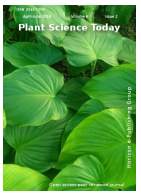
ISSN: 2348-1900
Plant Science Today
http://www.plantsciencetoday.online



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Research Article

Assessment of eco-diversity status of *Homalomena aromatica* (Spreng.) Schott and its habitat in tropical forest of Indian Eastern Himalaya

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Article history
Received: 26 October 2018
Accepted: 10 January 2019
Published: 01 April 2019

Editor
Prof. Manuel Losada Gavilanes
Federal University of Lavras
Lavras, Brasil

Publisher
Horizon e-Publishing Group

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Abstract

Homalomena aromatica (Spreng.) Schott is one of the economically important plant species occurring in the North east and Eastern Himalayan region of India which received least attention in its ecological and conservation studies. The current study has been undertaken in the north eastern state of Arunachal Pradesh. The population, phytosociological status of its habitat, regeneration and species association of *H. aromatica* were worked out using standard ecological methods. Out of the 15 selected forest sites for survey, *H. aromatica* was found only in 9 sites. A total of 288 species representing 99 families are documented from the selected sites where Euphorbiaceae, Meliaceae, Araceae, Dipterocarpaceae and Poaceae are found dominant in all the 9 sites. Species diversity index (H') of all the three habits *i.e.* the tree, shrub, and herb were found highest in Happy Valley site followed by Ganga Lake. A total of 219 individuals of *H. aromatica* recorded which were found confined within the altitudinal ranges of 350m-450m asl. The IVI (1.95 to 9.64) and Frequency % (5 to 12.5) range of *H. aromatica* found significantly low at all the survey sites. Pearson's correlation analysis reveals that there is a positive relationship between the population size and the species diversity index, where shrub showed the strongest relationship (r(7)=0.900, *P*=0.001) followed by tree r(7)=0.736, *P*=0.024 and the herbs with weakest relationship (r(7)=0.39, *P*=0.269). The Chi-square test of association indicated significant association of 10 species with *H. aromatica* in the various sites where *Alocasia acuminate* (Aracaceae), *Amomum* sp. (Zingiberaceae) and *Pteris* sp. (Pteridaceae) showed highest association with higher Chi square value. The poor population status with average density of 3041.67/hectare and 8.89 frequency percentage as well the existing anthropogenic threats to the species recorded in the present study has warrants for its immediate conservation.

Keywords: Arunachal Pradesh; Tropical forest; *Homalomena aromatica*; Eastern Himalaya; Population status; Species association and Threats

Citation: Ronald K, Gajurel PR, Singh B. Assessment of eco-diversity status of *Homalomena aromatica* (Spreng.) Schott and its habitat in tropical forest of Indian Eastern Himalaya. Plant Science Today 2019;6(2):71-83. https://doi.org/10.14719/pst.2019.6.2.435

Indexing: Plant Science Today is covered by Scopus, CAS, AGRIS, CABI, Google Scholar, etc. Full list at http://www.plantsciencetoday.online

Introduction

One of the greatest challenges facing humanity is to halt the decline of biodiversity worldwide (1). Moreover, rare species are at greater risk of extinction because of their small geographic ranges, low abundances, and greater susceptibility to environmental changes (2-5) and these rare species

are important for the recognition of a local plant community (6). The genus *Homalomena* of Araceae family is although reported with more than 200 species, about 106 species are presently with accepted names (7). Out of 6 species recorded in India, 2 species namely *Homalomena aromatica* (Spreng) Schott and *Homalomena pendula* (Bl.) Hakh. are found in North east India and the rest 4 species are restricted to Andaman and Nicobar Island only (8). The studies on population and regeneration behavior of a species are needful in understanding the species life cycle and they also provide significant ecological data useful in formulation of conservation strategies (9). During the past few years study on ecology, distribution and population status of some rare and endangered plant species have been attempted by various workers. The study on *Homalomena bellula* Schott by Kusuma and Astuti (10); on *Gymnocladus assamicus* by Choudhury et al. (11); on *Paris polyphylla* by Paul et al. (12); on *Pinus merkusii* by Das et al. (13) are found significant which generates various useful information for conservation of rare and threatened species. The North east India with its eastern Himalaya is a home of numerous economically and ecologically important plant species and many of these species are becoming endangered with very limited population in the natural habitats. The *Homalomena aromatica* (Photo plate 1) is one of such species which qualify for its population assessment for its future management.

Background of the Species: *Homalomena aromatica* (Spreng.) Schott also known as "Sughandmantri" is a rhizomatous aromatic perennial herb, belonging to Araceae family of Monocotyledon. Its essential oils of the species reported to have various medicinal and industrial uses along with antimicrobial activities. Besides the uses in perfumery and cosmetic industries, it is used traditionally for cold and cough, jaundice, stomach problems, skin diseases, etc. and also possesses antioxidant properties (14). The plant has two trademarks, Sugandhimantri (dry rhizome) and Montria oil which are used in perfume, cosmetic and dhup (incense) industries (15). It is also reported that ethnobotanically the species is used in various forms like vegetable, medicine, etc. in different states of North eastern region of India and in Maulvibazar district of Bangladesh (16-21). It is observed that the plant is having potential antibacterial activity (22-24). The ulcer protective activity from the ethanolic extracts of *H. aromatica* was also reported (25). The essential oil from the species is reported of having insect repellent activity (26). The Indian Red Data Book (28) listed 620 rare and endangered plant species in India but *H. aromatica* was not included in the list. However, Ved et al. (29) listed 51 threatened species from north east regions of India, where *H. aromatica* is categorized under Endangered in Assam and Vulnerable in Arunachal Pradesh. At present there is only one species *i.e. Homalomena lauterbachii* Engl. listed in IUCN Red List as Least Concern (27). The *H. aromatica* is mostly encountered in the foothills of Indian Eastern Himalayan states. The recent phytosociological studies on medicinal plants from the state has mostly conducted in high altitudinal forests (12,30,31) which do not provide any information of the species. As the species is assume to be a rare and endangered in the north eastern region and also been exploited for both commercially and locally, there is a need of understanding its real status of occurrence in its natural habitat so that specific conservation strategy can be formulated. In this context the present study has been undertaken for better understanding the population and regeneration status, species association, relation between species diversity and population size with various threats of *H. aromatica* in Arunachal Himalaya.

Material and Methods

Exploration Area:

The Indian Eastern Himalayan regions consist of five political territories of which three are under Indian territory; Darjeeling (West Bengal), Sikkim and Arunachal Himalaya. The others are Nepal and Bhutan Himalaya (32). The present study was undertaken in the Arunachal Himalaya which is located in the extreme north eastern part of India (27.06°N and 93.37°E). Based on the distributional records and habitat preferences of the *Homalomena aromatica* (Spreng.) Schott, 15 specifics most diverse forest sites from six districts of Arunachal Pradesh were selected for preliminary field exploration and identification of sites for population study. The details of the study sites with their GPS points along with the inhabiting tribes in the locality are presented in Table 1. The study sites were predominantly hilly and mountainous in nature. The forest of the study sites falls under Tropical semi evergreen (2/B/C1/Ia, 2/B/C1b/ISI), Tropical evergreen (1/B/C1, 1/B/C2), (33), and mixed bamboo forest as per Kaul & Haridasan (34).

Sampling Method:

The field surveys were conducted based on the secondary information and consultation with the local communities. Preliminary surveys in 15 sites covering the 6 districts of Arunachal Pradesh were undertaken during November, 2015 to December, 2016. Based on the accessibility and availability of the species, 9 distinct sites of 1km x 1km size were selected from 3 districts (Fig. 1). Vegetation sampling of all the three habits (tree, shrub, and herb) was done through random quadrates methods. Twenty quadrates of 10m x 10m were laid in each selected plot for tree species and individuals with diameter at breast height (DBH) more than 15cm where recorded. Within the 10m x 10m quadrate two numbers of 5m x 5m quadrate

Photo Plate 1: *Homalomena aromatica* (spereng.) Schott and its habitats A. Habitat of the species, B. Species in its natural habitat, C. The species grown in nursery and D. Inflorescence.

for shrub and four 1m x 1m quadrate for herb species were plotted. Specimens of all species were collected and herbarium specimens were prepared (35) and identification was done following taxonomic literature and herbarium specimens of regional and national herbaria (ASSAM and ARUN). The community characteristic of the selected sites was studied using quantitative analytical methods. Important ecological parameters like density, frequency, abundance, importance value index (IVI) were calculated using standard methods (36,37). Species diversity index (H') was also calculated following Shannon & Weaver (38). An attempt has also been made to know whether there is any mutual relationship between the species diversity of the habitat and the population of *Homalomena aromatica* in the study sites. So, Pearson's correlation test (r) was used to analyses the relationship using software IBM SPSS statistics 19 (39). Data on population structure for the species *H. aromatica* occurring at the sites was collected at two levels, namely young (Y) and adult (A). The individuals, with ≤15 cm height were considered as young plant while individuals with ≥30 cm height were considered as adult plant. The relative proportion of young and adults of the species at each study site was calculated. The distribution pattern of *H. aromatica* was also calculated as per the following formula (40).

$$\text{Distribution pattern} = \frac{\text{Abundance}}{\text{Frequency}}$$

The distribution pattern was determined if the A/F ratio is <0.025 (as regular n); between 0.025 and 0.05 (random) and >0.05 (contagious or clumped).

Regeneration status was determined based on the data of population size of young and adult plant (41). As the targeted species is a rhizomatous herb, so the regeneration status was considered only in two stages i.e. young and adult. The categorization is set as (a) good regeneration, if

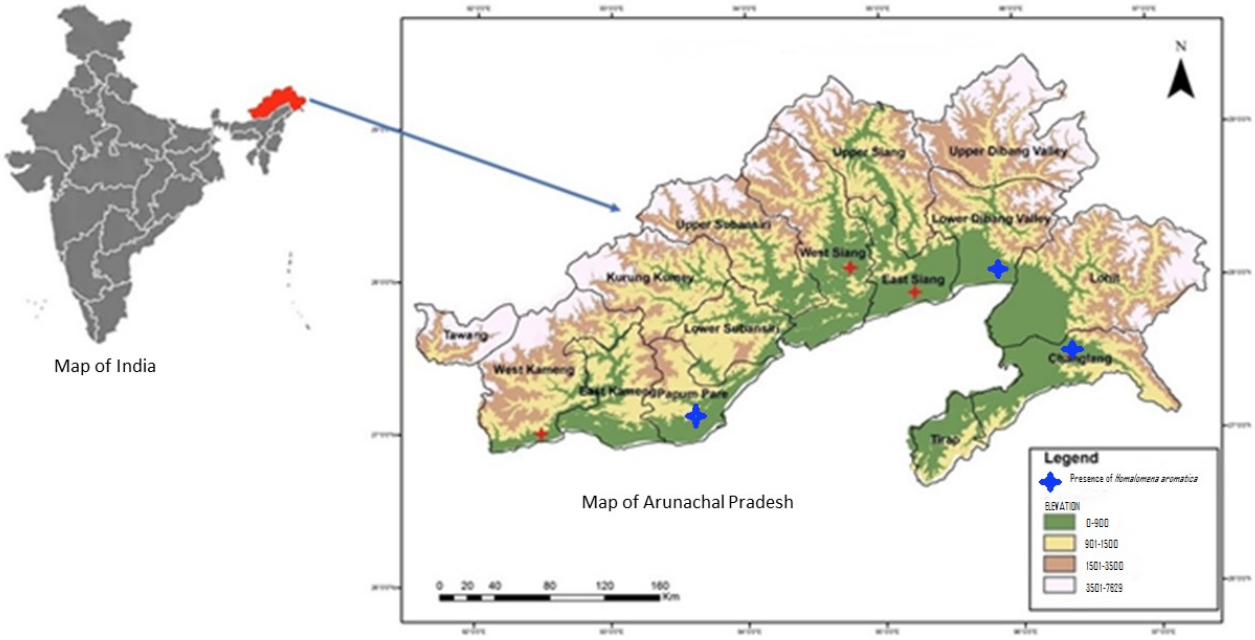

Fig. 1. Map of Arunachal Pradesh indicating the study sites

Table 1: Details of the study sites

Sl No.	District	Major Tribe	Survey Sites	Geographic location	Elevation
1	Papumpare	*Nishi*	Banderdewa	27° 06'19.8"N 93°49'19.29"E	120-400 m asl
			Karsingsa	27° 06'24.52"N 93°46'31.55"E	
			Ganga Lake	27° 4'35.15"N 93°34'5.27"E	
2	West Kameng	*Monpa, Aka, Shertokpen*	Bhalukpong	27° 0'41.75"N 92°38'30.47"E	150-213 m asl
			Tipti	27° 2'7.37"N 92°36'19.78"E	
3	East Siang	*Adi*	Pasighat (Belak)	28° 3'49.98"N 95°17'10.13"E	153-380 m asl
			Pasighat (Mirbuk)	28° 3'38.87"N 95°18'23.37"E	
4	West Siang	*Galo*	Aalo	28°10'3.61"N 94°49'1.27"E	600-750 m asl
			Jirdin	28° 9'12.89"N 94°50'38.46"E	
5	Changlang (Namdapha National Park)	*Lisu, Tangsa, Shingpho*	Happy Valley	27°31´09.63″N 96°23´53.51″E	400-600 m asl
			Near Hornbill Camp	27°32´24.2″N 96°24´33.0″E	
			Deban Camp	27°32'21.24"N 96°23'42.28"E	
6	Lower Dibang Valley	*Adi, Mishing*	Koronu	28° 4'36.22"N 95°55'19.54"E	350-500 m asl
			Bhismaknagar	28° 3'33.57"N 95°59'38.68"E	
			Abongo Camp	28° 5'52.00"N 95°54'24.92"E	

number of young plants > adults, (b) fair regeneration, if number of young plants > or ≤ adults, (c) poor regeneration, if the number of young plant < adults, (d) no regeneration if young plant of a species were absent but only adults were present, and (e) new, if adults were absent, but only young stages of the species were present. To understand the species association of *Homalomena aromatica* with other plant species in the study sites, a Chi-square test of association was used to indicate the probability that whether the two species are distributed independently, or are associated with one another (42). To quantify the strength of association which ascertains the species that are closely associated with the study species, the Cramer's V of association was

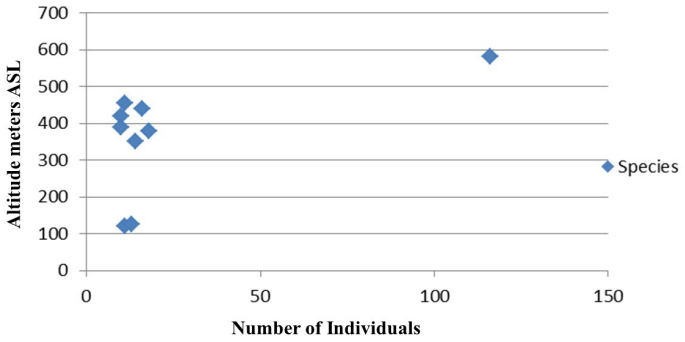

Fig. 2. Distribution of *Homalomena aromatica* based on altitudinal level

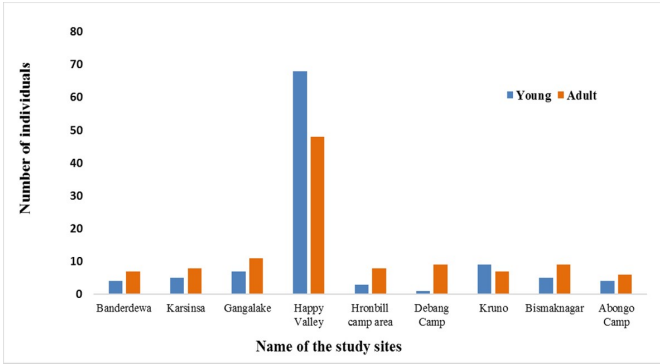

Fig. 3. Population structure of *Homalomena aromatica* in different study plots

Table 2: Community characteristic of the selected study sites

Parameters	Habit	Study sites*								
		Papumpare district			Lower Dibang Valley ditrict			Changlang district		
		Site 1	Site 2	Site 3	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
Species richness	Tree	27	24	34	42	21	27	48	33	26
	Shrub	20	19	21	18	21	20	32	22	20
	Herb	36	25	22	33	38	25	34	41	24
No. Genus	Tree	21	21	30	40	18	24	40	30	26
	Shrub	18	17	19	17	21	19	27	20	19
	Herb	30	22	19	31	23	22	29	33	22
No. Family	Tree	19	17	22	29	18	17	29	21	18
	Shrub	13	12	16	12	14	13	20	15	15
	Herb	21	15	12	25	20	14	22	22	16
Species Diversity index (*H'*)	Tree	3.10	2.96	3.40	3.33	2.89	3.06	3.68	3.27	3.12
	Shrub	2.75	2.71	2.90	2.77	2.89	2.83	3.31	2.95	2.84
	Herb	3.31	3.07	2.91	3.19	3.02	3.08	3.41	3.55	3.00
Density (Individual ha^{-1}).	Tree	820	475	895	955	595	550	1435	750	850
	Shrub	3650	2510	2860	2070	3650	1890	6460	2320	2700
	Herb	177750	153125	100750	168875	229375	145875	60093.75	103625	88000
Basal area (m^2 ha^{-1})	Tree	16.634	6.895	19.035	38.151	8.736	8.234	63.669	13.786	63.669
	Shrub	-	-	-	-	-	-	-	-	-
	Herb	-	-	-	-	-	-	-	-	-

* Papumpare district: Site 1 = Banderdewa, Site 2 = Karsingsa, Site3 = GangaLake; Lower Dibang Valley district: Site 1 = Koronu, Site 2 = Bismaknagar, Site 3 = Abongo Camp; Changlang district: Site 1 = Happy Valley, Site 2 = Hornbill Camp area, Site 3 = Deban Camp

calculated (43). The strength was indicated as weak when the value is between 0.00 and 0.10; moderate if the value is between 0.11 and 0.30 and strong when the value is greater than 0.30. To run the test of association, five herb species each from all the studied plots were selected based on the highest numbers of sharing in same quadrate with *H. aromatica*.

Results

The field exploration carried out in the selected 15 sites of the six districts (Table 1) resulted the occurrence of *Homalomena aromatica* only in 9 sites of the three districts (Table 3). So, the further study on the distribution, population structure, species composition and species association were carried out in those 9 sites where *H. aromatica* was present.

Species composition and community characteristic in the habitats of *H. aromatica*

A total of 288 species representing 209 genera belonging to 99 families have been documented from the 9 forest sites. Among these, 116 are tree species representing 84 genera under 47 families; 72 species are shrubs belonging to 58 genera of 39

Table 3: Occurrence of Homalomena aromatica in the studied plots

Sl. No.	District	Survey Site	No. of Individuals*	Frequency %	Density (Individual ha^{-1}).	IVI	Distribution pattern	Threats
1	Papumpare	Banderdewa	11	5	1375	1.95	Clumped	Landslides, heavy flood, road widening, urbanization, and collection of rhizome and other resources
		Karsingsa	13	7.5	1625	3.15	Clumped	
		Ganga Lake	18	12.5	2250	4.39	Clumped	
2	Changlang (Namdapha National Park)	Happy Valley	116	21.25	14500	9.64	Clumped	Plant is eaten as vegetables by local people
		Hornbill Camp area	11	6.25	1375	3.06	Clumped	
		Deban Camp	10	5	1250	3.42	Clumped	
3	Lower Dibang Valley	Koronu	16	10	2000	3.61	Clumped	Landslides, road widening, deforestation for agriculture and collection of rhizome and other resources.
		Bhismaknagar	14	7.5	1750	2.66	Clumped	
		Abongo Camp	10	5	1250	2.25	Clumped	

Total number of individuals recorded from all the sites is 219.

families and, 99 species are herbs under 74 genera of 46 families.

Among all the sites, the species richness is found highest in the sites of Changlang district with 177 species under 148 genera and 88 families followed by sites of Lower Dibang Valley district with 140 species under 117 genera and 67 families and lowest in Papumpare district with 136 species from 113 genera and 62 families.

The most dominant families recorded in the sites of Lower Dibang valley are Poaceae (10 species) and Meliaceae (7 species) followed by Euphorbiaceae, Araceae and Lauraceae with 6 species each. Whereas, the sites in Changlang district is dominated by the families Euphorbiaceae with 9 species, Araceae with 7 species and Lauraceae, Meliaceae and Moraceae with 5 species each followed by Arecaceae and Rubiaceae with 4 species. While, in sites under Pampumpare district the family Asteraceae and Araceae dominates with 6 species each followed by Dipterocarpaceae, Meliaceae, and Poaceae with 5 species each and Euphorbiaceae with 4 species.

Shannon-Wiener index of species diversity (H') of all the 9 studied sites were worked out and it is found that among the tree habit the Happy valley site of Changlang district has the highest diversity index with 3.68 followed by Ganga Lake of Papumpare district with 3.40 and 3.33 in Koronu of Lower Dibang Valley district (Table 2). Whereas, for shrubby species, the highest is found again in Happy Valley with 3.31 followed by Hornbill Camp area with 2.95 and with 2.90 Ganga Lake of Papumpare district. While among herbs, the highest diversity index is found in Hornbill Camp area with 3.55 followed by Happy valley with 3.41 both in Changlang district and 3.31 in Banderdewa of Papumpare district.

The important value index (IVI) of all the species were calculated and it is found that among the tree species in the sites of Changlang district, *Shorea assamica* (36.57) is the highest followed by *Canarium strictum* (22.8) in Debang Camp. In the sites of Papumpare district *Duabanga grandifolia* (36.37) is the highest followed by *Mallotus philipensis* (26.83) in Karsingsa. In Lower Dibang Valley sites the highest IVI is found for *Terminalia myriocarpa* (34.44) in Koronu site followed by *Castanopsis indica* (25.65) in Abongo Camp. Whereas, among the shrub species *Phrynium pubinerve* (32.20) in Ganga Lake has the highest IVI value followed by *Thysanolaena latifolia* (30.552) in Karsingsa of Papmpare district. *Thysanolaena latifoloa* (23.18) has the highest IVI in Koronu followed by *Buddleja asiatica* (22.59) in Bhismaknagar of Lower Dibang Valley and in Changlang district the highest IVI is found in *Dendrocalamus hamiltonii* (22.06) followed by *Phrynium pubinerve* (17.65) both in Hornbill Camp area. Among herbs species, the highest IVI is observed in *Colocasia affinis* (23.74) in Ganga Lake followed by *Diplazium dilatatum* (22.92) in Karsingsa of Papumpare district. The highest tree density is recorded in Happy Valley of Changlang district with 1435 individual ha^{-1} followed by, 995 individual ha^{-1} in Koronu of Lower Dibang Valley. While the highest shrub density is also recorded in Happy Valley of Changlang district with 3230 individual ha^{-1} followed by Banderdewa of Papumpare and Bhismaknagar of Lower Dibang Valley with 1825 individual ha^{-1} each. The highest density of herb species is also found in Happy Valley of Changlang district with 240375 individual ha^{-1} followed by Bhismaknagar of Lower Dibang Valley with 229375 individual ha^{-1}. So, the density of all the habit forms is found highest in Happy Valley site of Changlang district.

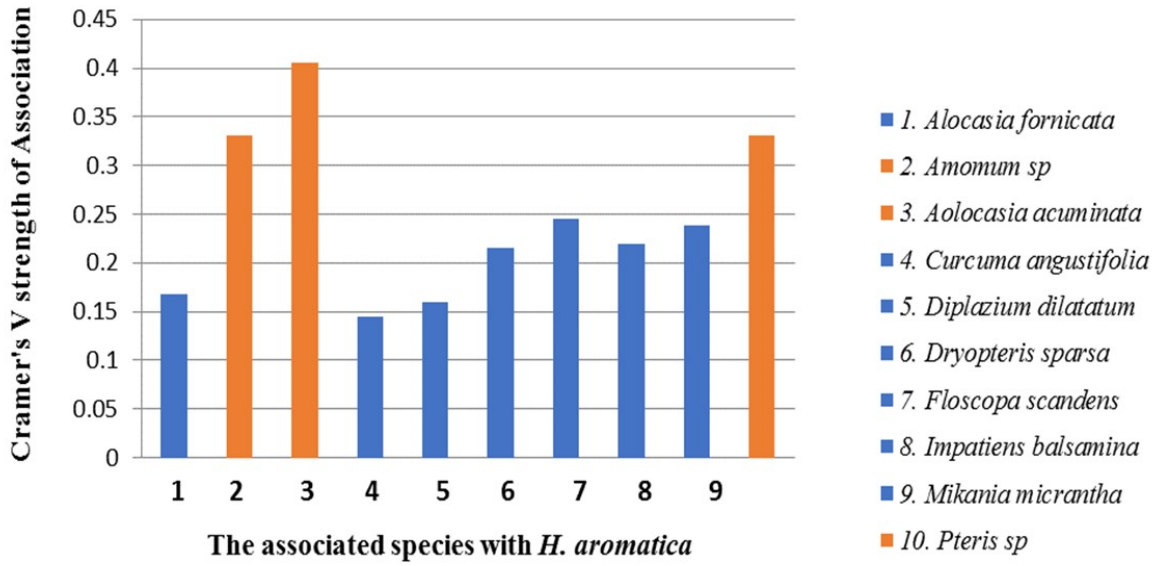

Fig. 4. Species wise comparison on strength of association with *Homalomena aromatica*

Table 4: Pearson's correlation between population size and species diversity index

	Tree diversity index	Shrub Diversity index	Herb diversity index
Population of *H. aromatca*	0.736*	0.900**	0.392
P value	0.024	0.001	0.296
N	9	9	9
DF	7	7	7

*. Correlation is significant at the 0.05 level (2-tailed); **. Correlation is significant at the 0.01 level (2-tailed).

Exploration study of *Homalomena aromatica* in Arunachal Pradesh

During the study, it was found that the *Homalomena aromatica* is distributed in the tropical evergreen and tropical semi evergreen forests of the state specifically at the adjoining areas of the state of Assam, within the altitude of 120m to 600m above sea level. Moreover, it was found that most of the individual populations of *H. aromatica* are distributed within the altitude of 350-450 meters above sea level (Fig. 2). Among the six selected districts, *H. aromatica* is recorded only in the three districts (Table 2). A total of 219 individuals are recorded from the 9 sites of three districts. Moreover, Changlang district represent the highest number of species with 137 individuals, followed by Papumpare with 42 individuals and Lower Dibang Valley with 40 individuals. It is recorded that the occurrence of higher number of species in the Changlang district is due to the presence of comparatively lesser threats on the target species. The values of IVI were also observed higher in one of the selected site Happy valley with 9.64 followed by Ganga Lake with 4.39. It was observed that the local people residing in and around the Namdapha National Park used to collect the species and their petiole are cooked as vegetables. Density (Individual ha^{-1}) of the species was also determined and it was found that Happy Valley in Changlang has the highest density (14500 Individual ha^{-1}) followed by Ganga Lake (2250 Individual ha^{-1}) in Papumpare and Koronu (2000 Individual ha^{-1}) in Lower Dibang Valley. Frequency % of *H. aromatic* is observed highest in Happy Valley in Changlang (21.25%) followed by Ganga Lake (12.5%) in Papumpare.

During the survey, various threats to the population of the *Homalomena aromatica* have also been observed. Except in the sites of the Changlang district which are located inside the Namdapha National parks and one site the Ganga lake of Papum Pare district the species is threatened by various threats in all the sites. The threats namely landslides, heavy floods, road widening and urbanization, deforestation for agriculture, collection of rhizomes of the species and other resources like bamboo are observed (Table 2) The distributional status reveals that the species was found occurring sparsely in all the three study districts. Whereas, in the districts of West Kameng, East Siang and West Siang the species is not observed in the wild. However, it is found cultivated in the herbal gardens of College of Horticulture and Forestry and Indian Institute of Traditional Folk Medicine in East Siang district collected from the wild.

The effect of species diversity index on population of *Homalomena aromatica*.

The value of Shannon diversity index increases along with the increase in species richness and

evenness of a particular community, which signifies that higher the index value means richer the diversity. The result on correlation between species diversity index and population of *Homalomena aromatica* shows that the highest was observed in the shrub species diversity index with significant positive relationship between r(7)=0.900, p=0.001 followed by tree species diversity index, r(7)=0.736, p=0.024 (Table 4). Wheras, a weak or no relationship was established between the poulation of *H. aromatica* and the species diversity index of herbs, r(7)=0.39, p=0.269.

Regeneration status and species association of *Homalomena aromatica*

The study on regeneration status of *Homalomena aromatica* in the selected plots reveals that the majority of the study sites are represented poor regeneration except for two study sites the Happy valley in Changlang district and Koronu in Lower Dibang Valley. Both the sites were representing good regeneration where the populations of the young plants are found more than the adult plants i.e. 68 young and 48 Adult in Happy Valley and 9 young and 7 adults in Koronu (Fig. 3).

The result on chi-square test of species association indicated that out of 45 selected associated species, 10 species are found with significantly higher association with *Homalomena aromatica* in the selected sites (Table 5). Among the top 10 associated species, *Alocasia acuminata* was found associated in two sites namely Ganga Lake of Papumpare district (x^2=13.134, *P*=0.004) with 0.405 Cramer's V strength of association and Debang Camp of Changlang district (x^2=11.88854, *P*=0.007) with 0.385 Cramer's V strength of association respectively. Likewise, the other significantly high associated species are *Amomum* sp. (x^2= 8.745, *P*=0.032) with 0.33 Cramer's V strength of association in Ganga Lake of Papumpare district and *Pteris* sp. (8.745, *P*=0.33) with 0.33 Cramer's V strength of association in Karsingsa of Papumpare district. *Floscopa scandens* (x^2=8.604 *P*=0.035) with 0.33 Cramer's V strength of association is found highly associated in Debang Camp of Changlang district (Table 5). The result on Cramer's V strength of association for all the associated species has revealed that the three species namely *Alocasia accuinata* (0.4); *Amomum sp* (0.33) and *Pteris sp* (0.33). are found with stronger association with *H. aromatica* while the rest 7 species showed moderate association (Fig. 4).

Discussion

The present study revealed that the *Homalomena aromatica* is mostly distributed in small pockets at the foothill's areas of the Arunachal Pradesh bordering to the state of Assam in the tropical evergreen and semi-evergreen forest and also mixed bamboo forest in the altitudinal ranges between 120 m to 600 m asl. Nath et al. (44) also reported the occurrence of the species in the similar forest types in the state in the areas bordering to Assam. Referring to its micro-habitat the species is found growing in the humus rich, moist and nearby water channel with dense canopy cover providing a moist shady environment. The study has also revealed that the population of *H. aromatica* in the wild has been decreasing gradually and are not available in all the districts of the foothill's areas. Although the earlier occurrence of the species in the forest areas of East Siang district is encountered, we could not locate any individual or population in the selected sites of the district indicating its rareness or present non-availability. So, it can be stated that the environmental stochastic has influence the small and uneven population size to decline and hence leading towards its extinction locally.

The result on species richness in the habitats of the *Homalomena aromatica* indicated a rich floristic diversity with 288 species. It shows the species diversity of these areas is almost similar with the result of Nath et al. (45) from the tropical forest of Changlang district of Arunachal Pradesh where 200 species were recorded. The tree diversity of 116 species from the selected study sites were found much higher than the reported species from the tropical forests of Assam and Mizoram (46,47). Kent and Coker (48) reported that Shannon-Weiner diversity index normally varies from 1.5 to 3.5 and rarely exceeds 4.5. In the present study also, the Shannon-Weiner diversity index was found in between 2.71 to 3.67 (Table 2). However, the value was found greater than Nath et al. (45) from the similar area i. e Tropical forest of Arunachal Pradesh. The tree density (>15cm DBH) in the selected sites varied from 475 to 1435 ha^{-1} which are found greater than Swamy et al. (49) 436-971 stem per hectare. Whereas, the values are found lesser in comparison to the tree density of 3656 - 5452 stems per hectare by Bhuyan et al. (50) in wet evergreen forest of Arunachal Pradesh. However, the average tree densities in the tropical forests of various regions are found ranges from 245 to 859 stem per hectare (51; 52; 53). The Basal area recorded from the selected study sites ranged from 6.895 to 63.669 m^2ha^{-1} for >15cm diameter threshold were found slightly below then the range recorded from different tropical forests by other workers like Barbhuiya et al. (54) as 98.6 ha-1, Swamy et al. (49) as 67.4 ha^{-1} and Burges (55) as 73.6 ha^{-1}. The present study on basal area ranges of the tree species (Table 2) indicates that *H. aromatica* is found in different stages of succession from homeostasis *Dipterocarpus* forest with higher basal area in Changlang district to Secondary forest of Papumpare district with low basal area which are largely affected by anthropogenic activity like abandoned *jhum* and agriculture land resulting to

Table 5: Chi-Square test of species association along with Cramer's V strength of association

Sl No	Name of Species	Papumpare District						Lower Dibang Valley District						Changlang District					
		Site 1		Site 2		Site 3		Site 1		Site 2		Site 3		Site 1		Site 2		Site 3	
		Chi square	Cramer's V	Chi square	Cramer's V	Chi square	Cramer's V	Chi square	Cramer's V	Chi square	Cramer's V	Chi square	Cramer's V	Chi square	Cramer's V	Chi square	Cramer's V	Chi square	Cramer's V
1	*Alocasia fornicate* (Araceae)	nil	nil	0.034	0.143	nil	nil	nil	nil	nil	nil	1.602	0.142	nil	nil	3.870	0.219	nil	nil
2	*Alocasia acuminata* (Araceae)	0.587	0.085	0.034	0.021	13.134	0.405	1.693	0.145	nil	nil	4.765	0.244	nil	nil	5.333	0.258	11.888	0.385
3	*Amomum sp* (Zingiberaceae)	nil	nil	4.168	0.227	8.745	0.330	nil	nil	nil	nil	nil	nil	nil	nil	2.610	0.181	nil	nil
4	*Curcuma angustifolia* (Zingiberaceae)	0.015	0.0137	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	6.037	0.274	nil	nil
5	*Diplazium dilatatum* (Athyriaceae)	nil	nil	1.157	0.120	1.120	0.118	nil	nil	nil	nil	4.396	0.234	nil	nil	2.210	0.166	nil	nil
6	*Dryopteris sparsa* (Dryopteridaceae)	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	2.470	0.175	nil	nil	5.167	0.254
7	*Floscopa scandens* (Commelinaceae	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	8.604	0.327
8	*Impatiens balsamina* (Balsaminaceae)	5.473	0.261	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil
9	*Mikania micrantha* (Asteraceae)	2.845	0.188	nil	nil	nil	nil	nil	nil	nil	nil	6.655	0.288	nil	nil	nil	nil	nil	nil
10	*Pteris sp* (Pteridaceae)	nil	nil	8.745	0.331	3.484	0.208	nil	nil	1.901	0.154	5.168	0.254	nil	nil	nil	nil	nil	nil

Note: Papumpare: site1=Banderdewa, site2=Karsingsa, site3= Ganga Lake; Lower Dibang Valley: site1=Koronu, site2=Bismaknagar, site3= Abongo Camp; Changlang: site1=Happy Valley, site2= Hornbill Camp area, site3= Deban Camp

landslide. The differences in species composition, successional stage of the forest, age structure and degree of disturbance contributes in size of basal area (49,56). The initiation of a successional process is strongly influence by major natural disturbances like landslide, hurricane, flood and windstorm (57,58,59)

The result on Pearson's correlation has reveals that there is a positive relationship between the population of *Homalomena aromatica* and the diversity index of tree, shrub. The strongest relationship of the population of *H. aromatica* with shrubs and trees has supported the fact that there is no close competition between shrub and tree species with *H aromatica.* So, it has been found that high species diversity in a habitat has a positive influence in maintaining the population of the rare species *H. aromatica* in the study site. However, there was no significant relationship with herb diversity index. It was found that invasive species like *Mikania micrantha* was associated with *H. aromatica* in Banderdewa and Abongo camp. The *Mikania micrantha* is a top invasive species with diverse distributional range and a larger extent of the Indian landmass is climatically suitable for *M. micrantha* growth (60). So, it can be said that *M. micrantha* could become a threat to *H. aromatica* as it shares the same habitat.

The species importance value index (IVI) represents the ecological success of the species. The higher the value known to be dominance and success of the species and lower the value, the less success of the species in establishing itself in the forest (61; 62). The IVI of *Homalomena aromatica* from the 9 selected sites, revealed that except the Happy Valley of Changlang district where the IVI is 9.64, it is found lower than 5 in rest of the sites. It shows that the IVI values of the *H. aromatica* are comparatively lower than many other species. Density Individual ha^{-1} of *H. aromatica* revealed that the highest was observed in Happy Valley of Changlang district (14500) and Ganga Lake (2250) in Papumpare district. The higher density of the species in these two sites attributed to least anthropogenic activities as both of the plots are under protected area as the Happy Valley falls under Namdapha National Park and the Ganga Lake a recreational park located under Itanagar Wild Life Sanctuary. The protection of habitat in these two sites has supported the better population of *H. aromatica* in wild. Dattagupta (63) reported the similar density of the species in three selected sites from Assam (ranges from 4608 to 7360 Individual ha^{-1}). However, the frequency % of *H. aromatica* in the present study is comparatively lower (5% to 21%), than the reported values (ranges from 69.6% to 80%) by Dattagupta (63). The results clearly indicated the biotic factors are directly influencing the population. The abundance of individuals is affected by biotic factors (64). The result on population structure of *H. aromatica* reveals that Happy Valley of Changlang district and Koronu of Lower Dibang Valley shows good regeneration while the rest of the 7 sites indicate the poor regeneration. Spellerberg (65) described that an uneven age structure or sex ratio in a population can precipitate its decline to extinction, while a balanced birth and death rates would ensure rapid growth. Moreover, the phenological observations of *H. aromatica* showed that the whole inflorescence dried up just after the anthesis (flowering period) without development of fruits in all the study sites. Kusuma and Astuti (10) has also reported that the species of Araceae family has its unique transition from sexual to vegetative reproduction along with very less flowering and fruiting. The low existing population of the species with the failure in regeneration through production of seeds threatened the existence of *H. aromatica* in the wild. The habitat of *H. aromatica* is exclusively in the forests and the species occur mostly in moist environment under deep shady forest floors. So, considering the habitat specificity and limited occurrence of *H. aromatica*, understanding and identifying the associated species could help to trace this rare species. Among the 10 closely associated species observed, the three species *Alocasia acuminata* (Aracaceae), *Amomum sp*. (Zingiberaceae) and *Pteris sp.* (Pteridaceae) are significantly associated with *H. aromatica* with stronger Cramer's V strength of association. The importance of associated species to trace the population of some rare species like *Swertia chirayita*, *Paris polyphylla*, and *Panax bipinnatifidus* has also been indicated by Lyngdoh (66) from Eastern Himalaya. The species association are important indicator for locating the species and are also useful in conservation and monitoring of vegetation change (67).

Conclusions

The present study explored and highlighted the present status of its distribution and population of the economically important species *Homalomena aromatica*. The low population status with very limited individuals (219 nos.) and poor regeneration status has been found challenging for the survival of the species in the wild. The species may be treated as critically endangered in the state. Moreover, the various anthropogenic activities like collection or resources, clearance forests for agriculture, the developmental activities like road widening, urbanization, etc. and the natural calamities like heavy flood and landslide have threatened the habitat and its population in the different forest areas. The failure of reproductive cycle has additionally challenged the stability of the species, limiting its dispersal and regeneration. So, the present findings emphasize on more future critical studies on reproductive biology, entomopalynology, and

palynology of *H. aromatica.* The present study has also provided some valuable information like community characters of *H. aromatica* habitats and species composition; species association and relationship between the population size and species diversity index, which are assumed as important parameter for conservation and management of the species. There is a need of extensive and thorough survey in other forests areas of the state to locate additional distributional areas so that some suitable sites can be selected for its in-situ conservation. Moreover, there is also a need of ex-situ conservation by introducing the species in different institutional areas and botanic garden and promoting of its commercial cultivation.

Conflict of interest

The authors declared that they have no conflict of interest.

Author's Contribution

PRG, KR and BS designed the objectives and planned the work. KR undertaken the field survey and data analysis. KR and PRG formulated and finalized the manuscript.

Acknowledgements

The Authors are thankful to the Department of Environment and Forest, Govt. of Arunachal Pradesh for permission and support in field works in various forest areas. We also thank Dr. Kabuk Lego, Deputy Ranger, Mehao Wildlife Sanctuary and Forest officials of Namdapha Tiger Reserved and National Park for necessary help and support during field work. The help and information rendered by the local people of different study sites is duly acknowledged. The authors are also grateful to the Director of NERIST for providing necessary facilities. The study was undertaken as a part of the financial grant received from North Eastern Council (NEC) Govt. of India for medicinal plants.

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