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IDENTIFYING TREE ASSEMBLAGES IN THE NATURAL FORESTS OF PATHARIA HILL RESERVE, BANGLADESH: A NUMERICAL APPROACH

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EXTENDED ABSTRACT

Aims

The present study aims to identify the tree communities and their aggregation in different habitats.

Location

The location of the study was natural forests (Sagarnal and Ragna) of Patharia Hill Reserve, Bangladesh.

Methods

There were sampled in total of 60 plots (30 plots from each forest) with a plot size of 20×20 m using arbitrary sampling technique without preconceived bias to collect vegetation and environmental data. TWINSPAN (Two-Way Indicator Species Analysis) the widely recognized method using the software WinTWINS 2.3 has been used to determine the communities and to identify the indicator species.

Results

In total 60 tree species belonging to 29 families and 49 genera were identified. Family Moreceae and genus Artocarpus comprise higher species number in comparison to other families and genera. By the TWINSPAN analysis five different communities were identified. Schima wallichii-Glochidion lanceolarium community represents highest number of indicator species which mostly like the valley lands with moderately acidic soil. A distinguishing feature of Artocarpus chama-Palaquium polyanthum community is the highest number of family, genus and unique species in comparison to other communities has the strong preference for dryer land. Artocarpus chaplasha community comprises the highest tree density occur in mid hill area of the forest. Duabanga grandiflora-Chisicheton cumingianus community is enrich in soil pH, MC and K than the other communities prefer near the foothill area for their occurrence. And the habitat of the Jatropha curcas community is top hill area represents only one indicator and unique species.

Conclusions

Patharia Hill Reserve Forest has the high structural complexity and show good assemblages of tree communities. Indicator species of each community indicates the habitat types which would be helpful for conservation of the tree species by proper monitoring, mapping and decision making in management plan.

Keywords: *Forest science, Natural forests, Patharia Hill Reserve, Community, Plant species.*

1. INTRODUCTION

Community ecology is concerned with explaining the concepts of plant communities, their successions in space and time, vegetation and ecosystem classification, patterns of distribution, abundance and interaction of species. Such patterns occur at different spatial scales and can vary with the scale of observation, time, environmental variables, land use patterns and others (Levin, 1992; Rosenzweig, 1995; Maurer, 1999; Chase and Leibold, 2002). In north-eastern part of Bangladesh, the composition of forest plants is lower in forests growing on former agricultural fields (recent forests) than in older (ancient) forests, but little is known about the influence of land-use history on the degree of compositional differentiation among sites (Vellend *et. al.,* 2007). Plant ecologists have long sought to predict species occurrence from environmental characteristics, both soil and climate (Warming, 1909; Braun-Blanquet, 1932). Research on natural vegetation on floristic composition of the plant communities in Bangladesh has been largely focused for an important approach to generate and test hypothesis with respect to vegetation and environment (Hill, 1979; Podani, 2000; ter Braak and Smilauer, 2002).

North-eastern forests of Bangladesh cover an area of 40000 ha (FD, 1996). Only a small part of the area (118.46 ha) comprises of fresh water swamp forest (Choudhury, 2003) and the rest are hill forests having a mixture of tropical evergreen and deciduous vegetations. Three reserve forest namely Patharia Hill Reserves (13725 ha), Tarap Hill Reserves (1095 ha) and Raghunandan Hill Reserves (4046.86 ha) represent the latitudinal gradient of the north-eastern hill system. Among these Patharia Hill Reserve is one of the most biologically diverse and ecologically least explored reserves (Muzaffer *et al*., 2007) and comprised of a number of natural fragments. An extensive bibliographic search showed that the study on floristic composition, community classification and interactions between vegetation and environmental variables has been poorly studied in descriptive way or many cases absent in the forests of Bangladesh. Specifically, in the natural fragments of the Patharia Hill Reserve no studies have examined the associations of vegetation patterns and the variation in plant community structure and composition. So, the current study aims to identify the tree communities by the numerical approach as this system maintains a systematic way of classification and leads to a quickest as well as easiest identification of species composition and habitat types of the communities of Patharia Hill Reserve. The main objective of this study is to identify the tree communities and their aggregation in different habitats. In detail, to classify tree species into groups based on their abundance value, to find out the indicator species of the communities, to explore the distribution of the tree communities in different topographical zones.

2. METHODOLOGY

2.1 Study Site

The study area was Sagarnal and Ragna forests which are situated in the Patharia Hill Reserve, Bangladesh. It stretches between $24^0$55ʿ238ʿʿ-$24^0$32ʿ580ʿʿN latitudes and $91^0$50ʿ028ʿʿ-$92^0$11ʿ762ʿʿE longitudes. It is located at Moulovibazar Range -1 under the Sylhet Forest Division, Bangladesh. Juri Natural Forest covers an area of 6870.58 ha and it is divided into four forest beats namely Lathitila (2279.91 ha), Putichara (1368.01 ha), Sagornal (1724.69 ha) and Ragna (1497.97 ha). The present study sites comprise of the two natural vegetation patches of Ragna beat and Sagarnal beat. The topography of the area varies from medium to steep slopes and water streams which locally called as Chara. Several channels with many tributaries spread over the forest (IUCN, 2004). The forest content several hills of different elevations with undulating valleys. The climate is in general warm and humid but the weather is cool and pleasant during winter. The temperature varies on an average from nearly 27°C in February to nearly 36°C in June. The humidity is high in the forest throughout the year, with monthly average humidity varying from 74% in March to 89% in July. There is heavy dew during winter when rainfall is low (Rosario, 1997). The water condensation is thus distributed throughout the year in different forms and greatly influences plants and wildlife. The area covered under the forest is one of the wettest in the country and so the rainfall is quite high with an annual average of 4,000 mm approximately, with maximum rainfall falling during June to September for South-West monsoon (IUCN, 2004).

2.2 Methods

The fieldwork was conducted in October-December, 2011. During early reconnaissance survey it was documented that tree species are generally aggregated in different habitats. Among the four beats of the Patharia Hill Reserve, Ragna and Sagarnal were chosen in this study as these two forests comprise of natural vegetation patches. In total 60 plots (30 plots from each forest) with a plot size of 20×20 m were selected using arbitrary sampling without preconceived bias (McCune and Grace, 2002) sampling technique to collect vegetation and environmental data. Above 7 cm. d.b.h., all the species were counted as tree species. All the tree species were identified to their appropriate taxa by the local expert knowledge and Encyclopedia of Flora and Fauna of Bangladesh by Asiatic Society of Bangladesh (2009) were used to determine the local and scientific names along with their family and genus. Soil pH, moisture content (%), elevation (m) were measured as environmental data. Data of soil pH and moisture content were taken by the help of digital soil pH and moisture meter, elevation data were collected by the help of hand-held digital GPS (Global Positioning System) machine. Four soil samples from each corner of the plot were picked up with the help of cylindrical soil borer; soil samples of 10cm were extracted. These were pulled together and mixed thoroughly in the field and marked as one sample which used to measure environmental variables. For the identification of the concentration of N, P, K and soil organic matter, soil samples were dried into open air circulated area rather than direct sunlight for a week. Then these soil samples were taken to SRDI (Soil Research Development Institute) to measure P, K, N, and OM.

To determine the communities and to identify the indicator species TWINSPAN (Two-Way Indicator Species Analysis) the widely recognized method using the software WinTWINS 2.3 (Hill, 1979; modified by ter Braak, 1987) has been used. TWINSPAN was applied using default options for minimum group size for division (5); maximum number of indicator species per division (7); pseudo-species cut levels 0, 0.05, 0.1, 0.2. Three levels of division were used. First two indicator species were used to name the respective community.

3. RESULT AND DISCUSSION

3.1 Result

Vegetation survey yielded in total 60 tree species belonging to 29 families and 49 genera. Family Moreceae and genus Artocarpus comprise higher species number in comparison to other families and genera. The relationship between species and sample plots can be easily seen in the results of the TWINSPAN result Figure.1. Summary of the TWINSPAN classification are given in Figure.2. The tree communities of this forest are considered with *Schima wallichii-Glochidion lanceolarium; Artocarpus chama-Palaquium polyanthum; Artocarpus chaplasha; Duabanga grandiflora-Chisicheton cumingianus*; *Jatropha curcas* indicator species (Fig.2). Summary of the communities are presented in Table.1. The community types with their dominant and unique species are given in Table.2.

Community Type A: *Schima wallichii-Glochidion lanceolarium*

Schima wallichii-Glochidion lanceolarium community consists of 12 sample plots with 27 tree species belonging to 15 families and 23 genera. These species mostly occur near the foothill or valley land of the hill. Mean elevation of this community is 34.37 m (with respect to above mean sea level, AMSL). The typical feature of this community indicates that the soil is moderately acidic with a mean pH 5 (±0.23) and tree density of this community is 216.67 ha^{-1}.

Community Type B: *Artocarpus chama-Palaquium polyanthum*

Artocarpus chama-Palaquium polyanthum community consists of the highest number sample plots (29), and tree species (35) belonging to 18 families and 33 genera. All the plots of this community mostly occur in the middle slope of the hill and the mean elevation is 40.97 m (with respect to above mean sea level, AMSL). The soil profile of this community indicates that it consists the highest

amount of N (0.104±0.06) and OM (1.99±1.15) than the other communities. Soil is moderately acidic. Tree density is 216.37 ha^{-1}. This community also horbors the highest number (9) of unique species.

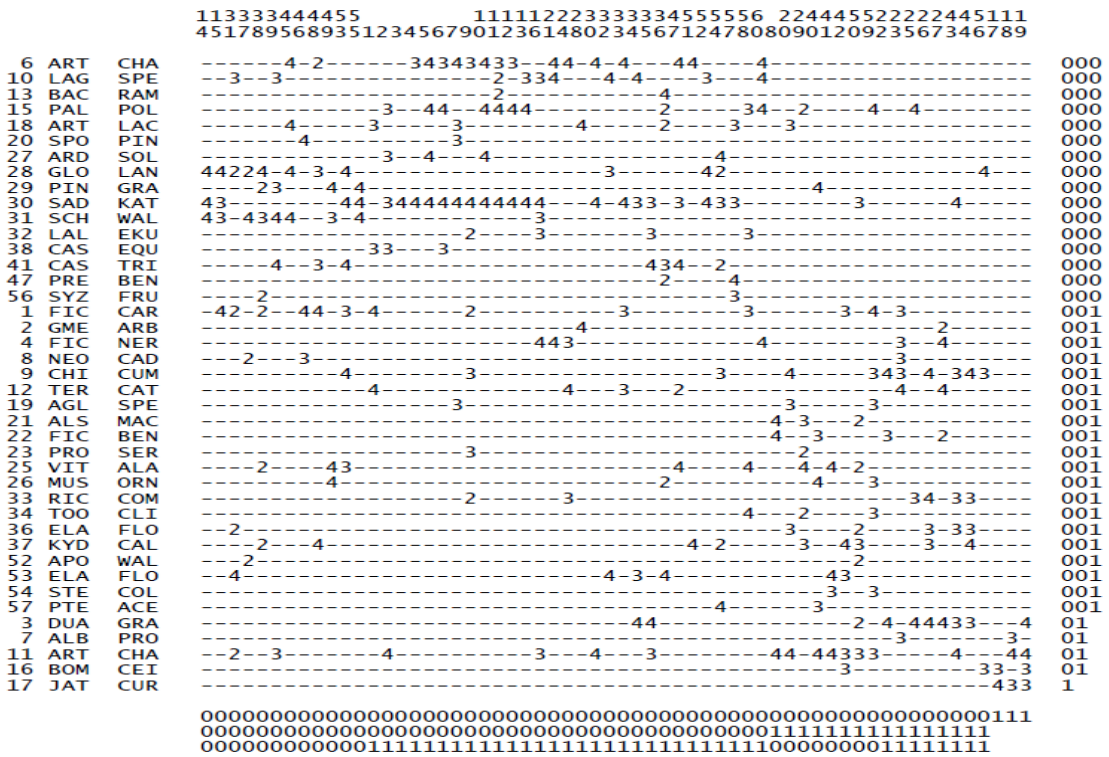

Figure.1: Two way ordered table of species and sample plots produced by TWINSPAN. Sample unit numbers are arrayed across the top by stacking the digits, species number (with scientific name) are arrayed along the left side. The patterns of zeros and ones below and on the right side indicate successive divisions of sample units and species respectively.

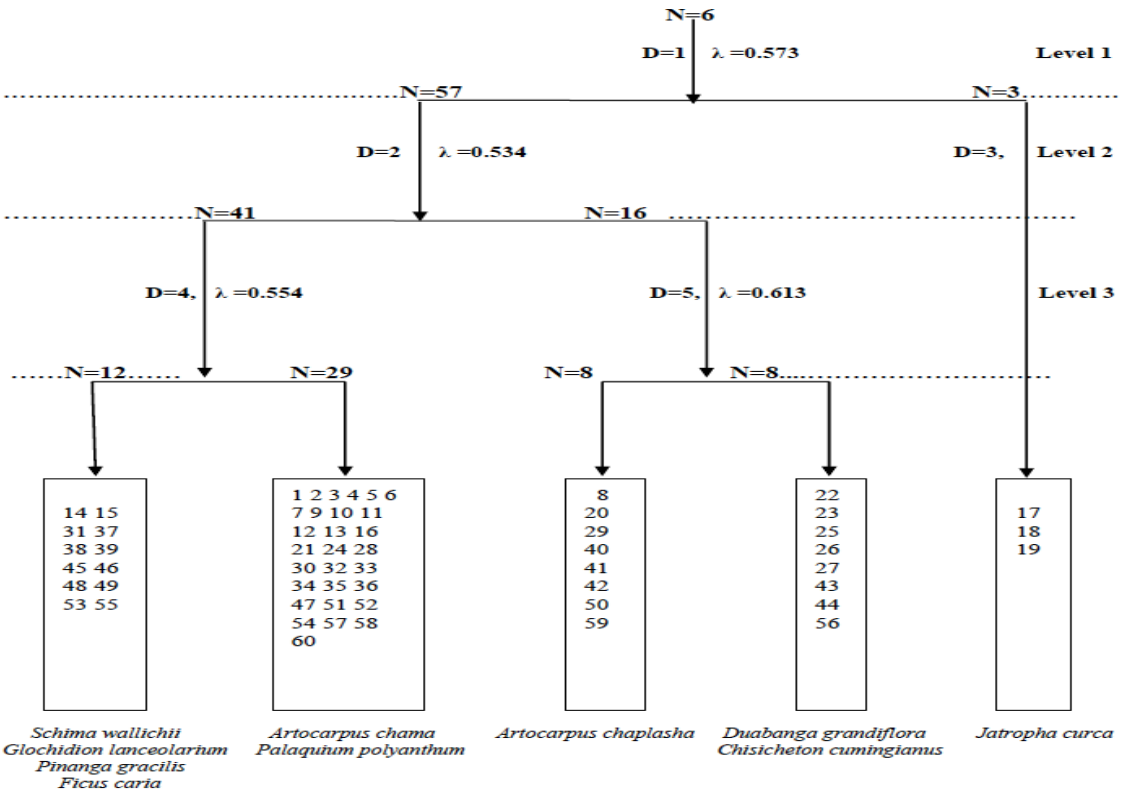

Figure.2: Tree communities identified by TWINSPAN. Sample plots (N), indicator species and respective eigenvalues (λ) of each division are indicated.

Community Type C: *Artocarpus chaplasha*

Artocarpus chaplasha community represents 8 sample plots with the number of tree species is 26 which belongs to 17 families and 23 genera. Tree density is the highest among the communities and it is 221.88 ha^{-1}. Most of the species of this community occur in the higher slope of the hill and the mean eleviation with standard deviation is (57.75±23.02) . Soil is moderately acidic with the value of pH (4.99±0.29). It shows the lowest MC (37.16±7.93).

Community Type D: *Duabanga grandiflora-Chisicheton cumingianus*

This community belongs to 8 sample plots with tree species (20) which represents 15 families and 17 genera. Most species occur in moist land of lower slope or near the foothill and it is moderately dense community among the five community gropes. Typical analysis of the soil of this community shows that this community is enrich in pH(5.08±0.58), MC(50.16±13.25), and K(2.51±0.95). These three soil variables show the highest amount of their values among the five communities.

Community Type E: *Jatropha curcas*

Jatropha curcas community has the 3 sample plots with tree species 5 which belong to 5 families and 5 genera. It represents only one unique species and tree density is 216.67 ha^{-1}. The mean elevation of this community is 105.67 (±37.61) (with respect to above mean sea level, AMSL). So the species of this community mostly occur in the pick hill area. Typical analysis of the soil shows that this community is enrich in P(1.74±1.71) and soil is moderately acidic with pH value 4.93(±0.40).

Table.1: Summary of community types with their indicator species and environmental conditions.

Community types	***Schima wallichii-Glochidion lanceolarium***	***Artocarpus chama-Palaquium polyanthum***	***Artocarpus chaplasha***	***Duabanga grandiflora-Chisicheton cumingianus***	***Jatropha curcas***
Indicator species	*Schima wallichii* *Glochidion lanceolarium* *Pinanga gracilis* *Ficus caria*	*Artocarpus chama* *Palaquium polyanthum*	*Artocarpus chaplasha*	*Duabanga grandiflora* *Chisicheton cumingianus*	*Jatropha curcas*
Plot Num.	12	29	8	8	3
Habitat	Valley land	Dryer land	Mid hill	Moist land	Hill top
No. of species	27	35	26	20	5
No. of unique species	6	9	6	3	1
No. of family	15	18	17	15	5
No. of genus	23	33	23	17	5
Density (ha^{1-})	216.67	216.37	221.88	212.5	216.67
Mean value of environmental data with standard deviation					
Soil pH	5.0±0.23	4.96±0.34	4.99±0.29	5.08±0.58	4.93±0.40
N	0.09±0.035	0.10±0.06	0.09±0.064	0.07±0.055	0.08±0.05
P	0.73±1.25	1.04±1.17	0.41±0.65	0.14±0.025	1.74±1.71
K	2.09±1.035	1.82±1.70	2.42±1.35	2.51±0.95	0.68±0.81
OM	1.96±0.73	1.99±1.15	1.96±1.32	1.39±1.12	1.61±0.99
Soil MC (%)	47.54±14.94	42.03±9.84	37.16±7.93	50.16±13.25	41.33±11.02
Elevation (m)	34.17±6.64	40.97±16.65	57.75±23.02	33.25±10.95	105.67±37.61

Table.2: Summary of community types with their dominant and unique species

Community types	**Dominant species**	**Unique species**
A: *Schima wallichii-Glochidion lanceolarium*	*Schima wallichii* (DC.) Korth. *Glochidion lanceolarium* Roxb. *Ficus caria* L.	*Grewia nervosa* (Lour.) Panigr.*Sapium baccatum* Roxb. *Acronychia pedunculata* (L.) Miq. *Artocarpus heterophyllus* Lamk. *Mangifera indica* L. *Glochidions phaerogynum* (Muell.-All) Kurz
B: A*rtocarpus chama-Palaquium polyanthum*	Sadakath* *Artocarpus chama* Buch.-Ham. *Palaquium polyanthum* Engl. *Lagerstroemia speciosa* (L.) Pers.	*Baccaurea ramiflora* Lour. *Drimycarpus racemosus* Hook. *Ficus semicordata* Buch.-Ham *Casuarina equisetifolia* Forst. *Dillenia indica* L. *Premna benghalensis* K. Schum. *Aegla mermelos* (L.) Corr. *Bauhinia purpurea* L. lal ekush*
C: *Artocarpus chaplasha*	*Artocarpus chaplasha* Roxb. *Vitex alata* Roxb.	*Alstonia macrophylla* Wall. *Vallaris solanaceae* (Roth) O. Kuntze *Pithecellobium angulatum* Benth. *Calophyllum polyanthum* Wall. *Stereospermum colais* Bauch.-Ham. *Flacourtia indica* (Burm. f.) Merr.

Community types	Dominant species	Unique species
D: *Duabanga grandiflora-Chisicheton cumingianus*	*Duabanga grandiflora* Roxb. *Chisicheton cumingianus* Harms.	*Ficus virens* Ait. *Vatica lanceaefolia* (Roxb.) Blume *Michelia oblonga* Wall.
E: *Jatropha curcas*	*Jatropha curcas L.* *Artocarpus chaplasha* Roxb.	*Jatropha curcas* L.

*unidentified species

3.2 DISCUSSION

In tropical region of Bangladesh, several studies have documented that, Patharia Hill Reserve as the tropical forest region also show the high degree of variability in tree species composition which is strictly influenced by the variation of environmental gradients in different parts of the forest (IUCN, 2004; Uddin and Hassan, 2011). In this study, the community types were defined for the Natural Forest of Patharia Hill Reserve. Five plant community types were generated after application of Two Way Indicator Species Analysis (TWINSPAN) to the cover estimates of 60 species in 60 plots. In the first division of TWINSPAN analysis, 60 quadrates have divided to two clusters that the left direction exists 57 quadrates and exists no indicator species. In right direction there exist 3 quadrates with *Jatropha curcas* indicator species. In level 2, 57 quadrates have divided into two (41 and 16). And in level 3, 41 quadrates divided into two (12 and 29) and 16 quadrates also divided into two (8 and 8) with their representive indicator species. Finally, five plant community types were identified after the application of TWINSPAN program which represented the tree species within these communities show topographical preference to co-exist. The community types are named after the characterizing species as follows: (1) *Schima wallichii-Glochidion lanceolarium,* (2) *Artocarpus chama-Palaquium polyanthum,* (3) *Artocarpus chaplasha,* (4) *Duabanga grandiflora-Chisicheton cumingianus,* (5) *Jatropha curcas. Schima wallichii-Glochidion lanceolarium* community prefers valley land and remains wet in the year round. In this community there are four indicator species- *Schima wallichii, Glochidion lanceolarium, Pinanga gracilis, Ficus caria* and also have six unique species- *Grewia nervosa, Sapium baccatum, Acronychia pedunculata* etc. *Artocarpus chama-Palaquium polyanthum* community has two indicator species whose names are used for naming this community. Sadakath and *Artcarpus chama* are the highly dominant species of this community which survive in the dryer land of the forest. This community also belongs to the highest number of the family, genera and unique species. *Artocarpus chaplasha* community has the only one characteristic species names *Artocarpus chaplasha*. The habitat of this community is in the mid hill of the forest. Some unique species of this community are *Alstonia macrophylla* Wall., *Vallaris solanaceae, Pithecellobium angulatum* etc. *Duabanga grandiflora-Chisicheton cumingianus* community survives in moist land as their habitat is in the low land. Water loving species are grown in this community as they can easily absorb the moister from the soil. *Ficus virens* Ait., *Vatica lanceaefolia, Michelia oblonga* Wall. are the unique species of this community. *Jatropha curcas* is the last community type among the five communities. The habitat of this characteristic species is in the top hill of the forest as the species of this community survive in high elevation of the hill. *Jatropha curcas L. and Artocarpus chaplasha* are the dominant species and *Jatropha curcas L.* is only one unique species of this community.

Implications for conservation

Plant communities are the assemblages of plant species showing different habitat variation along with their environmental variables. So to determine the pattern of the habitat of plant community, classification is needed and this classification is an important tool for the conservation because it is not possible to conserve all the individuals of the whole forest area but it will be more easy to conserve the species if all species are classified into different communities depend on their habitat type, environmental gradients as like soil pH, moisture content etc. In this study five plant communities are found which represent most of the species and their habitat types of the Patharia Hill Reserve Forest. For each community there has some indicator species which represent the probability of occurrence of the species. All the five communities have some unique species which are found only

in their specific community. In Bangladesh forests are now under threat not only for the anthropogenic pressure but also for the climate change. So conserving the remaining vegetations has become forefront. The knowledge of successful conservation is required which can facilitate in the decision making for the conservation of the forest. Distribution of the tree communities presented in this study can help to make the proper vegetation monitoring and to assess the site qualities for the species occurrence. It also provides technique for ranking tree communities with respect to their importance in conservation management planning and to develop the habitat maps and habitat suitability indices which in future will help to identify the change of land use pattern and the effect of climate change. However, further research is required to provide a meaningful integration of the environmental factors and ecosystem processes effecting the distribution and abundance of tree species in the natural forest of Patharia Hill Reserve.

4. CONCLUSIONS

Patharia Hill Reserve Forest represents the high structural complexity and it also seeks high degree of conservation technique. The floristic composition is quite good and helps to create significantly distinct groups. TWINSPAN analysis of this study identified five communities namely (1) *Schima wallichii-Glochidion lanceolarium*, (2) *Artocarpus chama-Palaquium polyanthum*, (3) *Artocarpus chaplasha*, (4) *Duabanga grandiflora-Chisicheton cumingianus*, (5) *Jatropha curcas* with 60 tree species where *Artocarpus chama-Palaquium polyanthum* community has the highest number of plots, family genera and unique species. In indicator species analysis *Schima wallichii*, *Glochidion lanceolarium* etc. was found to be the indicator species of valley land with moderate pH, *Artocarpus chama* and *Palaquium polyanthum* are the indicator species of the dry land with moderate slopes. *Artocarpus chaplasha* is the only one indicator species of community type C which indicates that the species of this community occur in the mid hill with dry soil or low moisture content. *Duabanga grandiflora* and *Chisicheton cumingianus* are the indicator species of the moist land with low elevation and *Jatropha curcas* is the only one indicator species of the top hill with moderate soil pH and moisture content. These indicator species of five communities represent the species distribution and the habitat pattern for each community uniquely. And five communities have some unique species which are not found without their each specific community. So understanding the community classification is needed for successful ecological restoration and conservation activities. Though the vegetation of forest of Bangladesh is under threat, this study can be helpful for conservation of the remaining natural patches of the Patharia Hill Reserve forest by proper monitoring, mapping, assessing site qualities and in decision making of the management plan.

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