.96
Garcinia xanthochymus Hook. f. ex Anderson Engl.	Clusiaceae	0.40	0.40	3	0.39
Gmelina arborea Roxb.	Verbenaceae	10.30	6.87	36	2.02
Grevillea robusta Cunn. ex R.Br.	Proteaceae	1.72	1.32	8	1.37
Heteropanax fragrans (Roxb.) Seem.	Araliaceae	4.76	3.04	11	1.16
Ilex umbellulata (Wall.) Loes.	Aquifoliaceae	1.32	1.19	8	0.38
Lagerstroemia flos reginae Retz.	Lythraceae	6.08	4.89	24	1.53
Litchi chinensis Sonn.	Sapindaceae	6.34	5.55	36	1.43
Litsea elongata Wall.	Lauraceae	0.79	0.53	3	0.32
Litsea monopetala (Roxb.) Pers.	Lauraceae	10.30	8.19	45	2.01
Litsea nitida Hook. f.	Lauraceae	12.29	8.06	37	1.86

Table 5: Continued.

Species	Family	Density (individuals ha^{-1})	Frequency (%)	Abundance	IVI
Litsea sebifera Pers.	Lauraceae	1.19	1.19	7	0.47
Livistona jenkinsiana Griff.	Arecaceae	1.72	1.45	7	1.2
Macaranga peltata (Roxb.) Mueller	Euphorbiaceae	0.13	0.13	1	0.22
Magnolia sphenocarpa Roxb.	Magnoliaceae	4.76	3.17	16	0.99
Mallotus philippinensis Muell. Arg.	Euphorbiaceae	3.57	3.43	24	0.84
Mangifera indica L.	Anacardiaceae	62.48	35.80	115	7.79
Manilkara zapota (L.) van Royen	Sapotaceae	0.13	0.13	1	1.07
Melia azedarach L.	Meliaceae	9.38	7.27	37	1.61
Mesua ferrea L.	Clusiaceae	5.15	3.57	24	1.01
Michelia champaca L.	Magnoliaceae	2.25	1.19	6	0.75
Mimusops elengi L.	Sapotaceae	0.66	0.66	5	1.42
Moringa oleifera Lam.	Moringaceae	4.62	4.10	29	1.15
Morus alba L.	Moraceae	2.25	1.32	9	0.56
Morus laevigata Wall.	Moraceae	0.13	0.13	1	0.2
Murraya koenigii (L.) Sprengel.	Rutaceae	2.38	1.85	12	0.49
Murraya paniculata (L.) Jack	Rutaceae	0.13	0.13	1	0.19
Musa acuminata Colla.	Musaceae	64.33	12.42	57	3.64
Musa balbisiana Colla.	Musaceae	137.38	24.83	92	7.4
Musa calosperma F. Muell.	Musaceae	72.26	14.40	62	4.14
Musa paradisiaca L.	Musaceae	0.53	0.26	2	0.19
Musa sp.	Musaceae	12.42	3.04	17	0.98
Myrica esculenta Buch.-Ham. ex D. Don	Myricaceae	2.64	1.98	12	0.7
Oroxylum indicum (L.) Kurz.	Bignoniaceae	5.02	4.36	24	1.13
Pachylarnax pleiocarpa Dandy	Magnoliaceae	0.92	0.79	5	0.96
Persea bombycina (King ex Hook. f.) Kost.	Lauraceae	3.04	2.25	15	0.86
Phoebe goalparensis Hutch.	Lauraceae	0.13	0.13	1	0.19
Phoenix dactylifera L.	Arecaceae	0.53	0.40	2	1.04
Phyllanthus acidus (L.) Skeels.	Phyllanthaceae	1.06	1.06	8	0.35
Phyllanthus emblica L.	Phyllanthaceae	5.15	5.02	31	1.26
Plumeria rubra L.	Apocynaceae	0.26	0.13	1	0.24
Polyalthia longifolia (Sonn.) Thw.	Annonaceae	6.87	2.64	14	0.76
Pongamia pinnata (L.) Pierre.	Papilionaceae	1.72	1.45	10	0.71
Premna bengalensis Cl.	Verbenaceae	5.55	4.49	25	1.14
Prunus cerasifera Ehrh.	Rosaceae	1.59	1.32	8	0.46
Prunus jenkinsii Hook. f. and Thoms.	Rosaceae	0.53	0.53	3	0.21
Prunus persica (L.) Batsch.	Rosaceae	0.92	0.92	6	0.31
Psidium gujava L.	Myrtaceae	16.64	12.42	63	2.5
Pyrus communis L.	Rosaceae	1.06	0.79	4	0.26
Salix tetrasperma Roxb.	Salicaceae	4.49	2.11	10	0.84
Samanea saman (Jacq.) Merr.	Mimosaceae	0.26	0.26	2	4.03
Sapindus mukorossi Gaertn.	Sapindaceae	1.85	1.72	10	0.64
Sapium baccatum Roxb.	Euphorbiaceae	1.32	1.06	4	0.63
Sapium eugeniaefolium Ham.	Euphorbiaceae	0.53	0.53	4	0.53
Schimawallichii (DC.) Korth.	Theaceae	4.76	2.91	16	1.12
Shorea robusta Gaertn. f.	Dipterocarpaceae	0.13	0.13	1	2.92
Spondias mangifera Wild.	Anacardiaceae	1.19	0.92	7	0.54
Stereospermum chelonoides DC.	Sterculiaceae	0.92	0.66	5	0.38

Table 5: Continued.

Species	Family	Density (individuals ha^{-1})	Frequency (%)	Abundance	IVI
Streblus asper Lour.	Moraceae	3.70	2.11	12	0.73
Symplocos grandiflora Wall.	Symplocaceae	0.13	0.13	1	0.22
Talauma hodgsonii Hook. f. and Thomson	Magnoliaceae	0.13	0.13	1	4.65
Talauma rabaniana Hk.ef. and Th.	Magnoliaceae	0.40	0.40	2	2.06
Tamarindus indica L.	Caesalpiniaceae	0.26	0.26	2	0.43
Tectona grandis L.	Verbenaceae	25.36	9.78	40	2.83
Terminalia arjuna (Roxb. ex DC.) Wight and Arn.	Combretaceae	0.26	0.26	2	0.57
Terminalia bellirica (Gaertn.) Roxb.	Combretaceae	0.13	0.13	1	0.16
Terminalia catappa L.	Combretaceae	0.40	0.40	3	0.89
Terminalia chebula Retz.	Combretaceae	14.66	12.42	64	2.95
Terminalia myriocarpa Van Heurck and Muell. Arg.	Combretaceae	0.26	0.26	2	0.39
Toona ciliata Roem.	Meliaceae	13.87	10.30	45	2.88
Tricalysia singularis (Korth.) K. Schum.	Rubiaceae	0.66	0.40	3	0.66
Vernonia travancorica J. Hk.	Asteraceae	0.13	0.13	1	0.04
Vitex negundo L.	Verbenaceae	0.79	0.79	6	0.4
Walsura robusta Roxb.	Meliaceae	0.40	0.40	3	0.38
Zanthoxylum rhetsa (Roxb.) DC.	Rutaceae	1.19	1.06	8	0.71
Ziziphus mauritiana Lam.	Rhamnaceae	4.62	4.36	27	1.26
Ziziphus sp.	Rhamnaceae	0.13	0.13	1	0.42
		Shrubs			
Acacia farnesiana (L.) Willd.	Mimosaceae	7.40	1.72	1.08	0.41
Adhatoda vasica Nees	Acanthaceae	79.26	4.10	4.84	1.52
Bisalyakarani*		5.28	0.13	10.00	0.07
Bougainvillea spectabilis Wild.	Nyctaginaceae	5.81	1.32	1.10	0.32
Caesalpinia pulcherrima L.	Caesalpiniaceae	2.11	0.53	1.00	0.13
Cajanus cajan (L.) Millsp.	Papilionaceae	28.01	1.72	4.08	0.59
Calamus tenuis Roxb.	Arecaceae	43.33	2.38	4.56	0.86
Callicarpa arborea Roxb.	Verbenaceae	11.10	0.79	3.50	0.26
Calotropis procera (Ait.) Ait. f.	Asclepiadaceae	4.76	0.92	1.29	0.23
Camellia sinensis (L.) O. Kuntze	Theaceae	1958.78	21.14	23.17	21.23
Capsicum annum L.	Solanaceae	67.11	5.42	3.10	1.68
Capsicum annum L. var. *longum*	Solanaceae	86.13	6.74	3.20	2.12
Capsicum chinense Jacq.	Solanaceae	61.29	6.21	2.47	1.80
Cassia alata L.	Caesalpinaceae	11.10	0.92	3.00	0.28
Cassia sophera L.	Caesalpinaceae	5.28	0.79	1.67	0.21
Cassia tora L.	Caesalpinaceae	7.93	0.53	3.75	0.18
Chromolaena odorata (L.) King and H.E. Robins.	Asteraceae	528.40	18.23	7.25	8.28
Clerodendrum colebrookianum Wall.	Verbenaceae	33.82	2.51	3.37	0.80
Clerodendrum japonicum (Thunb.) Sweet	Verbenaceae	22.72	1.85	3.07	0.57
Clerodendrum viscosum Vent.	Verbenaceae	984.94	29.59	8.32	14.54
Codiaeum variegatum (L.) Juss.	Euphorbiaceae	56.01	7.13	1.96	1.94
Coffea benghalensis Roxb. ex Schult.	Rubiaceae	18.49	1.59	2.92	0.48
Dracaena steudneri Engl.	Dracaenaceae	5.28	0.79	1.67	0.21
Euonymus japonicus Thunb.	Celastraceae	144.25	6.87	5.25	2.65
Euphorbia neriifolia L.	Euphorbiaceae	8.45	1.72	1.23	0.42
Flacourtia cataphracta Roxb. ex Willd.	Flacourtiaceae	11.10	2.38	1.17	0.58

Table 5: Continued.

Species	Family	Density (individuals ha^{-1})	Frequency (%)	Abundance	IVI
Flemingia strobilifera (L.) R. Br.	Papilionaceae	22.19	2.38	2.33	0.68
Gardenia jasminoides Ellis.	Rubiaceae	41.22	5.94	1.73	1.57
Glochidion arborescens Bl.	Euphorbiaceae	1.06	0.26	1.00	0.06
Gossypium arboreum L.	Malvaceae	25.36	4.62	1.37	1.16
Hibiscus mutabilis L.	Malvaceae	4.23	0.92	1.14	0.23
Hibiscus rosa-sinensis L.	Malvaceae	76.09	9.25	2.06	2.54
Hibiscus sabdariffa L.	Malvaceae	57.07	3.30	4.32	1.17
Ixora javanica (Blume) DC.	Rubiaceae	22.72	2.64	2.15	0.74
Jasminum officinale L.	Oleaceae	6.87	1.45	1.18	0.36
Jatropha gossypiifolia L.	Euphorbiaceae	5.28	0.79	1.67	0.21
Justicia gendarussa Blanco.	Acanthaceae	56.54	2.11	6.69	0.92
Lawsonia inermis L.	Lawsoniaceae	10.57	2.25	1.18	0.55
Leea indica (Burm. f.) Merr.	Leeaceae	11.62	1.45	2.00	0.40
Malvaviscus arboreus Cav. var. *drummondii* (Torr. and Gray) Schery.	Malvaceae	14.27	1.98	1.80	0.53
Melastoma normale D. Don.	Melastomataceae	70.81	4.49	3.94	1.53
Mussaenda frondosa L.	Rubiaceae	28.01	3.57	1.96	0.97
Nerium indicum Mill.	Apocynaceae	11.10	2.11	1.31	0.53
Nyctanthes arbor-tristis L.	Oleaceae	26.95	5.68	1.19	1.39
Ocimum gratissimum L.	Lamiaceae	8.45	1.06	2.00	0.29
Ocimum sanctum L.	Lamiaceae	67.64	6.21	2.72	1.85
Phlogacanthus thyrsiflorus (Roxb.) Nees	Acanthaceae	38.04	2.11	4.50	0.76
Pogostemon benghalensis (Burm. f.) O. Kuntze	Lamiaceae	20.61	0.66	7.80	0.31
Punica granatum L.	Punicaceae	12.15	2.64	1.15	0.64
Ravenala madagascariensis Sonnerat.	Strelitziaceae	6.87	0.40	4.33	0.14
Ricinus communis L.	Euphorbiaceae	172.79	5.55	7.79	2.62
Rosa alba L.	Rosaceae	33.29	3.17	2.63	0.93
Saccharum officinarum L.	Poaceae	239.37	3.70	16.18	2.82
Sida cordifolia L.	Malvaceae	15.85	0.53	7.50	0.24
Solanum indicum L.	Solanaceae	5.28	0.79	1.67	0.21
Solanum melongena L.	Solanaceae	93.00	6.08	3.83	2.04
Solanum subtrucatum	Solanaceae	0.53	0.13	1.00	0.03
Solanum torvum Swartz.	Solanaceae	11.10	1.59	1.75	0.42
Tabernaemontana divaricata G. Don.	Apocynaceae	63.94	7.27	2.20	2.03
Thuja occidentalis L.	Cupressaceae	3.17	0.66	1.20	0.16
Urena lobata L.	Malvaceae	172.79	6.47	6.67	2.81
		Herb			
Abelmoschus esculentus (L.) Moench	Malvaceae	244	0.40	6.17	0.11
Achyranthes aspera L.	Amaranthaceae	18032	26.02	6.93	7.83
Acorus calamus L.	Araceae	185	0.13	14.00	0.06
Ageratum conyzoides L.	Asteraceae	22120	37.52	5.90	10.48
Alocasia odora (Lindl.) Koch.	Araceae	2583	7.46	3.46	1.71
Alpinia allughas L.	Zingiberaceae	20	0.07	3.00	0.01
Alternanthera sessilis (L.) R. Br. ex DC.	Amaranthaceae	5713	10.17	5.62	2.78
Amaranthusblitum L. var. *oleracea* Hook. f.	Amaranthaceae	535	0.99	5.40	0.27
Amaranthus caudatus L.	Amaranthaceae	145	0.73	2.00	0.14

Table 5: Continued.

Species	Family	Density (individuals ha^{-1})	Frequency (%)	Abundance	IVI
Amaranthus spinosus L.	Amaranthaceae	264	0.59	4.44	0.15
Amaranthus viridis L.	Amaranthaceae	7345	9.58	7.67	3.03
Amorphophallus campanulatus (Roxb.) Bl. ex Decne.	Araceae	304	0.79	3.83	0.19
Ananas comosus (L.) Merr.	Bromeliaceae	7999	9.78	8.18	3.20
Asparagus racemosus Willd.	Asparagaceae	26	0.13	2.00	0.03
Atriplex hortensis L.	Chenopodiaceae	277	0.46	6.00	0.13
Axonopus sp.	Poaceae	60885	34.28	17.76	18.07
Bacopa monnieri (L.) Pennell	Scrophulariaceae	383	0.40	9.67	0.14
Benincasa hispida (Thunb) Cogn.	Cucurbitaceae	178	0.92	1.93	0.18
Borreria articularis (L. f.) F. N. Will.	Rubiaceae	18336	23.91	7.67	7.57
Borreria hispida (L.) K. Schum.	Rubiaceae	2272	4.62	4.91	1.20
Brassica juncea (L.) Czern. and Cross. var. *cuneifolia* (Roxb.) Kitam.	Brassicaceae	2067	1.65	12.52	0.69
Brassica oleracea L. var. *botrytis* L.	Brassicaceae	515	0.59	8.67	0.20
Brassica oleracea L. var. *capitata* L.	Brassicaceae	608	0.73	8.36	0.24
Brassica oleracea L. var. *gongylodes* L.	Brassicaceae	872	1.12	7.76	0.36
Bryophyllum pinnatum Lam.	Crassulaceae	1849	4.43	4.18	1.08
Cannabis sativa L.	Cannabaceae	661	1.52	4.35	0.38
Carex sp.	Cyperaceae	211	0.46	4.57	0.12
Catharanthus roseus L.	Apocynaceae	211	0.79	2.67	0.17
Celosia sp.	Amaranthaceae	159	0.53	3.00	0.12
Centella asiatica (L.) Urban	Apiaceae	7325	13.80	5.31	3.69
Chenopodium album L.	Chenopodiaceae	251	0.86	2.92	0.19
Chrysopogon aciculatus (Retz.) Trin.	Poaceae	6532	3.76	17.35	1.95
Cleome viscosa L.	Capparaceae	192	0.79	2.42	0.16
Clitoria ternatea L.	Papilionaceae	46	0.40	1.17	0.07
Coccinia cordifolia (L.) Cogn.	Cucurbitaceae	185	0.92	2.00	0.18
Coleus sp.	Lamiaceae	159	0.33	4.80	0.08
Colocasia esculenta (L.) Schott	Araceae	13349	20.94	6.38	6.06
Commelina benghalensis L.	Commelinaceae	4505	8.72	5.17	2.30
Coriandrum sativum L.	Apiaceae	1572	0.59	26.44	0.42
Costus speciosus (Koen. ex Retz.) Smith	Costaceae	159	0.66	2.40	0.14
Crassocephalum crepidioides (Benth.) Moore.	Asteraceae	462	1.25	3.68	0.29
Cucumis sativus L.	Cucurbitaceae	159	0.46	3.43	0.11
Cucurbita pepo L.	Cucurbitaceae	297	1.32	2.25	0.27
Cuphea carthagenensis (Jacq.) JF Macbr.	Lythraceae	1955	3.83	5.10	1.01
Curcuma longa L.	Zingiberaceae	4914	3.43	14.31	1.56
Cynodon dactylon (L.) Pers.	Poaceae	20086	19.29	10.41	7.21
Cyperus brevifolius (Rottb.) Endl. ex Hassk.	Cyperaceae	3554	6.08	5.85	1.69
Cyperus rotundus L.	Cyperaceae	14650	20.34	7.20	6.24
Cyperus sp.	Cyperaceae	6968	13.41	5.20	3.55
Daucus carota L. var. *sativa* DC.	Apiaceae	1770	0.99	17.87	0.52
Desmodium elegans DC.	Papilionaceae	26	0.13	2.00	0.03
Dioscorea alata L.	Dioscoreaceae	476	2.11	2.25	0.43
Dioscorea deltoidea Wall.	Dioscoreaceae	40	0.26	1.50	0.05
Diplazium esculentum (Retz.) Sw.	Athyriaceae	1830	4.76	3.85	1.13
Dolichos lablab L.	Papilionaceae	132	0.79	1.67	0.15

Table 5: Continued.

Species	Family	Density (individuals ha^{-1})	Frequency (%)	Abundance	IVI
Drymaria cordata (L.) Wild ex Roemer and Schultes	Caryophyllaceae	7919	9.51	8.33	3.14
Dryopteris sp.	Dryopteridaceae	12450	18.23	6.83	5.45
Eclipta prostrata L.	Asteraceae	139	0.86	1.62	0.16
Eryngium foetidum L.	Apiaceae	489	1.06	4.63	0.27
Houttuynia cordata Thunb.	Saururaceae	1836	1.65	11.12	0.64
Impatiens balsamina L.	Balsaminaceae	1440	2.51	5.74	0.69
Imperata cylindrica (L.) Raeusch.	Poaceae	264	0.07	40.00	0.07
Justicia simplex D. Don.	Acanthaceae	8303	16.91	4.91	4.38
Lagenaria siceraria (Mol.) Standl.	Cucurbitaceae	244	1.25	1.95	0.25
Leucas aspera (Willd.) Spreng.	Lamiaceae	2715	6.74	4.03	1.62
Longbon*	Rubiaceae	1030	2.44	4.22	0.60
Luffaacutangula (L.) Roxb.	Cucurbitaceae	462	1.45	3.18	0.32
Luffa cylindrica (L.) Roem.	Cucurbitaceae	304	1.32	2.30	0.27
Lycopersicon esculentum Mill.	Solanaceae	601	1.65	3.64	0.38
Mentha viridis L.	Lamiaceae	416	0.53	7.88	0.17
Mikania micrantha Kunth ex H.B.K.	Asteraceae	6559	15.92	4.12	3.86
Momordica charantia L.	Cucurbitaceae	79	0.33	2.40	0.07
Momordica dioica Roxb. ex Willd	Cucurbitaceae	410	1.45	2.82	0.31
Mimosa pudica L.	Mimosaceae	244	0.99	2.47	0.21
Mirabilis jalapa L.	Nyctaginaceae	462	1.06	4.38	0.26
Oldenlandia corymbosa L.	Rubiaceae	4287	5.75	7.46	1.79
Oplismenus sp.	Poaceae	37457	28.93	12.95	12.34
Oryza sativa L.	Poaceae	449	0.26	17.00	0.14
Oxalis corniculata L.	Oxalidaceae	4822	7.79	6.19	2.22
Oxalis debilis H.B.K. var. *corymbosa* (DC.) Lour.	Oxalidaceae	5588	8.39	6.66	2.48
Paederia foetida L.	Rubiaceae	198	0.46	4.29	0.11
Panicum sp.	Poaceae	38573	38.64	9.98	14.09
Passiflora foetida L.	Passifloraceae	119	0.66	1.80	0.13
Peperomia pellucida L.	Piperaceae	5033	7.79	6.46	2.27
Phyllanthus fraternus Webster	Euphorbiaceae	6420	14.73	4.36	3.64
Piper betle L.	Piperaceae	4868	12.62	3.86	2.99
Piper nigrum L.	Piperaceae	1856	5.35	3.47	1.22
Piper sylvaticum Roxb.	Piperaceae	627	0.92	6.79	0.28
Pollia sp.	Commelinaceae	165	0.33	5.00	0.09
Polygonum chinense L.	Polygonaceae	205	0.20	10.33	0.07
Polygonum hydropiper L.	Polygonaceae	1777	1.85	9.61	0.66
Polygonum microcephalum D. Don	Polygonaceae	159	0.13	12.00	0.05
Potentilla indica (Andrews) Wolf.	Rosaceae	403	0.79	5.08	0.21
Pteris sp.	Pteridaceae	1110	2.84	3.91	0.68
Raphanus sativus L.	Brassicaceae	1004	0.86	11.69	0.34
Rhynchostylis retusa (L.) Blume.	Orchidaceae	99	0.59	1.67	0.11
Scoparia dulcis L.	Scrophulariaceae	1982	4.43	4.48	1.11
Selaginella sp.	Selaginellaceae	1096	0.66	16.60	0.33
Siral*	Cucurbitaceae	13	0.07	2.00	0.01
Solanum nigrum L.	Solanaceae	178	0.92	1.93	0.18

Table 5: Continued.

Species	Family	Density (individuals ha^{-1})	Frequency (%)	Abundance	IVI
Solanum tuberosum L.	Solanaceae	1202	0.46	26.00	0.32
Spilanthes paniculata Wall. ex DC.	Asteraceae	10416	16.64	6.26	4.78
Spinacia oleracea L.	Chenopodiaceae	852	1.25	6.79	0.37
Tagetes patula L.	Asteraceae	1466	3.76	3.89	0.89
Vigna sinensis (L.) Savi ex Hassk.	Papilionaceae	218	0.86	2.54	0.18
Zingiber officinale Roscoe	Zingiberaceae	1731	1.12	15.41	0.54

*Locale name.

by *A. malaccensis* which is ranged from 17.94 to 72.63 with a mean of 49.36 ± 2.64. 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 113 ± 7 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 m^2 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.

Conflict of Interests

The authors (Dr. P. Saikia and Professor M. L. Khan) declare that there is no conflict of interests regarding the publication of this paper.

Acknowledgments

The authors would like to express their sincere gratitude towards the people of upper Assam, for the free access to their homegardens, for their cooperation during the survey and interviews, and for the permission to collect plant samples. Financial support from DBT, Govt. of India, through the project "Mapping and quantitative assessment of geographic distribution and population status of plant resources of Eastern Himalayan region" is highly acknowledged.

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