INVENTORY AND ASSESSMENT OF BIODIVERSITY

Rapid Biodiversity Survey Report - III

Pleione hookerianum

Department of Forest, Environment and Wildlife Management
Government of Sikkim
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MESSAGE

Sikkim, covering just 0.2 % of the geographical area of India, has 26% of the Country's total bio-diversity and has been identified as one of the hotspots in the Eastern Himalayas. The State has drawn the attention of many for botanical exploration in the past and such interests have increased over the years.

Inventory of Biodiversity RBS III is one of the series of publications on biodiversity of Sikkim showcasing the richness of biodiversity in few of the Protected Areas and Reserved forests of Sikkim. These publications are valuable as it provides the much required baseline data on biodiversity for Management Plans of Protected Areas, Working Plans of Forest areas and Ecotourism activities.

We are grateful to JICA for facilitating the study on Biodiversity of Sikkim and compilation of such scientific data. I would also like to record my appreciation to the Department of Forests Environment and Wildlife Management for the publication.

(Pawan Chamling)

T.W. Lepcha

Foreword

I am delighted to present the Inventory of biodiversity – RBS III published under Sikkim Biodiversity Conservation and Forest Management Project (SBFP).

This publication is a compilation of scientific datas, which are very handy and immensely useful to the students, researchers, policy planners, tourists and civil society. It is evident that these series of puclications on biodiversity of Sikkim are of great service to the forest managers in formulating management plans of PAs/working plan/ecotourism activities.

I wish the Sikkim Biodiversity Conservation and Forest Management Project (SBFP) team all success in its efforts to publish the series on biodiversity of Sikkim.

(T.W. Lepcha)

Minister for Forests Environment & Wildlife Management Department/Mines, Minerals & Geology,Science and Technology Department, Government of Sikkim.

Dr. Thomas Chandy

Preface

Biodiversity Conservation is one of the major component under JICA assisted Sikkim Biodiversity Conservation and Forest Management Project (SBFP) and inventorization of biodiversity is the main activity undertaken to collect the baseline data on biodiversity for betterment of conservation initiatives, policy decisions, future reference and monitoring.

So far, two publications Rapid Biodiversity Survey Report I & II have been published which portrays the biodiversity found in most of the Protected Areas in Sikkim.

The present compilation is one of the series in biodiversity publication based on Rapid Biodiversity Survey studies done in few of the Protected Areas and Reserve Forests. We are happy that these scientific databases are being utilized for better management of forest & wildlife in Sikkim. We are also hopeful that a strong linkage can be built between these scientific studies, management practices and livelihood of the people.

(Dr. Thomas Chandy) IFS,
Principal Chief Conservator of Forest-cum Principal Secretary,
Sikkim Conservation and Forest Management Project,
Forest Environment & Wildlife Management Department.

Foreword

I am immensely pleased to present the Inventory of biodiversity-RBS III published under Sikkim Biodiversity Conservation and Forest Management Project (SBFP).

Biodiversity Conservation is one of the core activity of SBFP, JICA and sincere efforts have been made to inventorise the biodiversity of different forest areas including Protected Areas to showcase the richness of our State. This publication is one of the series of Rapid Biodiversity Survey Report and is being referred by the forest managers for writing management plans as well. We hope this series of publication would be a great asset to the whole society in days to come.

C. S. Rao, IFS
APCCF-cum-Project Director
Sikkim Biodiversity Conservation and Forest Management Project
Department of Forests, Environment and Wildlife Management Project
Government of Sikkim

Acknowledgement

This book titled "Inventory of Biodiversity Rapid Biodiversity Survey-Report III" is the compilation of study reports of Rapid Biodiversity Survey works done in various Protected Areas and a Reserved Forest and is one of the series in Rapid Biodiversity Survey publications. We are hopeful that this compilation will be useful for Forest Managers, Researchers, Students and Policy makers as well.

On behalf of Sikkim Biodiversity Conservation and Forest Management Project, Department of Forests, Environment and Wildlife Management, Government of Sikkim, I would like to acknowledge the significant contribution of the following institutions and individuals.

Firstly, we are thankful to Japanese International Co-operation Agency for their support and providing necessary guidance.

We are grateful to Government of Sikkim for their support and encouragement in publishing such scientific reports.

Heartful thanks to our GIS and Survey team of SBFP for their inputs and support and dedication in fieldworks.

We would also like to extend our humble and sincere gratitude to Dr. Thomas Chandy, Pr. Secretary-cum- PCCF, FEWMD and Shri C.S. Rao, CCF-cum- Project Director, SBFP, FEWMD for their continuous guidance and encouragement in our endeavor.

Udai Gurung, IFS
Additional Project Director - II
Sikkim Biodiversity Conservation & Forest Management Project
Department of Forests, Environment & Wildlife Management
Government of Sikkim

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Introduction

Plant communities are the foundation for terrestrial plants and animals habitat supporting large species composition and their physiognomy (Gates, 1993). These plant communities together form a vegetation type of a certain area exhibiting a unique system having its own structural, functional and spatial features that define the habitat type selected by plants and animals. Quantitative assessment and analysis of community structure are important for the precise evaluation of biodiversity and a necessary context for planning and interpreting long-term ecological research. The quantitative analysis/study of vegetation is called "Phytosociology" and its aim is to describe the vegetation, explain or predict its pattern and classify it in a meaningful way. This term was suggested by Paczoski in 1896 (Gehu, 2011). A Phytosociological study is a prerequisite for understanding the structure and function of any forest tract.

Field studies of vegetation began in the early 19th century with the work of Alexander von Humbolt (1805) in plant geography that dealt with the study of spatial distribution of taxa and their evolutionary relationships and has become a novel of the natural sciences (Causton, 1988; Randall, 1978). In recent years, the baseline value of vegetation is becoming so important that standardized classification of ecological communities using vegetation has been recognized as an essential tool for identification, monitoring and conservation of ecosystems (Grossman et al. 1988).

Rapid Biodiversity Assessment approach is a tool developed by Conservation International for systematic biodiversity data collection and has been well accepted throughout the world. It is a medium of quickly collecting information on the floral and faunal species present in a given area and provides key information that can be used to manage and protect species of conservation concern and overall biodiversity. Under Biodiversity Conservation Component of SBFP (Sikkim Biodiversity Conservation and Forest Management Project), Rapid Biodiversity Survey is being carried out in different protected areas, buffer zones and reserve forests of Sikkim with the aim:

1) To develop baseline information on key biological elements in forest, alpine, freshwater and agro ecosystems for monitoring and evaluation of the impacts of forest and biodiversity management,

2) To identify critical areas that require immediate protection. As the forest and biodiversity information base synthesizes information from both the biophysical and social sciences, it should be accurate and complete.

Under this subcomponent, rapid biodiversity surveys, which would display the ecosystems throughout the state, will be conducted. The survey will be carried out using both the coarse filter and fine filter approaches.

(a) Implementation of Rapid Biodiversity Survey (1,000 sample plots)

Approximately 1,000 sample plots will be randomly generated throughout Sikkim for quantitative biodiversity study using the digital spatial information base (in case the randomly selected plots are the point which is not important due to the snow covered area, such plots are not necessarily included).

(b) Detailed Survey at Hotspots (300 sample plots)

In addition, known hotspots in forest, alpine, freshwater, and agro-ecosystems will have approximately

300 more plots to present more detailed information. Enumeration and observation of all sample plots will be conducted.

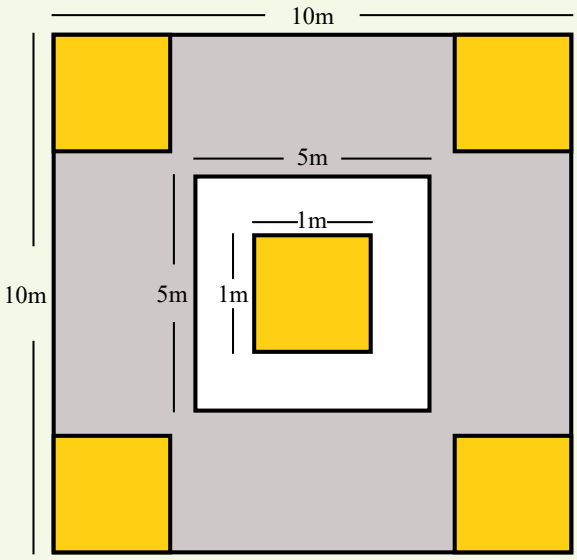
Sikkim being an integral part of eastern Himalaya with an area of 7096sq. km under Himalayan (2) Bio-geographic zone and Central Himalaya (2c) biotic province. Its altitude varies from 225m in the south to 6100m in the north and north-east and 8598m in the north-west and constitutes a diverse habitat for both flora and fauna. India is one of the twelve mega diversity centers of the world. Sikkim state harbour over 4500 species of flowering plants, 410 pteridophytes (Kholia, 2014), over 16 species of conifers, 39 species of Rhododendrons (Dahal et al., 2017), Bamboos over 20 species, medicinal plants 490 species (Sharma & 30 species, Mammals over 144 species, Birds 550 species, fishes over 48 species, butterflies over 600 species. An account of the rich biodiversity of the state has been provided by Hooker JD (1872-1897), Stapf .O (1905), V (2001), Gammie GA (1893), Polunin. O and Stainton. A (1984), Lucksom S.Z. (2007), Sharma TP & Sharma S (2010), Hooker JD (1849), Arrawatia and Tambe (2011), Ali. S (1989), Kholia (2010), Kholia (2014), Das (2009), Maiti and Maiti (2007), S (2015-16), Pradhan & Badola (2008), Pradhan KC (2008), Pradhan UC and Lachungpa ST (1990), Pradhan BK et al (2013), Pradhan BK et al (2015), Dahal S (2015-16), Dahal S, Sharma TP and Borthakur SK (2017), Sabita Dahal et al (2017) in the form of flora, orchids, medicinal plants, Rhododendrons, ferns and ferns allies, avifauna, mushrooms etc. In order to protect such rich bio-resources of the state, 46.93% of the total geographical area of Sikkim has been brought under the Protected Area Network (PAN) within the four broadly classified vegetation zones viz.; Tropical, Temperate, Sub alpine and Alpine regions. Recently during 2015, Sikkim Biodiversity Conservation and Forest Management Project under the Department of Forest, Environment and Wildlife Management, Government of Sikkim have come out with the Rapid Biodiversity Survey Report – I and Rapid Biodiversity Survey Report – II after conducting Rapid Biodiversity Survey along various sampling paths in Fambong Lho Wildlife Sanctuary (East Sikkim), Khangchendzonga Biosphere Reserve (West Sikkim & North Sikkim), Maenam Wildlife Sanctuary (South Sikkim), Shingba Rhododendron Sanctuary (North Sikkim) etc.

The book **Inventory of Biodiversity Rapid Biodiversity Survey Report – III** is one of the series in RBS publilications and is sequel to Rapid Biodiversity Survey Report – I and Rapid Biodiversity Report – II. These reports are an attempt to assess the present phytosociological status of Kitam Bird Sanctuary and Tendong Reserve Forest in South Sikkim, Barsey Rhododendron Sanctuary in West Sikkim and Thangu – Lashar Valley (Lachen RF) in North Sikkim. This book also contains the compilation of various publications including research papers and articles under Sikkim Biodiversity Conservation and Forest Management Project (SBFP).

METHODOLOGY

Inventory and monitoring of the biodiversity were done using Rapid Biodiversity Survey Techniques (RBST). Prior to field work, literatures were scrutinised to have a general idea about the biodiversity of the area (Polunin and Stainton, 1984; Stainton, 1988; Hooker, 1871-1897; Sharma and Sharma, 2010; Dahal S. 2015-16; Arrawatia & Tambe, 2011; Lachungpa et al., 2007; Kholia, 2010 & 2014; Das 2009; etc.) including web references such as (*www.efloras.org; www.flowersofindia.net* etc.). The checklist of the species (both flora and fauna) was prepared and was taken to the field to confirm their presence in the study area. During the field work, general listing of all the species occurring in the area (both flora and fauna) were made to have fair knowledge on the biodiversity of the area.

In the field, the quantitative as well as qualitative data on floral biodiversity was recorded using a Standard Quadrat Sampling method, wherein, a random plot of 10m x 10m were established which was followed



Sampling Plot Design For Vegetation Survey

by l of plot after every 0.5 to 0.6 km approximate distance. Within the plot, all the tree species were listed and the individual tree width CBH> 30 cm (1.3 m above the ground) was measured. Within the mother plot, a quadrat of 5m x 5m was laid in the centre to record the number of saplings present; the same quadrat was used to record the percent cover of the shrub species. 5 number of 1m x 1m quadrat were laid; 2 at the alternate corners of the 5m x 5m quadrat and 1 at the centre for recording the percent cover of the herb species; the same quadrat was used to record the number of seedlings. General listing of all the species (flora) encountered along the sampling plots as well as outside were also done to have fair idea on the species availability in the area. Parameters such as coordinates and altitude of each sample plots were recorded using hand held GPS; slope aspect and slope angle of each plots were also recorded.

In case of trees, recorded data were analyzed for density, frequency, abundance, basal area etc. Importance value index (IVI) was determined as the sum of percentage density and percentage basal area. Species diversity for each plot was determined with the Shannon and Wiener information function, which reads as $H'=-\Sigma(ni/N) \log_2 ni/N$, where 'ni' represents total number of individuals of particular species, and 'N' represents total number of individuals of all species. Species richness was calculated using Margalef's index as $I=(S-1)/\ln(N)$, where 'S'=the number of species in the sample and 'N'=the total number of individuals in the sample. Species evenness was determined by Shannon index of evenness as, $E=H/\ln(S)$ where 'H'=Shannon' Index of diversity and 'S'=number of species in the sample. Concentration of dominance was measured by Simpson's Index, which reads as, $D=\Sigma(n_i/N)^2$ where, 'n_i'represents total number of individuals of particular species and 'N' represents total number of individuals of all species. In case of shrubs and herbs, populations were calculated in terms of Average Percent Cover.

1. Frequency (F) = $\frac{\text{Total no. of quadrates in which species occurred}}{\text{Total no. of quadrates studied}} \times 100$

2. Density (D) = $\frac{\text{Total no. of individual in all the quadrates}}{\text{Total no. of quadrates studied}} \times 100$

3. Abundance (A) = $\frac{\text{Total no. of individual of a species}}{\text{Total no. of quadrates in which the species occurred}} \times 100$

4. Basal cover = $Pi*r^2$ (where, "Pi" is a constant value = 3.14 and "r" is the radius)

5. Relative frequency (RF) = $\frac{\text{Frequency of a species}}{\text{Frequency of all species}} \times 100$

6. Relative density (RD) = $\frac{\text{No. of individual of a species}}{\text{Total no. of individual of all species}} \times 100$

7. Relative dominance (RDo) = $\frac{\text{Total basal cover of individual species}}{\text{Total basal cover of all species}} \times 100$

8. Importance value index (IVI) = Relative density (RD) + Relative frequency (RF) + Relative dominance (RDo)

9. Species diversity for each plot was determined by the Shannon – Weiner diversity index as:

$$H' = -\sum_{S} ((ni/N) \log_2 ni/N)$$

Where, i = 1; '**ni**' represents total number of individuals of particular species and '**N**' represents total number of individuals of all species.

10. Species richness is the number of species per unit area and is determined using Margalef's index as:

$$I = (S-1)/\ln(N)$$

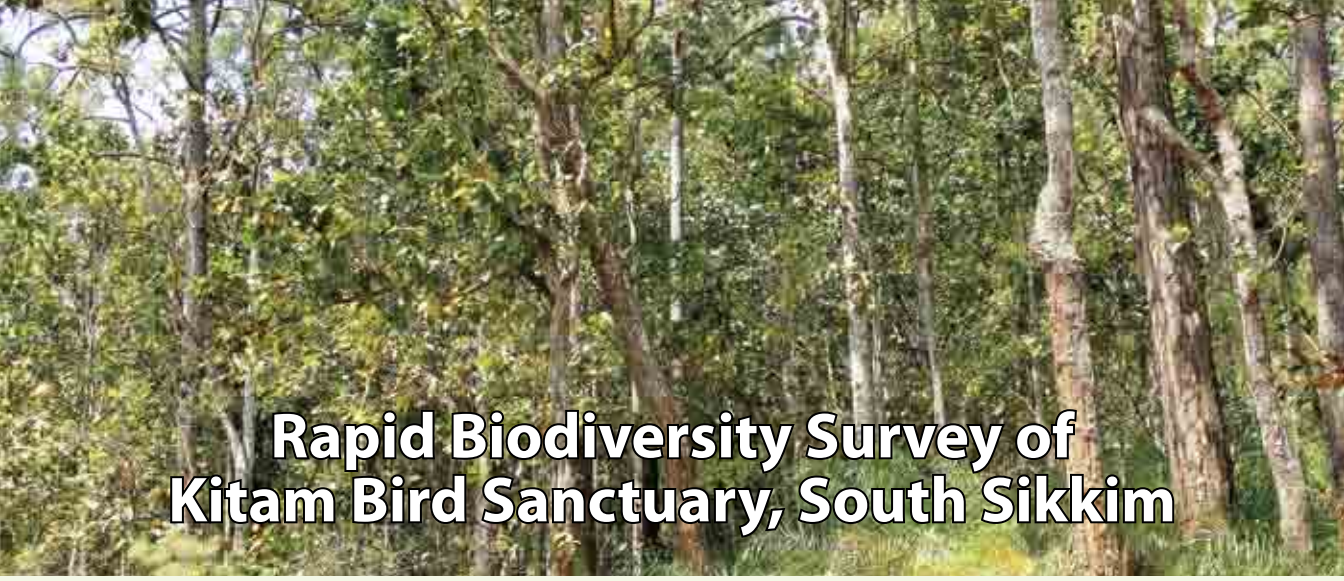
Where, '**S**' represents the number of species in the sample and '**N**' represents the total number of individuals in the sample.

To record the faunal element occur in the area, trail sampling (walking through the trail) and sign surveys (records of digging sign, foraging sign, hoof mark, etc.) were made. During the survey, direct evidences like call sound and indirect evidences like feather, pellets, scats, droppings etc. were recorded. Photo capture was also done, depending upon the feasibility.

Classification scheme of Forest Survey of India (FSI) were followed to analyse forest density on the basis of canopy cover which are defined herewith:

Very Dense Forest	Canopy density of 70% and above
Mod Dense Forest	Canopy density between 40% and 70%
Open forest	Canopy density between 10% and 40%
Scrub	Forest land with poor tree growth, mainly small or stunted trees having canopy density less than 10%

Aconitum palmatum



Rapid Biodiversity Survey of Kitam Bird Sanctuary, South Sikkim

Sabita Dahal, Dorjee Chewang, Sumitra Nepal, Sanchi Subba

STUDY AREA

A field trip for conducting Rapid Biodiversity Survey to Kitam Bird Sanctuary, South Sikkim were carried out during March 2016, sample plots of which are represented by Figure 1. Kitam Birds Sanctuary is the only bird's sanctuary in Sikkim and was declared in 2006 vide notification number 37/FEWMD dated 17th June 2006 under the provision of Wildlife (Protection) Act, 1972. The sanctuary is one of the much promoted eco-tourism potential zone with respect to its ecological, floral, faunal, and natural significance and hence, a need for the protection, propagation and development of wildlife and its environment. The area of the sanctuary is 6.0 square kilometers and is located in the tropical eco-region at an altitudinal range of 320-875m from the mean sea level. An area upto 25m from the boundary of Sanctuary has been extended and notified as an eco-sensitive zone, in which, lies two villages namely Upper Kitam and Lower Kitam and in the southern part up to the outer bank of the river Rangeet. The eco sensitive zone of the sanctuary lies between 27˚5'53" N to 27˚7'15"N latitude and 88˚21'7" E to 88˚21'51" E longitude bordering with West Bengal by Great Rangeet River. The slope angle of the sampled sites ranged between mild (10 degree) to 40 degree and was faced towards E, N and NE aspect (**Annexure I**). The area is prone to the forest fire which is a continuous phenomenon especially during the month of March – April. This has caused severe damages to the biodiversity of the area.

The forest types of the sanctuary were represented by Sub-Tropical Mixed Broad Leaved Forests with a unique association of *Shorea robusta* (Sal) and *Pinus roxburghii* (Chir Pine). Ground is highly covered with saplings and seedlings of *Phoenix sylvestris.* The other plant species available in the area are *Terminalia chebula*, *Terminalia bellirica*, *Castanopsis* sp., *Engelhardtia* sp., *Tectona grandis, Woodfordia fruiticosa*, *Bauhinia vahlii, Anthocephalus cadamba, Oroxylum indicum, Eugenia kurzii, Asparagus racemosus, Piper* sp. etc.

The sanctuary harbours common mammals such as *Panther pardus* (Common Leopard), *Paguma larvata* (Himalayan Palm Civet), *Sus scrofa* (Wild Boar), *Hystrix brachyuran* (Crestless Porcupine), *Manis pentadactyla* (Chinese pangolin) etc. The Indian Rock Python is common among the Reptiles. The Avi fauna includes Peafowl, Black Crested bulbul, Common Green Magpie, Common Myna, Common Pigeon, Red-Vented Bulbull etc. and the common butterflies and moths includes Golden Sapphire, Indian Tortoise Shell, Cabbage White, and Common Grass Yellow etc.

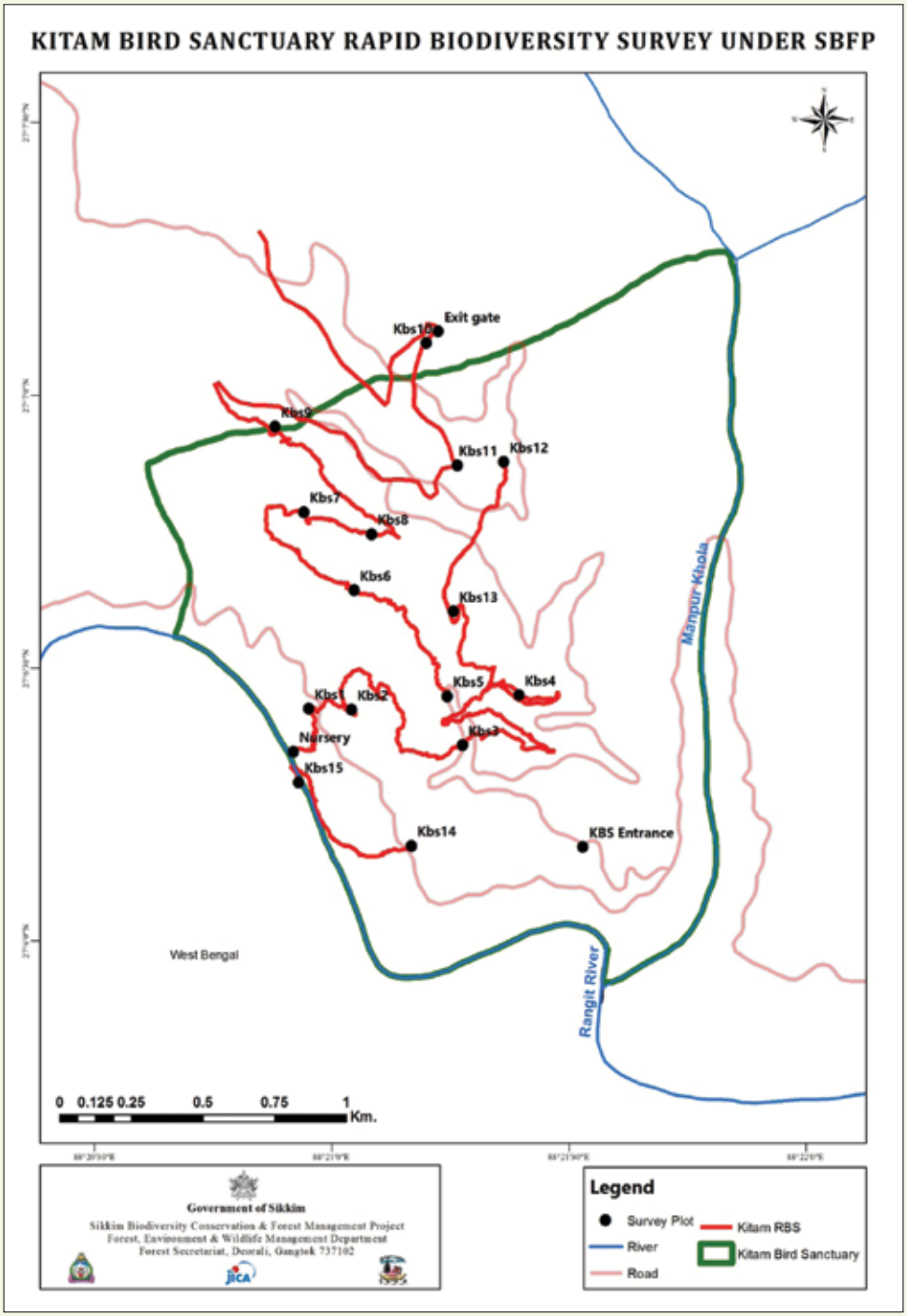


Figure 1. Map showing the sample plots along Kitam Bird Sanctuary, South Sikkim

SBFP survey team laying plots and recording data at Kitam Bird Sanctuary

OUTCOMES OF THE SURVEY

FLORA

During the survey, a total of 15 plots were laid covering 0.15 ha area **(Annexure I; Figure 1)**, from which 32 tree, 7 small tree/ shrubs, and 6 herb species were recorded and are marked with (*) in **Annexure II**. A general checklist of 110 species of the area (including the areas outside of the plots) were prepared of which, trees represented the highest number of species (58 species belonging to 51 genus and 33 family) followed by small tree/large shrub represented by 14 species belonging to 14 genus and 7 family; 22 species of herbs represented by 17 genus and 9 family and 15 species including epiphytes, climbers and ferns (belonging to 13 genera and 8 families) and 1 bamboo species were recorded. (**Table 1**). Family wise analysis revealed that belonging to the tree category Moraceae was the dominant family with 5 species, followed by Meliaceae, Fabaceae and Euphorbiaceae with 4 species and Lythraceae, Combretaceae and Verbenaceae with 3 species **(Figure 4)**, while in the case of small trees or shrubs Asteraceae with 4 species appeared as the dominant family **(Figure 5)**. Further, for the herbs, Poaceae family appeared as dominant with 13 species (**Figure 6**).

The forest being the tropical-sub tropical type, *Shorea robusta* was the most predominating tree species in the area followed by *Pinus roxburghii, Schima wallichii* and *Toxicodendron wallichii*. Other tree species encountered within the sampling plots were *Ailanthes integrifolia, Aphanamixis polystachya, Bombax ceiba , Bischofia javanica, Bridelia retusa, Chukrasia tabularis, Dubanga grandiflora, Ficus semicordata,*

Firmiana colorata , *Garuga pinnata, Gmelina arborea, Grewia optiva, Largerstroemia parviflora, Litsea monopeltata, Malatus philippensis, Neonauclea purpurea, Phoenix sylvestris, Phyllanthus emblica, Stercolia villosa, Syzygium cumini, Syzygium kurzii, Taxodium* sp. , *Tectona grandis, Terminalia belerica, Terminalia chebula* , *Terminalia crenata, Tetrameles nudiflora* and *Toona ciliata.*

In the case of tree species, cumulatively for adult, sapling and seedling, *Shorea robusta* was present in 14 of the 15 plots and *Pinus Roxburghii* was recorded from 8 plots, *Schima wallichii* and *Toxicodendron wallichii* was recorded from 7 plots, which shows that the regeneration status of the forest is comparatively good. Since, *Shorea robusta* was the most dominant tree species in the area, it had the highest cumulative adult stem density (686.67 ±1.07 ind/ha; Rel. Den.: 45.37, IVI: 105.62) as well as the total basal cover (TBC: 3397.28 m^2/ha; Rel. Dom.: 39.35%) followed by *Pinus Roxburghii* with cumulative adult stem density (180.00 ±0.94 ind/ha; Rel. Den.: 11.89, IVI: 43.41) as well as the total basal cover (TBC: 1690.17 m^2/ha; Rel. Dom.: 19.58%), and *Schima wallichii* with cumulative adult stem density (126.67 ±0.63 ind/ha; Rel. Den.: 8.37, IVI: 27.57) as well as the total basal cover (TBC: 755.21 m^2/ha; Rel. Dom.: 8.75%). On the other hand, the lowest adult stem density was recorded for *Terminalia chebula, Terminalia belerica, Stercolia villosa, Largerstroemia parviflora, bridelia retusa, Garuga pinnata* etc. (**Table 2, Figure 7, 8).**

In the case of saplings, the highest density was recorded for *Phonix sylvestrys* (986.67 ± 2.14 ind/ha) followed by *Shorea robusta* (453.33 ± 2.58 ind/ha) **Figure 8**, **Table 2**. Similarly, the highest seedling density was recorded for *Phoenix sylvestris* (34000.00 ± 166.48ind/ha) followed by *Shorea robusta* (18666.66 ± 206.93 ind/ha) **Figure 9, Table 2**.

In terms of frequency of occurrence of adult trees, *Shorea robusta* was the most frequently occurring species with Rel. Freq.: 20.90%), followed by *Pinus roxburghii* with Rel. Freq.: 11.64 %. Other species had comparatively low frequency of occurrence **(Figure 10).** The sampled area was comparatively rich in terms of tree species richness (I = 25.82) and recorded comparatively high species diversity (H' = 1.71) (**Table 3).**

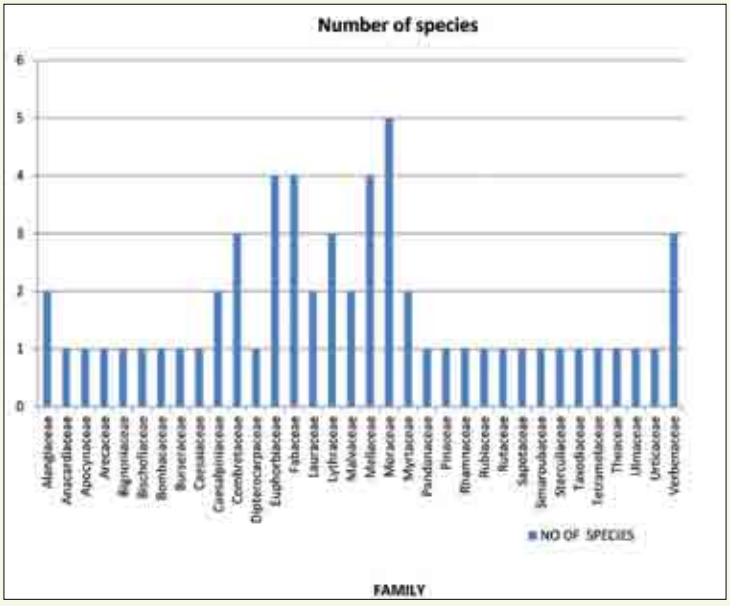


Figure 2: Family-wise distribution of tree species

Table 1: Distribution of Floral species in Kitam Birds Sanctuary, South Sikkim			
Habit	**Species**	**Genus**	**Family**
Trees	58	51	33
Shrubs / small trees	14	14	7
Herbs	22	17	9
Climber/ Epiphytes/ Ferns	15	13	8
Bamboo	1	1	1
Total	**110**	**96**	**58**

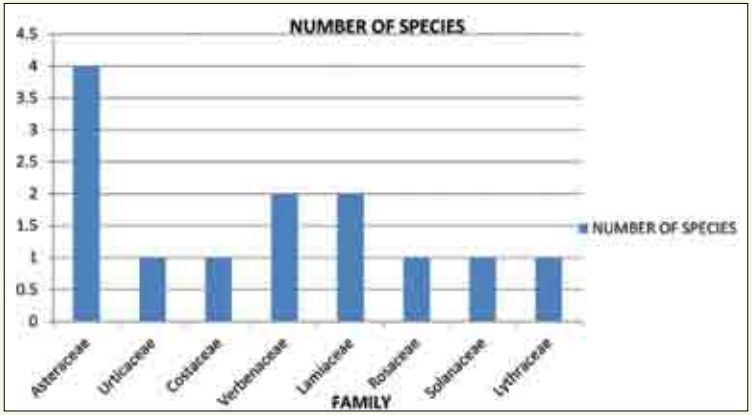


Figure 3: Family-wise distribution of shrub species

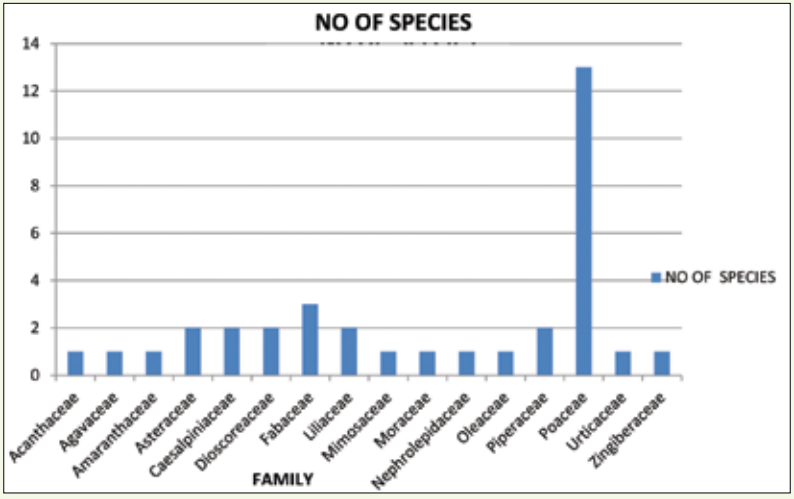


Figure 4: Family-wise distribution of herbs, climbers, epiphytes & ferns

Table 2: Availability and distribution of tree species in Kitam Birds Sanctuary, South Sikkim

Species	Adult				Sapling	Seedling
	Density (Ind/ha) ± SE	TBC (m2/ha)	A/F ratio	IVI	Density (Ind/ha) ± SE	Density (Ind/ha) ± SE
Ailanthes integrifolia	33.33 ±1.29	49.46	0.750	4.27	-------	------
Aphanamixis polystachya	26.67 ±1.03	45.19	0.600	3.77	240.00 ± 2.32	------
Bischofia javanica	20.00 ± 0.77	48.37	0.450	3.37	-------	------
Bombax ceiba	13.33 ± 0.52	293.13	0.300	5.77	-------	------
Bridelia retusa	6.67 ± 0.26	64.23	0.150	2.67	26.67 ± 0.26	666.00 ± 25.82
Chukrasia tabularis	13.33 ±0.52	110.40	0.300	3.65	-------	2000.00 ± 77.46
Dubanga grandiflora	20.00 ±0.77	67.88	0.450	3.60	-------	------
Ficus semicordata	-----	----	-----	2.07	------	2666.66 ± 103.28
Firmiana colorata	6.67 ± *0.26*	17.44	0.150	2.13	-------	------
Garuga pinnata	6.67 ± 0.26	31.68	0.150	2.30	-------	------
Gmelina arborea	13.33 ±0.52	73.51	0.300	3.22	-------	------
Grewia optiva	-------	------	-------	12.48	-------	666.66 ± 25.82
Largerstroemia parviflora	6.67 ± 0.46	257.39	0.066	12.03	53.33 ± 0.52	------
Litsea monopeltata	-----	----	----	12.35	-----	1333.33 ± 51.64
Malatus philippensis	-----	-----	------	2.03	266.67 ± 2.58	2000.00 ± 23.90
Neonauclea purpurea	13.33 ±103.51.64	139.50	0.300	3.99	-------	------
Phoenix sylvestris	46.67 ± 0.88	16.20	0.263	6.26	986.67 ± 2.14	34000.00 ± 166.48
Phyllanthus emblica	6.67 ± *0.26*	8.07	0.150	2.02	-------	------

Pinus Roxburghii	180.0 ±0.94	1690.17	0.063	43.41	53.33 ± 0.52	5333.33 ± 89.62
Schima wallichii	126.6 ± 60.63	755.21	0.058	27.27	-------	------
Shorea Robusta	686.67 ±1.07	3397.28	0.079	105.62	453.33 ± 2.58	18666.66 ± 206.93
Stercolia villosa	6.67 ±0.26	64.23	0.150	2.67	-------	------
Syzygium cumini	13.33 ±0.52	9.30	0.300	2.48	106.67 ± 0.50	3333.33 ±30.86
Syzygium kurzii	------	-----	-----	3.95	160.00 ± 0.50	3333.33 ± 47.14
Taxodium sp.	6.67 ± 0.26	12.23	0.150	2.07	-------	------
Tectona grandis	80.00 ± 1.07	276.13	0.113	14.46	-------	1333.33 ± 51.64
Terminalia belerica	6.67 ±0.26	29.86	0.150	2.28	-------	------
Terminalia chebula	6.67 ± 0.26	4.16	0.150	1.98	-------	666.66 ±25.82
Terminalia crenata	53.33 ± 0.65	356.13	0.133	12.12	53.33 ± 0.52	------
Tetrameles nudiflora	20.00 ±0.77	629.64	0.450	10.10	-------	------
Toona ciliata	-----	-----	-----	2.12	------	1333.33 ± 51.64
Toxicodendron wallichii	53.33 ± 0.24	186.80	0.024	16.13	-------	------
SE: Standard Error, **TBC:** Total Basal Cover, **A/F Ratio:** Abundance to Frequency Ratio, **IVI:** Importance Value Index						

Table 3: Species diversity and distribution in Kitam Birds Sanctuary, South Sikkim.

Parameters	Trees	Saplings	Seedlings
Diversity Index (H)	1.71	-1.77	-0.98
Concentration of Dominance (D)	0.03	---	---
Species richness index (I)	25.82	2.77	2.81
Species evenness index (E)	0.07	-0.77	-0.37

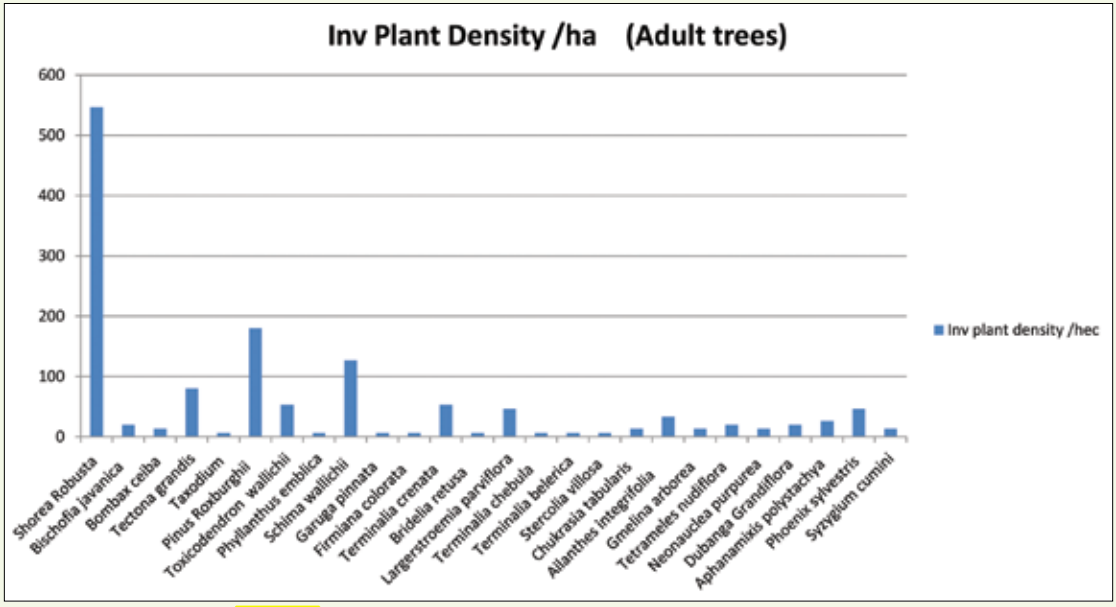


Figure 7: Individual plant density /ha of Adult trees in the sampling site

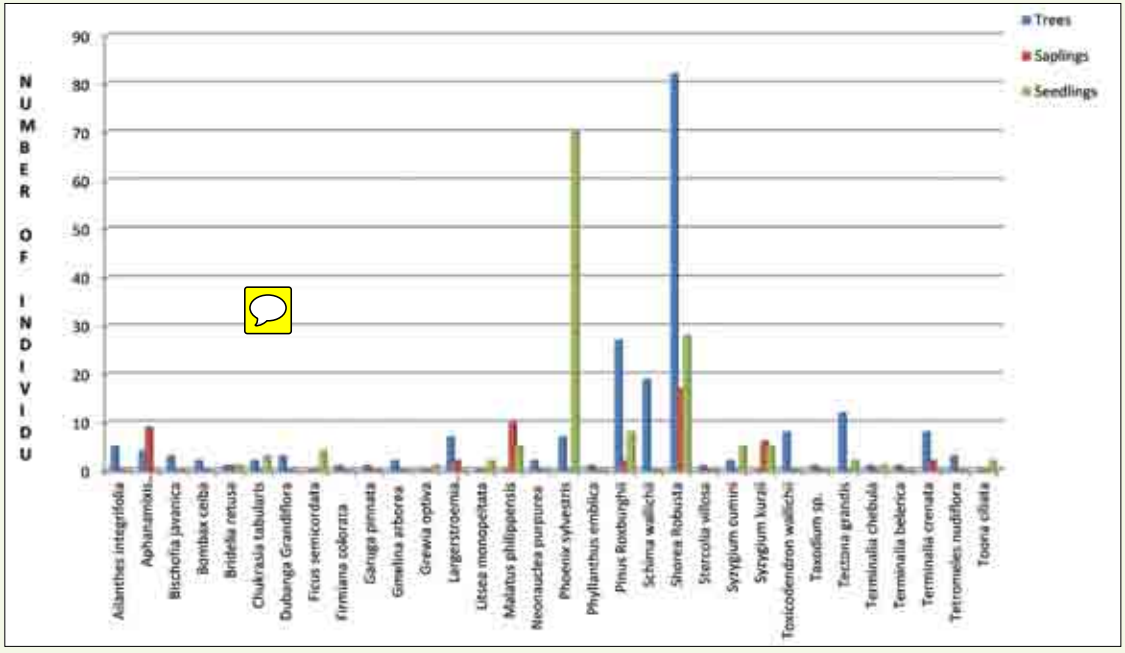


Figure 5: Availability of different categories of tree species in the sampling site

Figure 6: Individual plant density of saplings

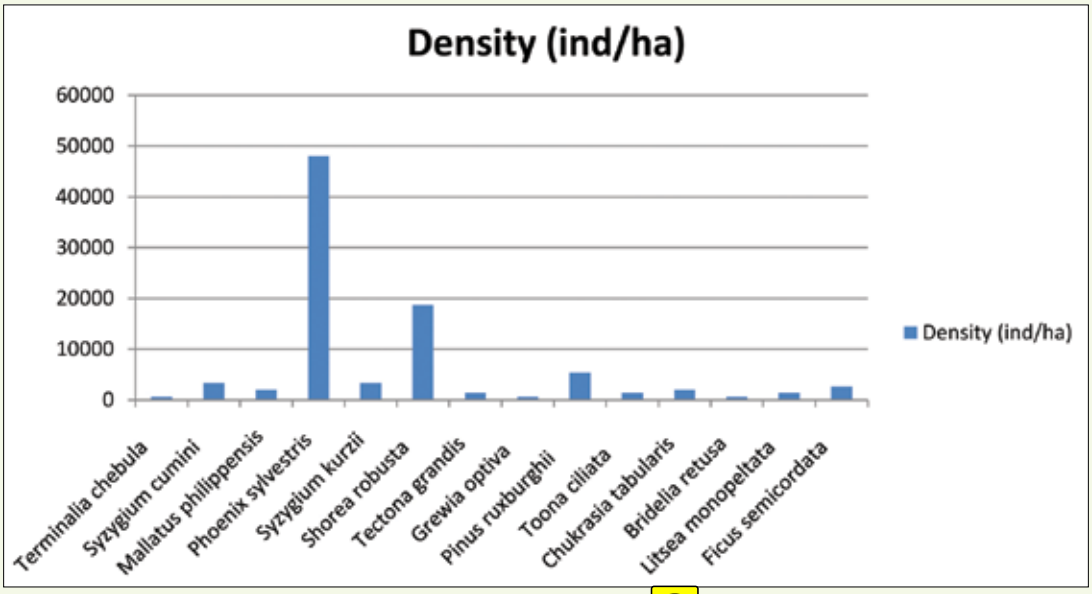


Figure 7: Individual Plant Density of Saplings

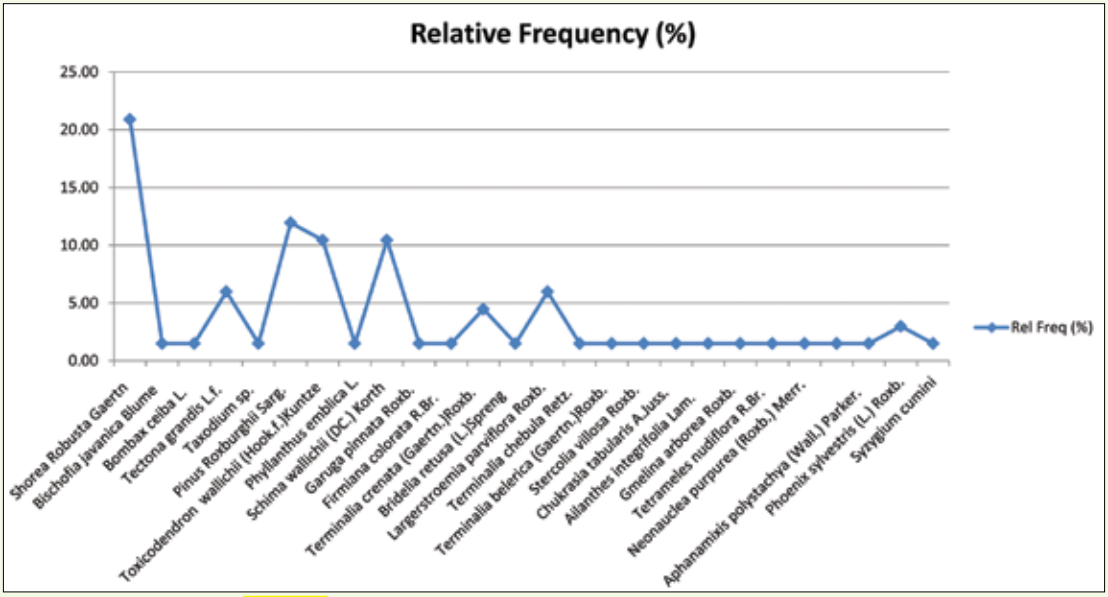


Figure 8: Frequency of occurrence of adult trees in the sampling site

On the basis of diameter class, the girth of the trees species falling in diameter class 20-29cm had the highest density, followed by above 100 cm, 30-39cm, 10-19cm, 40-49cm, 80-89cm, 70-79cm and 90-99cm **(Figure 9)**; the availability of the trees species in the forest, starting from the diameter class from 10 cm upto above 100 cm shows that the status of the forest is comparatively stable. Likewise, the diameter class distribution for some dominant tree species in the area has been represented by **Figure 10** below**.**

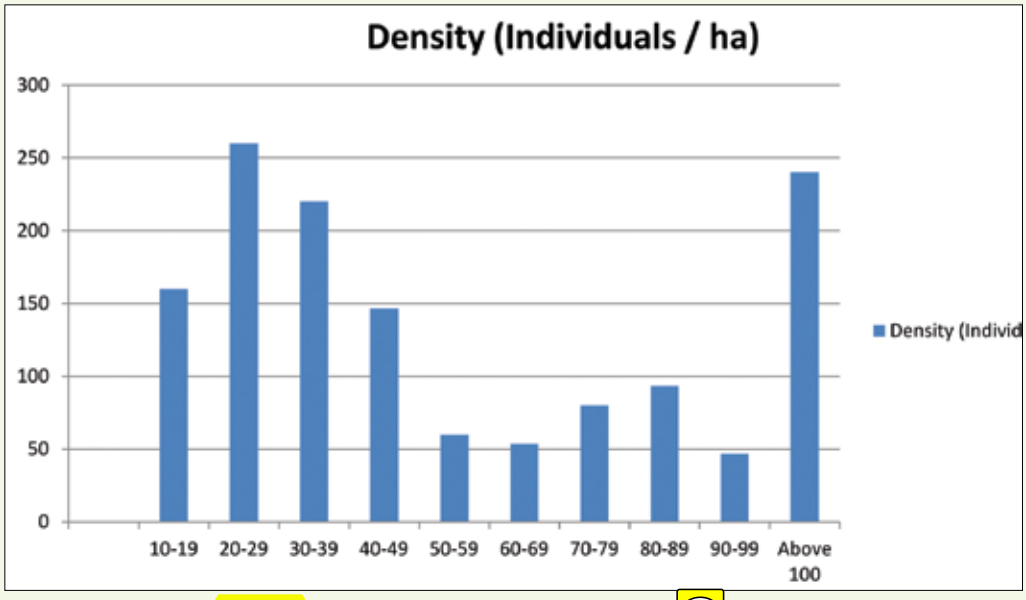
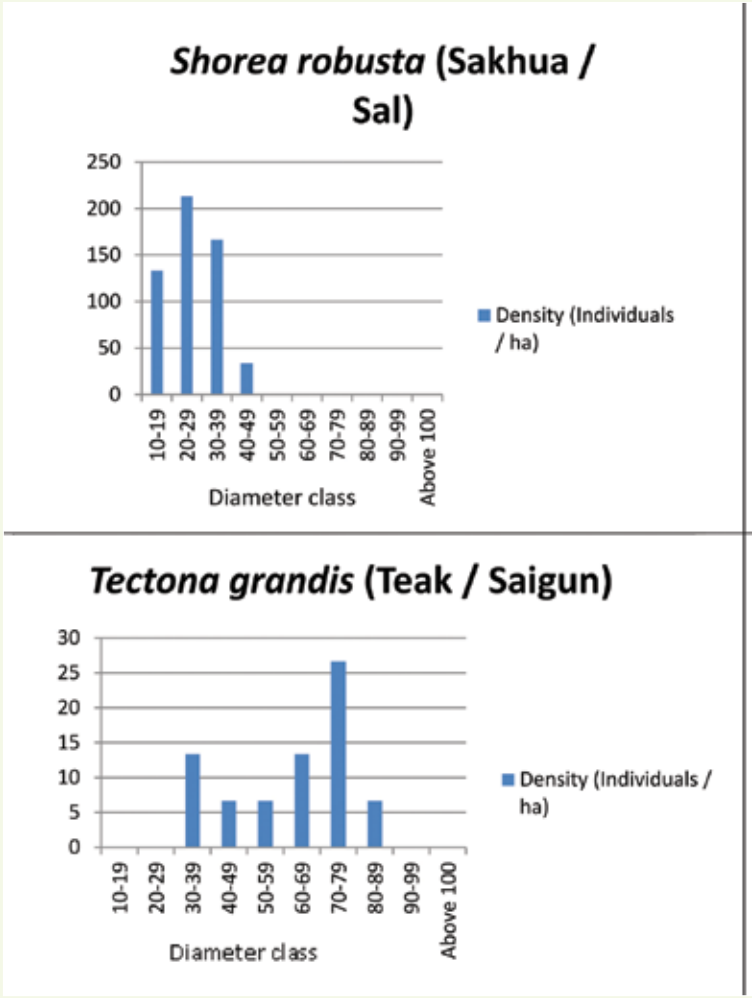
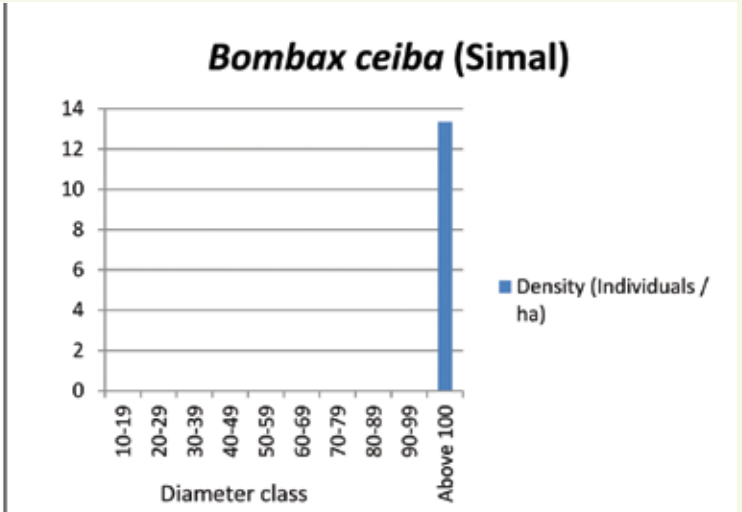


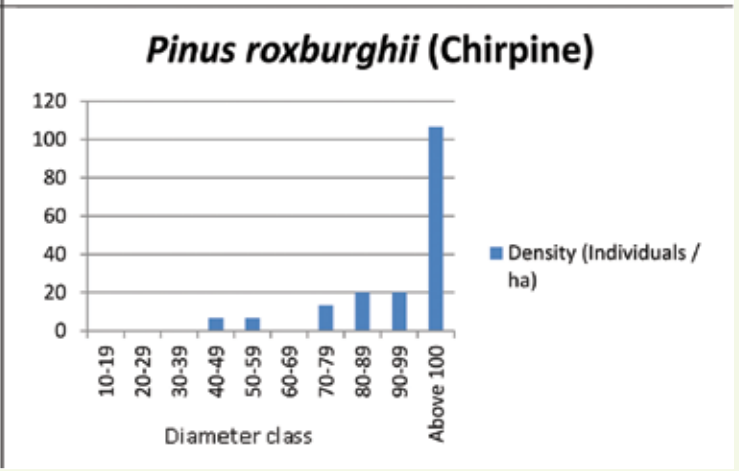
Figure 9: DBH class of the tree species of Kitam Bi[illegible]anctuary

The small tree/ shrub recorded from the sample plots are *Ageratina adenophora, Clerodendron* sp., *Lantana camara, Thysanolaena latifolia, Acer* sp., *Woodfordia fruiticosa* and one unidentified species, Maitalu Kanra (Nepali). Of the 7 species recorded, *Lantana camara* had the highest frequency of occurrence (20.00%) followed by *Woodfordia fruiticosa and Thysanolaena latifolia* (13.33% each) **[Figure 11];** *Ageratina adenophora, Clerodendron sp. And Maitalu kanra* (N) had the lowest frequency of occurrences (6.67% each). With respect to percent cover, *Lantana camara* was dominant with average percent cover /25 m^2 of 32 %, followed by *Woodfordia fruiticosa*, *Clerodendron* sp., and *Ageratina adenophora* having average percent cover /25 m^2 of 20% **[Figure 11]**. In the case of herbaceous species, a total of 7 species were recorded from 15 plots, of which, *Eragrostis* sp. had the highest frequency of occurrences (67%). Other species such as *Poa* sp., *Hedychium* sp., *Setaria palmifolia*, *Jasminum* sp and *Neyraudia arundinaceae* had low frequency of occurrences. With regard to average density in terms of percent cover, *Eragrostis sp.* (average percent cover /m^2: 29%) was dominant over other species, comparatively **(Figure 12)**. The number of species per plot for trees, small trees / shrubs and herbs ranged between 2 and 8, 0 and 2, 0 and 3 respectively; shrubs and herbs were not available in most of the plots **(Figure 13.)**.


Shorea robusta (Sakhua / Sal)
250
200
150
100
50
0
10-19
20-29
30-39
40-49
50-59
60-69
70-79
80-89
90-99
Above 100
Diameter class
Density (Individuals / ha)


Bombax ceiba (Simal)
14
12
10
8
6
4
2
0
10-19
20-29
30-39
40-49
50-59
60-69
70-79
80-89
90-99
Above 100
Diameter class
Density (Individuals / ha)

Tectona grandis (Teak / Saigun)
30
25
20
15
10
5
0
10-19
20-29
30-39
40-49
50-59
60-69
70-79
80-89
90-99
Above 100
Diameter class
Density (Individuals / ha)


Pinus roxburghii (Chirpine)
120
100
80
60
40
20
0
10-19
20-29
30-39
40-49
50-59
60-69
70-79
80-89
90-99
Above 100
Diameter class
Density (Individuals / ha)

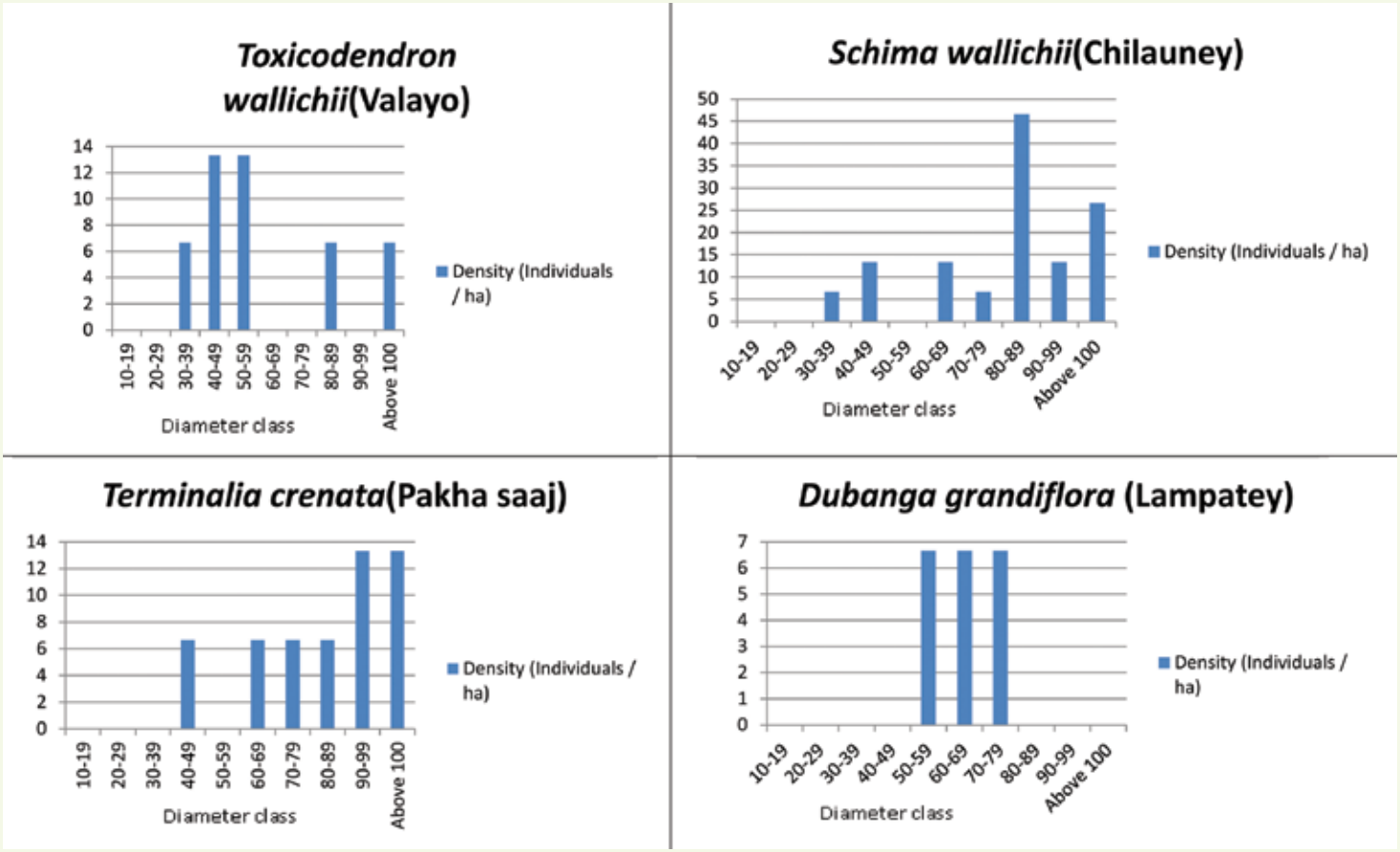


Figure 10: **Class wise availability (DBH class) of individual tree species in the sampling site, at Kitam Birds Sanctuary.**

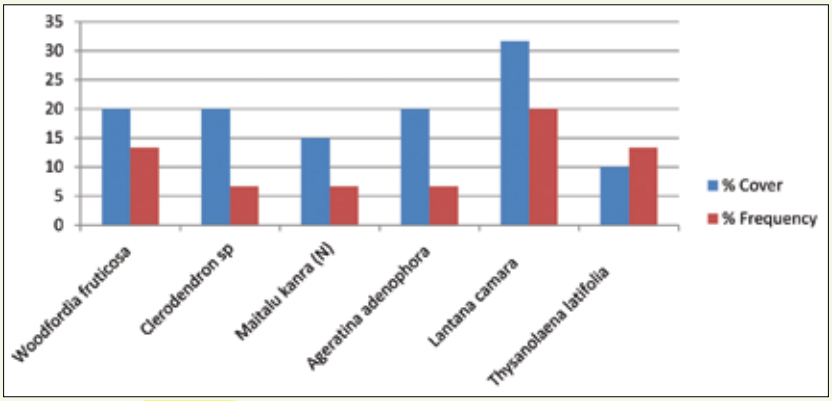


Figure 11: Status of shrubs / small trees in the sampling plot

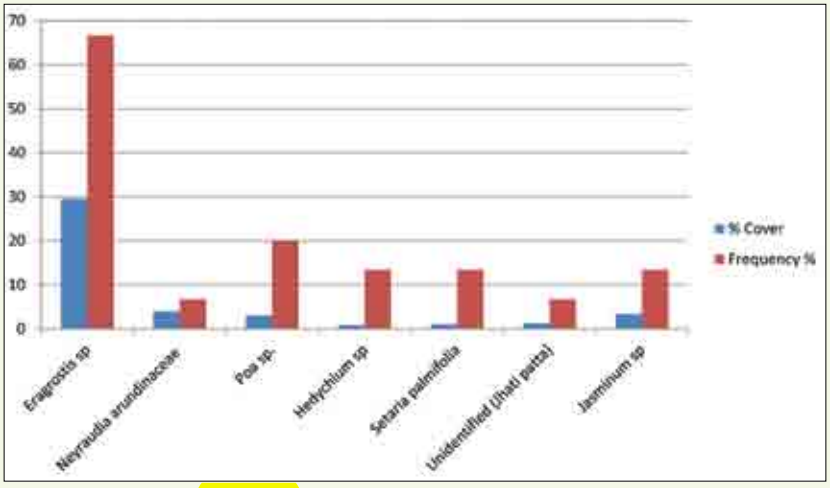


Figure 12: Status of Herbs in the sampling plot

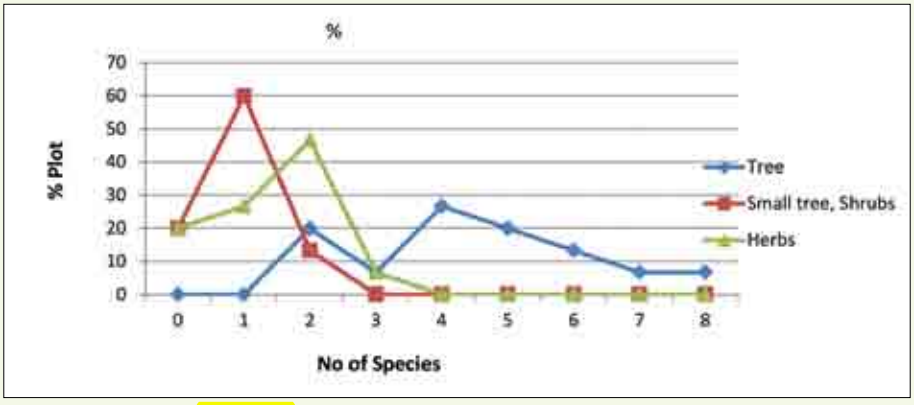


Figure 13: Species availability in different sampling plots

FAUNA

During the trial sampling, existence of faunal species including 6 mammalian species, 26 birds species and some butterflies species was confirmed through direct sighting and indirect evidences.

List of Faunal Species Recorded From Kitam Birds Sanctuary, South Sikkim			
Sl. No.	**Common Name**	**Scientific Name**	**Family**
1	Barking Deer	*Muntiacus muntjak*	Crevidae
2	Chinese Pangolian	*Manis pentadactyla*	Manidae
3	Common Leopard	*Panther pardus*	Felidae
4	Himalayan palm Civet	*Paguma larvata*	Viverridae
5	Porcupine	*Hystrix sp.*	Erethizontidae
6	Wild Boar	*Sus scrofa*	Suidae
AVI-FAUNAL SPECIES			
7	Ashy Drongo	*Dicrurus leucophaeus*	Dicaeidae
8	Black-crested Bulbul	*Pycnonotus flaviventris*	Pycnonotidae
9	Blue-throated Barbet	*Megalaima asiatica*	Megalaimidae
10	Blue Whistling Thrush	*Myophonus caeruleus*	Turdiae
11	Common Myna	*Acridotheres tristis*	Sturnidae
12	Common Pigeon	*Columba livia*	Columbidae
13	Common Tailorbird	*Orthotomus sutorius*	Cisticolidae
14	Common Green Magpie	*Cissa chinensis*	Corvidae
15	Crimson Sunbird	*Aethopyga spiraja*	Nectariniidae
16	Greater Yellownape	*Chrysophlegma flavinucha*	Picidae
17	Green Backed tit	*Parus monticulus*	Paridae
18	Green-billed Malkoha	*Rhopodytes tristis*	Cuculidae
19	Green tailed sunbird	*Aethopyga nipalensis*	Nectariniidae
20	House Crow	*Corvus splendens*	Corvidae
21	House Sparrow	*Passer domesticus*	Passeridae
22	Grey-headed canary-flycatcher	*Culicicapa ceylonensis*	Stenostiridae

23	Indian Peafowl	*Pavo cristatus*	Phasianidae
24	Kalij Pheasant	*Lophura leucomelanos*	Phasinidae
25	Orange-Headed thrush	*Zoothera citrine*	Turdidae
26	Oriental white eye	*Zosterops palpebrosus*	Zosteropidae
27	Red Junglefowl	*Gallus gallus*	Phasianidae
28	Red-vented bulbul	*Pycnonotus cafer*	Pycnonotidae
29	Scarlet Minivet	*Pericrocotus speciosus*	Campephagidae
30	Velvet-fronted Nuthatch	*Sitta frontalis*	Certhiidae
31	White capped Redstart	*Chaimarrornis leucocephalus*	Muscicapidae
32	Grey-capped Pygmy Woodpecker	*Dendrocopos canicapillus*	Picidae
BUTTERFLIES SPECIES			
34	Dark Evening Brown	*Melanitis phedima*	Nymphalidae
35	Common Tinsel	*Catapaecilma major*	Lycaenidae
36	Dark Pierrot	*Tarucus ananda*	Lycaenids
37	Common Jester	*Symbrenthia* sp.	Nymphalidae
38	Common Grass Yellow	*Eurema hecabe*	Pieridae
39	Dark Judy	*Abisara fylla*	Riodinidae
40	Common Map	*Cyrestis* sp.	Nymphalidae
41	Indian Tortiseshell	*Aglais caschmirensis*	Nymphalidae
42	Chocolate Pansy	*Junonia iphita*	Nymphalidae
43	Common Nawab	*Polyura athamas*	Nymphalidae

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Annexure I: Field characteristics of the sampling plots along Kitam Birds Sanctuary, South Sikkim.

Site code	Forest Type	Altitude (M)	GPS		Slope (degree)	Slope Aspect	Canopy cover (%)	Dominate Taxa	Disturbances
			Lat	Long					
KBS 01	Sub-Tropical Broad Leaved Forest	385	27°10'6992	88°34'93"	35	E	60, Moderately dense	Trees	**Forest Fire prone area**
KBS 02	Sub-Tropical Broad Leaved Forest	410	27°10'6955	88°35'08"	30	E	60, Moderately dense	Trees	
KBS 03	Sub-Tropical Broad Leaved Forest	487	27°10'5827	88°35'47"	20	E	60, Moderately dense	Trees	
KBS 04	Sub-Tropical Broad Leaved Forest	560	27°10'73"	88°35'67"	10	E	80, Very dense	Trees	
KBS 05	Sub-Tropical Broad Leaved Forest	571	27°10'73"	88°35'41"	30	E	70, very dense	Trees	
KBS 06	Sub-Tropical Broad Leaved Forest	559	27°11'06"	88°35'09"	20	N	80, very dense	Trees	
KBS 07	Sub-Tropical Broad Leaved Forest	586	27°11'30"	88°34'92"	30	N	60, moderately dense	Trees	
KBS 08	Sub-Tropical Broad Leaved Forest	632	27°11'23"	88°35'15"	30	N	70, very dense	Trees	
KBS 09	Sub-Tropical Broad Leaved Forest	689	27°11'56"	88°34'82"	30	NE	60, moderately dense	Trees	
KBS 10	Sub-Tropical Broad Leaved Forest	781	27°11'81"	88°35'35"	10	E	60, moderately dense	Trees	
KBS 11	Sub-Tropical Broad Leaved Forest	741	27°11'43"	88°35'46"	20	E	70, very dense	Trees	
KBS 12	Sub-Tropical Broad Leaved Forest	693	27°11'44"	88°35'62"	30	E	70, very dense	Trees	
KBS 13	Sub-Tropical Broad Leaved Forest	615	27°10'99"	88°35'44"	35	NE	70, very dense	Trees	
KBS 14	Sub-Tropical Broad Leaved Forest	333	27°10'27"	88°35'28"	40	NE	60, moderately dense	Trees	
KBS 15	Sub-Tropical Broad Leaved Forest	305	27°10'47"	88°34'89"	40	NE	50, moderately dense	Trees	

Annexure II: Floral Species Recorded Along Kitam Bird Sanctuary in South Sikkim				
Sl. No.	**Botanical Name**	**Local name**	**Family**	**Altitudinal Range (m)**
TREES				
1	*Actinodaphne obovata* (Nees) Blume	Runchay	Lauraceae	300-1400
2	**Ailanthes integrifolia* Lam.	Gokul	Simaroubaceae	450-700
3	*Alangium chinense* (Lour.) Harms	Singarey	Alangiaceae	240-2000
4	*Alangium begoniaefolium* (Roxb.) Baill	Akhanay	Alangiaceae	450-2000
5	*Albezia chinensis* (Osbeck) Merr.	Rato siris	Fabaceae	450-1500
6	*Albezia procera* (Roxb.) Benth.	Seto siris	Fabaceae	400-1200
7	*Alstonia scolaris* (L.) R.Br.	Chattiwan	Apocynaceae	300-1000
8	**Aphanamixis polystachya* (Wall.) Parker.	Lasunay	Meliaceae	600-1800
9	*Artocarpus lacucha* Hamilton	Badahar	Moraceae	300-1500
10	*Bauhinia purpurea* L.	Taaki	Caesalpiniaceae	300-1500
11	*Bauhinia veriagata* L.	Koiralo	Caesalpiniaceae	300-1800
12	**Bischofia javanica* Blume	Kaijal	Bischofiaceae	400-1500
13	*Boehmeria rugulosa*	Daar	Urticaceae	300-700
14	**Bombax ceiba* L.	Simal	Bombacaceae	300-1200
15	**Bridelia retusa* (L.)Spreng	Gayo	Euphorbiaceae	400-1500
16	*Callicarpa arborea* Roxb.	Guenlo	Verbenaceae	400-1500
17	*Cassia fistula* L.	Rajvriksha	Caesaiaceae	Upto 1400
18	*Celtis timorensis* Span.	Khari	Ulmaceae	300-600
19	**Chukrasia tabularis* A.Juss.	Chukrasay	Meliaceae	300-1200
20	*Delonix regia* (Hook.) Raf.	Golmaar	Fabaceae	200-1500
21	*Citrus maxima* (Burman) Merrill	Foksay	Rutaceae	300-1800
22	*Diploknema butyracea* (Roxb.) H.J.Lam	Chiuri	Sapotaceae	700-1500
23	**Dubanga Grandiflora* (Roxburgh ex Candolle) Walpers, Repert.	Lampatey	Lythraceae	Upto 1000
24	*Erythrina stricta* Roxb.	Faledo	Fabaceae	300-1600
25	*Ficus auriculata* Lour.	Nevaro	Moraceae	300-1500
26	*Ficus benjamina* L.	Sami	Moraceae	400-1200
27	*Firmiana colorata* R.Br.	Phirpheray	Sterculiaceae	300-900
28	**Ficus semicordata* Buch.-Ham.ex Sm.	Khasrey khaniu	Moraceae	600-1500
29	**Garuga pinnata* Roxb.	Dabdabey	Burseraceae	300-1200
30	**Gmelina arborea* Roxb.	Khamari	Verbenaceae	200-1000
31	**Grewia optiva* J.R.Drumm.ex Burret	Syal Phusray	Malvaceae	Upto 1800
32	**Largerstroemia parviflora* Roxb.	Budo Dhayero	Lythraceae	200-900
33	*Largerstroemia speciosa* (L.) Pers.	Jarul	Lythraceae	300-900
34	**Litsea monopeltata* (Roxb.) Persoon	Kutmero	Lauraceae	300-1500
35	*Macaranga denticulata* (Blume) Muell.	Malato	Euphorbiaceae	400-1000
36	**Mallotus philippensis* (Lam.) Mull.Arg.	Sinduray	Euphorbiaceae	300-1600
37	*Melia azedarach* L.	Bakaino	Meliaceae	300-1600
38	*Morus australis* Poir.	Kimbu	Moraceae	350-2000
39	**Neonauclea purpurea* (Roxb.) Merr.	Kadam	Rubiaceae	300-750
40	*Oroxylum indicum* (L.) Vent.	Totala	Bignoniaceae	300-1500
41	*Pandanus furcatus* Roxb.	Tarika	Pandanaceae	200-1500
42	**Phyllanthus emblica* L.	Aamla	Euphorbiaceae	300-1500

43	**Pinus Roxburghii* Sarg.	Chirpine	Pinaceae	400-2500
44	**Phoenix sylvestris (L.) Roxb.*	Thakkal	Arecaceae	300-1200
45	**Schima wallichii* (DC.) Korth	Chilauney	Theaceae	400-1800
46	**Shorea Robusta* Gaertn.	Sakhua / Sal	Dipterocarpaceae	100-1500
47	**Stercolia villosa* Roxb.	Odal	Malvaceae	
48	**Syzygium cumini* (L.) Skeels	Jamuna	Myrtaceae	300-1200
49	**Syzygium kurzii* (Duthie)N.P.Balakr.	Amboke	Myrtaceae	150-700
50	**Taxodium* sp.	Tarpin	Taxodiaceae	Planted
51	**Tectona grandis* L.f.	Saigun/ Teak	Verbenaceae	100-600
52	**Terminalia belerica* (Gaertn.)Roxb.	Barro	Combretaceae	300-1200
53	**Terminalia chebula* Retz.	Harro	Combretaceae	400-1500
54	**Terminalia crenata* (Gaertn.)Roxb.	Pakha saaj	Combretaceae	250-1000
55	**Trameles nudiflora* R.Br.	Maina	Tetramelaceae	200-900
56	**Toona ciliata* Roem.	Tooni	Meliaceae	300-1700
57	**Toxicodendron wallichii* (Hook.f.)Kuntze	Valayo	Anacardiaceae	500-2000
58	*Ziziphus jujuba* Mill.	Bayer	Rhamnaceae	300-900
SHRUBS				
1	*Abrus precatorious*			
2	**Ageratina adenophora* (Spreng.) King & Robinson	Kali Jhar	Asteraceae	300-2000
3	*Ageratum conyzoides* L.	Elamey	Asteraceae	200-2000
4	*Atemisia indica* Willd.	Titepati	Asteraceae	300-2400
5	*Bidens pilosa* Linn	Kuro	Asteraceae	300-2400
6	*Boehmeria macrophylla* D.	Kamley	Urticaceae	Upto 1860
7	*Cheilocostus speciosus* (J. Konig) C. Specht.	Betlauri	Costaceae	300-1800
8	**Clerodendron* sp			
9	*Colebrookea oppositifolia* Smith.	Dhusrey	Lamiaceae	200-1700
10	**Lantana camara* Linn.	Banmara	Verbenaceae	300-1700
11	*Leucoceptrum sp*	Bhimsen pati	Lamiaceae	
12	*Rubus diffusus* Sm.	Aiselu	Rosaceae	
13	*Solanum turvum* Swartz.	Jangali Behi	Solanaceae	300-1500
14	*Vitex nigundo* L.	Simali	Verbenaceae	300-1500
15	*Woodfordia fruticosa* (L.) Kurz.	Dhayero	Lythraceae	
16	*	Maitalu Kanra		
17	*	Phirphiray		
HERBS				
1	*Agave Americana* L.	Hattibar	Agavaceae	359-1200
2	*Alternenthera sessilis* (L.) R.Br.ex DC.	Bhringi jhaar	Amaranthaceae	350-1500
3	*Arundinaria* sp.	Musey kharuki	Poaceae	
4	*Capillipedium* sp.	Thulo kharuki	Poaceae	
5	*Eragrostis* sp	Chaptey banso	Poaceae	
6	*Eragrostis* sp	Ghodey banso	Poaceae	
7	**Eragrostis* sp.	Banso	Poaceae	
8	*Eragrostis* sp.	Jangali banso	Poaceae	
9	*Gonostegia hirta* (Blume ex Hassk.) *Miq.*	Chiplay	Urticaceae	500-2600m
10	**Hedychium* sp.	Sara	Zingiberaceae	

11	*Imperata cylindrica*	Siru	Poaceae	300-2400m
12	*Ischaemum rugosum* Salisb	Babyo	Poaceae	100-1800m
13	**Jasminum* sp.		Oleaceae	
14	*Mikania micrantha* Kuntha		Asteraceae	300-1500
15	*Mimosa pudica* L.	Buhari jhar	Mimosaceae	300-1500
16	**Neyraudia arundinaceae* (L.)	Ghungring	Poaceae	200-2000m
17	*Phlogacanthus pubinervius* T.Anderson	Titay	Acanthaceae	200-1700m
18	**Poa* sp	Phurkay	Poaceae	
19	**Setaria palmifolia* (J.Koenig) Stapf	Dhoti sara	Poaceae	300-1800m
20	**Thysanolaena latifolia* (Roxb.ex Hornem.) Honda	Amliso	Poaceae	300-1800
21		Gahatay jhar		
CLIMBER/ EPIPHYTES/ BAMBOOS/ FERNS				
1	*Acacia pinnata* (L.)Willd.	Arari	Fabaceae	200-1200m
2	*Asparagus racemosus* Willd.	Kurilo	Liliaceae	200-1500m
3	*Bauhinia vahlii* Wight & Arn.	Bhorlo	Caesalpiniaceae	200-1500m
4	*Dendrocalamus hamiltonii* Nees & Arn.ex Munro	Choya bans	Poaceae	700-4000m
5	*Dioscorea pentaphylla* L.	Bantarul	Dioscoreaceae	300-1800m
6	Dioscorea sp.			
7	*Ficus sarmentosa* Buch.	Duday lahara	Moraceae	500-2500m
8	*Mikania micrantha* Kuntha		Asteraceae	300-1700m
9	*Mucuna imbricate* DC.	Kauso	Fabaceae	Upto 1000
10	*Neprolepis auriculata* (L.) Trimen	Pani amala	Nephrolepidaceae	300-2000
11	*Piper boehmeriaefolium* (Miq.) DC.	Jungali pan	Piperaceae	500-2200m
12	*Piper* sp.	Chabo/ Pan	Piperaceae	
13	*Smilax* sp.	Kukurdainey	Liliaceae	
14	*Spatholobus parviflorus* (DC.) Kuntze	Debre lahara	Fabaceae	200-2000m
15		Pareyandrey		
16		Darmay Kanra		

Note: (*) represents the species recorded inside the sample plots.

Crimson Sunbird

Indian Peafowl

Rapid Biodiversity Survey of Tendong Reserve Forest, South Sikkim

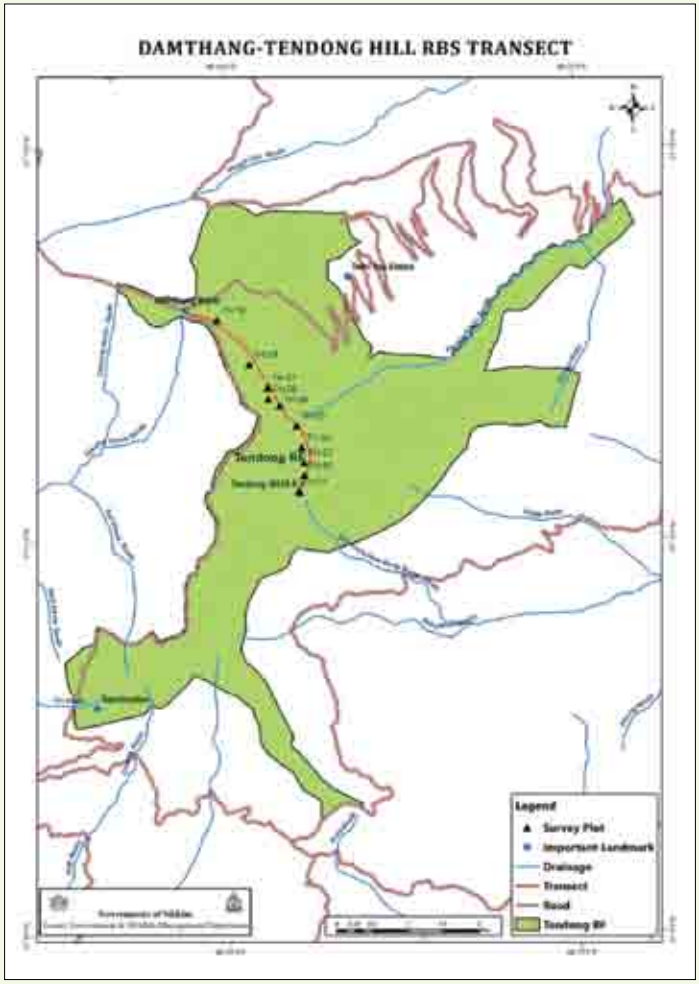
Nimesh Chamling, Anjana Pradhan, Suraj Subba, Dorjee Chewang Bhutia and Meena Tamang

View of the trekking trail of Tendong Reserve Forest

STUDY AREA

Tendong Reserve Forest, located in South District under South Territorial Division of Namchi, is a famous tourist destination known for its serene environment and the breathtaking panoramic views of the Eastern Himalayas. The name "Tendong" is derived from the Lepcha dialect which means "the land of the horn". Legend has it that when a massive flood occurred in the area, the ancestors of Rongkup Rumkups (Lepchas) took refuge on this hill as a horn miraculously arose to rescue the people. Prayers were offered to the **Itbu Rum** (creator) by the Lepchas and offerings of fermented millet were made. The flood subsided when **KohomFo** (a hill partridge) appeared and had a few grains of the offering. The Lepchas believed that this was the sign of acceptance. Keeping in mind the historical and religious significance of this place and event, the Government of Sikkim declared in 1997 that the 8th of August will be a state holiday to commemorate the day of the ***TendongLho Rum Faat.***

The current survey was carried out along the trekking route of Tendong Reserve Forest starting from Damthang to the hill top where the monastery is located. Distance to the hill top is 6km from Damthang Bazar and the trek route goes through lush and thick green vegetation rich in flora and fauna representing a moist temperate broad-leaved forest **(Photo 1)**. The altitude of the surveyed path ranged from 2156m to 2626m asl lying between 27°15'0''N – 27°09'0''N latitude and 88°27'0''E – 88°24'0''E longitude (**Map**). The slope angle of the surveyed area ranged from 10° to 60° and aspect facing towards NE, SE and NW. Recognized for its sacredness, Tendong RF is a famous tourist destination known for its serene environment and the breathtaking panoramic views of the Eastern Himalayas. The Reserve Forest is in South District under South Territorial Division of Namchi. The field visit was done from 14th to 15th November 2016. Random sampling was done using a standard quadrat method by laying 10 plots of 10m x 10m at every 70 – 100m distance depending upon the site feasibility. The unidentified specimens were photographed and/or collected and identified later by consulting plant taxonomists, herbaria and literature (**Table 1; Photo 2**).



Map 1: Rapid Biodiversity Survey plots along the sampling path of Tendong Reserve Forest

Table 1: **Site characteristics of the sampling plots along Tendong Reserve Forest, South Sikkim**

Site Code	Forest Type	Altitude (m)	GPS coordinates		Slope Aspect	Slope Angle (°)	Canopy Cover (%)	Anthropogenic disturbance
			Latitude (N)	Longitude (E)				
TH 01	Moist-Temperate Broad-Leaved	2630	27°12'21.5"	88°24'27.1"	N	15	20, open forest	Fuelwood/ Fodder
TH 02	Moist-Temperate Broad-Leaved	2594	27°12'28.9"	88°24'30.0"	NE	Mild	30, open forest	
TH 03	Moist-Temperate Broad-Leaved	2514	27°12'34.8"	88°24'29.9"	SE	30	45, moderately dense	
TH 04	Moist-Temperate Broad-Leaved	2445	27°12'41.7"	88°24'28.8"	NE	25	65, moderately dense	
TH 05	Moist-Temperate Broad-Leaved	2363	27°12'51.8"	88°24'26.2"	NE	30	60, moderately dense	
TH 06	Moist-Temperate Broad-Leaved	2313	27°13'01.1"	88°24'17.7"	E	15	55, moderately dense	
TH 07	Moist-Temperate Broad-Leaved	2265	27°13'09.2"	88°24'11.6"	SW	30	40, moderately dense	Grazing
TH 08	Moist-Temperate Broad-Leaved	2227	27°13'04.0"	88°24'12.0"	NE	Mild	65, moderately dense	
TH 09	Moist-Temperate Broad-Leaved	2172	27°13'20.0"	88°24'02.2"	NE	15	40, moderately dense	Felling of trees
TH 10	Moist-Temperate Broad-Leaved	2156	27°13'40.5"	88°23'46.0"	NW	40	70, very dense	

NOTE: N, North; NE, North-East; SE, South-East; E, East; SW, South-West; NW, North-West

Photo 1: Moist-Temperate Broad-Leaved Forest of Tendong RF

CBH measurement

Laying of plot and recording data

Team briefing

RESULT

Tendong Reserve Forest, as per the survey, is a moist dense temperate forest with a total of 91 floral species recorded, including the area outside the plots, under 85 genera belonging to 63 family members. Herbs represented the highest number of species (32 species) belonging to 20 families with 30 genera. Trees represented the second highest number of species (26 species) belonging to 17 families with 23 genera. Shrubs represented with 14 species belonging to 13 genera and 9 families. Fern and fern-allies were represented by 10 species belonging to 10 genera and 9 families. Climbers and epiphytes were 8 in number (8 genera and 7 families); and only 1 bamboo species was recorded in the entire area (**Table 2 & 3**).

Table 2: Distribution of floral species along Tendong Reserve Forest sampling path

Habit	Species	Genus	Family
Tree	26	23	17
Shrub	14	13	9
Herb	32	30	20
Fern and fern-allies	10	10	9
Climbers and epiphytes	8	8	7
Bamboo	1	1	1
Total	**91**	**85**	**63**

Table 3: General checklist of floral species recorded along Tendong Reserve Forest sampling path

Sl. No.	Scientific Name	Local Name	Family
TREES			
1	*Abies densa* Griff.	Gobre Salla	Pinaceae
2	*Acer cappadocicum* Gled.	Kapasey	Sapindaceae
3	*Castanopsis hystrix* Hook. f. & Thomson ex A. DC.	Patley Katus	Fagaceae
4	*Castanopsis tribuloides* (Sm.) A.DC.	Musrey Katus	Fagaceae
5	*Cedrela febrifuga* Blume	Tooni	Meliaceae
6	*Cinnamomum verum* J.Presl	Sinkoli	Lauraceae
7	*Cryptomeria japonica* (Thunb. ex L.f.) D.Don	Dhuppi	Taxodiaceae
8	*Elaeocarpus lanceifolius* Roxb.	Bhadrasey	Elaeocarpaceae
9	*Engelhardtia spicata* Blume.	Mauwa	Juglandaceae
10	*Eurya acuminata* DC.	Jhinginey	Pentaphylacaceae
11	*Exbucklandia populnea* (R.Br. ex Griff.) R.W.Br.	Pipli	Hamamelidaceae
12	*Leucosceptrum canum* Sm.	Ghurpis	Lamiaceae
13	*Lithocarpus pachyphyllus* (Kurz) Rehder	Bantey	Fagaceae
14	*Lyonia ovalifolia* (Wall.) Drude	Angeri	Ericaceae
15	*Macaranga pustulata* King ex Hook.f.	Malato	Euphorbiaceae
16	*Machilus edulis* King ex Hook.f.	Lapche kawla/Pomsee	Lauraceae
17	*Prunus cerasoides* Buch.-Ham. ex D.Don	Payew	Rosaceae
18	*Pterospermum acerifolium* (L.) Willd.	Hattipaila	Malvaceae
19	*Quercus lamellosa* Sm.	Bajranth	Fagaceae

20	*Rhododendron arboreum* Sm.	Lali Gurans	Ericaceae
21	*Rhododendron hodgsonii* Hook. f.	Gurans	Ericaceae
22	*Symplocos glomerata* King ex C.B. Clarke	Kholmey	Symplocaceae
23	*Symplocos lucida* (Thunb.) Siebold & Zucc.	Kharaney	Symplocaceae
24	*Tetradium febrifuga*	Khanakpa	Rutaceae
25	*Tsuga dumosa* (D.Don) Eichler	Thengra Salla	Pinaceae
26	*Zanthoxylum acanthopodium* DC.	Boke timmur	Rutaceae
SHRUB			
1	*Ardisia macrocarpa* Wall.	Damai Phal	Primulaceae
2	*Azelea* sp.		Ericaceae
3	*Cestrum elegans* (Brongn. ex Neumann) Schltdl.		Solanaceae
4	*Cotoneaster* sp.		Rosaceae
5	*Daphne cannabina* Lour. ex. Wall.	Kalo algeri	Thymelaeaceae
6	*Dichroa febrifuga* Lour.	Bhaasak/Ganhaaune Paat/ Aseru	Hydrangeaceae
7	*Edgeworthia gardnerii* Meissn.	Algeri / Lokti	Thymelaeaceae
8	*Mahonia napaulensis* DC.	Chutro	Berberidaceae
9	*Osbeckia stellata* Buch.-Ham. ex Ker Gawl.	Chulesi	Melastomataceae
10	*Pyracantha* sp.		Rosaceae
11	*Rubus ellipticus* Sm.	Aiselu	Rosaceae
12	*Rubus splendidissimus* H. Hara	Phusre aiselu	Rosaceae
13	*Solanum viarum* Dunal	Junglee bey	Solanaceae
14	*Viburnum erubescens* Wall.	Asare	Adoxaceae
HERBS			
1	*Ageratina adenophora* (Spreng.) R.M.King & H.Rob.	Kalijhar	Compositae
2	*Anaphalis contorta* (D.Don) Hook.f.	Buki Phool	Compositae
3	*Arisaema speciosum* (Wall.) Mart	Sapko Makai	Araceae
4	*Artemesia vulgaris* Linn.	Titepati	Asteraceae
5	*Astilbe rivularis* Buch.-Ham. ex D.Don	Buro Okhati	Saxifragaceae
6	*Begonia tessaricarpa C.B.Clarke*	Magar kajey	Begoniaceae
7	*Bidens pilosa* L.	Kuro	Compositae
8	*Calceolaria bilatata*	Lady's purse	Calcolariaceae
9	*Campanula pallida* Wall.	Gaanobuti/Nepali bikh	Campanulaceae
10	*Carex* sp.	Harkatto	Cyperaceae
11	*Cautleya* sp.		Zingiberaceae
12	*Centella asiatica* (L.) Urb.	Golpatta	Apiaceae
13	*Clinopodium umbrosum* (M.Bieb.) Kuntze		Lamiaceae
14	*Elatostema platyphyllum* Wedd.	Gagleto	Urticaceae
15	*Eragrostis* sp.	Banso	Poaceae
16	*Fragaria nubicola* (Lindl. ex Hook.f.) Lacaita	Bhui Aiselo	Rosaceae
17	*Girardinia diversifolia* (Link) Friis	Bhangrey Sisnu	Urticaceae

18	*Gynura cusimbua* (D.Don) S.Moore		Compositae
19	*Hedychium gardnerianum* Sheppard ex Ker Gawl.	Saro	Zingiberaceae
20	*Hedychium spicatum* Sm.	Saro	Zingiberaceae
21	*Hemiphragma heterophyllum* Wall.	Lalgeri	Plantaginaceae
22	*Impatiens stenantha* Hook.f.		Balsaminaceae
23	*Laportea bulbifera* (Siebold & Zucc.) Wedd.	Patley sisnu	Urticaceae
24	*Oxalis corniculata* L.	Amilo Jhar	Oxalidaceae
25	*Persicaria capitata* (Buch.-Ham. ex D.Don) H.Gross	Ratneulo	Polygonaceae
26	*Pilea umbrosa* Blume	Chipley Jhar	Urticaceae
27	*Polygonum molle* D. Don	Thotney	Polygonaceae
28	*Polygonum runcinatum* Buch.-Ham. ex D. Don	Ratnaulo	Polygonaceae
29	*Rubia manjith* Roxb. ex Fleming	Majhito	Rubiaceae
30	*Rubus calycinus* Wall. ex D.Don	Bhalu Aisilo	Rosaceae
31	*Sarcopyramis napalensis* Wall.		Melastomataceae
32	*Trifolium repens* L.	Dhungri jhar/Teen patey	Leguminosae
EPIPHYTES AND CLIMBERS			
1	*Cissus elongata* Roxb.	Charcharey lahara	Vitaceae
2	*Crawfurdia speciosa* C.B.Clarke	Blue bell flower	Gentianaceae
3	*Piper boehmeriifolium* (Miq.) Wall. ex C. DC.	Jungle Paan	Piperaceae
4	*Pleione praecox* (Sm.) D.Don		Orchidaceae
5	*Rhaphidophora decursiva* (Roxb.) Schott	Kanchirna	Araceae
6	*Tetrastigma serrulatum* (Roxb.) Planch.	Charcharey lahara	Vitaceae
7	*Trichosanthes lepiniana* (Naudin) Cogn.	Indreni	Cucurbitaceae
8	*Usnea* sp.		Parmeliaceae
FERNS AND FERN-ALLIES			
1	*Cyathea chinensis* Copel.	Ruhk uniu, Tree Fern	Cyatheaceae
2	*Diplazium himalayense Panigrahi*	Danthey ningro	Athyriaceae
3	*Dryopteris redactopinnata* S.K. Basu & Panigrahi	Unew	Dryopteridaceae
4	*Gleichenia longissima* Blume	Kalamey Unew	Gleicheniaceae
5	*Lycopodium japonicum* Thunb.	Nagbelli	Lycopodiaceae
6	*Nephrolepis cordifolia* (L.) C. Presl	Pani Amala	Nephrolepidaceae
7	*Peranema cyatheoides* D. Don		Dryopteridaceae
8	*Pteridium revolutum* (Blume) Nakai	Sottarey uniu, Pere ningro	Dennstaedtiaceae
9	*Pteris wallichiana* J. Agardh	Chatey Uniu	Pteridaceae
10	*Selaginella* sp.	Sindure	Selaginellaceae
BAMBOO			
1	*Yushania maling* (Gamble) R.B.Majumdar & Karthik.	Maling	Poaceae

A total of 44 plant families containing 66 species of plants represented the floral diversity from the survey site. Family-wise analysis revealed that the maximum species recorded was from the family Rosaceae with 7 species which was followed by Urticaceae, Compositae, Ericaceae, Fagaceae (4 species each), Polygonaceae and Zingiberaceae (3 species each). In case of herbs, Urticaceae represented the dominant family with 4 species viz. *Laportea bulbifera, Pilea umbrosa, Girardiania diversifolia* and *Elatostema platyphyllum* followed by 3 species each in Polygonaceae viz. *Persicaria capitata, Polygonum molle*, *Polygonum runcinatum* and Zingiberaceae viz. *Hedychium spicatum, Hedychium gardnerianum, Cautleya* sp. were dominant in herb (**Figure 1**).

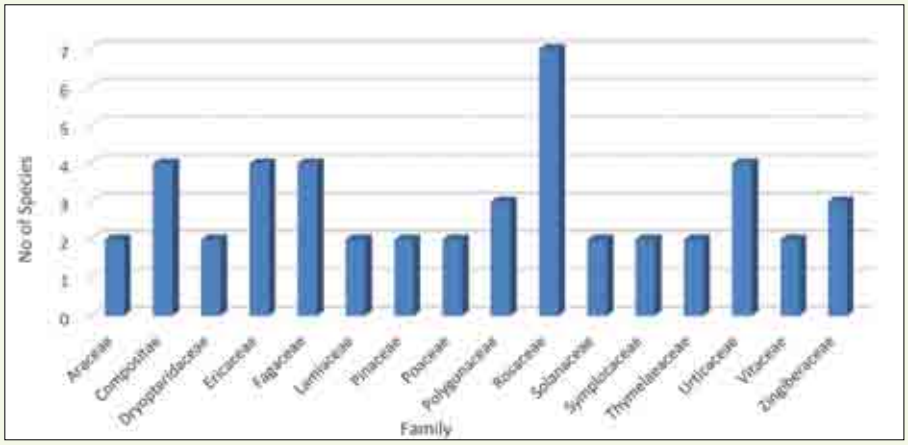


Figure 1: Family-wise distribution of all species

During the survey, a total of 10 plots were laid covering 0.10ha area (**Map 1**), from which 20 trees, 6 shrubs, 21 herb species, 10 fern and fern-allies species, 8 climber/epiphyte species and 1 bamboo species were recorded. The forest being a moist temperate broad-leaved type, the forest is largely dominated by oak species of *Quercus lamellosa*, *Castanopsis hystrix*, *Castanopsis tribuloides*, *Lithocarpus pachyphyllus*, and other prominent trees of *Machilus* sp., *Symplocos glomerata* and *Symplocos lucida*; other tree species encountered within the sampling plots were *Acer cappadocicum, Elaeocarpus lanceifolius, Cinnamomum verum, Macaranga pustulata, Machilus edulis* and *Tsuga dumosa*. While the upper part of the forest is mostly covered by *Yushania maling* bamboo, the lower part is covered by species of oak providing a dense canopy cover. At lower elevations, trunks and branches of trees are swarmed with lichens like *Usnea* species and mosses providing a habitat for various epiphytic growth. Buttresses at the base of tree trunks and lianas are the predominant sights in the forest.

Of the 20 large tree species recorded from the reserve forest (cumulatively 10 plots), the adult individuals of *Quercus lamellosa* (130±0.68 ind/ha) followed by *Machilus edulis* (120±0.26 ind/ha) and *Symplocos lucida* (110±0.48 ind/ha) recorded the highest density; whereas in terms of total basal cover, *Lithocarpus pachyphyllus* (8119918.61m^2/ha), *Machilus edulis* (5451593.59 m^2/ha) and *Castanopsis hystrix* (4799193.98 m^2/ha) had the highest value (**Table 4**). The highest IVI value was recorded for *Lithocarpus pachyphyllus* (46.26) followed by *Machilus edulis* (45.68), *Castanopsis hystrix* (26.61), *Symplocos lucida* (21.99), *Quercus lamellosa* (19.80) and *Symplocos glomerata* (18.59) **[Table 4]**. The highest frequency of occurrence was observed for *Machilus edulis* (60%), *Quercus lamellosa* (50%) and *Symplocos lucida* (50%) **[Figure 2].**

Table 4: Availability of tree species in Tendong RF sampling path

Species	Density (ind/ha) ±SE	TBC (m2/ ha)	Frequency (%)	A/F ratio	IVI
Acer cappadocicum	50±0.50	235399.05	20	0.13	9.20
Abies densa	30±0.50	124205.92	20	0.08	7.64
Castanopsis hystrix	30±0.50	4799193.98	20	0.08	26.61
Castanopsis tribuloides	30±0.50	471057.85	20	0.08	8.62
Cedrela febrifuga	20±0.00	326764.10	20	0.05	7.01
Cinnamomum verum	30±0.50	594309.37	20	0.08	9.14
Cryptomeria japonica	30±0.50	136001.81	20	0.08	7.23
Elaeocarpus lanceifolius	50±0.33	638476.06	30	0.06	13.16
Eurya acuminata	40±0.33	465891.22	30	0.04	11.43
Exbucklandia populnea	20±0.00	91422.36	20	0.05	6.04
Lithocarpus pachyphyllus	70±0.33	8119918.61	30	0.08	46.26
Lyonia ovalifolia	30+-0.50	125694.51	20	0.08	7.19
Macaranga pustulata	30±0.50	157264.78	20	0.08	7.32
Machilus edulis	120±0.26	5451593.59	60	0.03	45.68
Prunus cerasoides	30±0.50	143367.69	20	0.08	7.26
Quercus lamellosa	130±0.68	415941.28	50	0.05	19.80
Symplocos glomerata	100±1.06	292492.33	40	0.06	18.59
Symplocos lucida	110±0.48	429735.78	50	0.04	21.99
Tetradium febrifuga	40±0.33	1060299.50	30	0.04	13.90
Tsuga dumosa	20±0.00	65636.00	20	0.05	5.93

SE: Standard error; TBC: Total basal cover; A/F Ratio: Abundance to frequency ratio; IVI: Important value index

The highest sapling density in the forest was evidenced for *Rhododendron arboreum* (90±3.50 ind/ha) followed by *Symplocos lucida* (80±0.24 ind/ha), *Lithocarpus pachyphyllus* (80±0.41 ind/ha) and *Rhododendron hodgsonii* (60±2.00 ind/ha); while the lowest sapling density was observed for *Elaeocarpus lanceifolius* (30±0.50 ind/ha) and *Mahonia nepalensis* (30±0.50 ind/ha) **[Table 4]**. Similarly, the highest seedling density was found in *Castanopsis hystrix* (70±0.25 ind/ha); while the lowest was observed in *Acer cappadocicum* (40±0.33 ind/ha) **[Table 5]**. The maximum frequency of occurrence for sapling was observed for *Castanopsis hystrix* (50%) and *Symplocos lucida* (50%) **[Figure 3]**; whereas, the maximum seedling frequency was evidenced for *Machilus edulis* (50%) and *Quercus lamellosa* (50%) **[Figure 4]**.

Table 5: Availability of Sapling and Seedling species in Tendong RF sampling path		
Species	Sapling	Seedling
	Density (ind/ha) ± SE	Density (ind/ha) ± SE
Acer cappadocicum	-	40±0.33
Castanopsis hystrix	60±0.20	70±0.25
Daphne sp	40±0.33	-
Elaeocarpus lanceifolius	30±0.50	-
Eurya acuminata	50±0.33	-
Exbucklandia populnea	50±0.25	-
Lithocarpus pachyphyllus	80±0.41	-
Machilus edulis	40±0.33	60±0.20
Mahonia nepalensis	30±0.50	-
Quercus lamellosa	40±1.00	70±0.24
Rhododendron arboreum	90±3.50	50±0.25
Rhododendron hodgsonii	60±2.00	-
Symplocos glomerata	50±0.33	50±0.67
Symplocos lucida	80±0.24	80±0.41
Tetradium febrifuga	50±0.25	-
SE: Standard error		

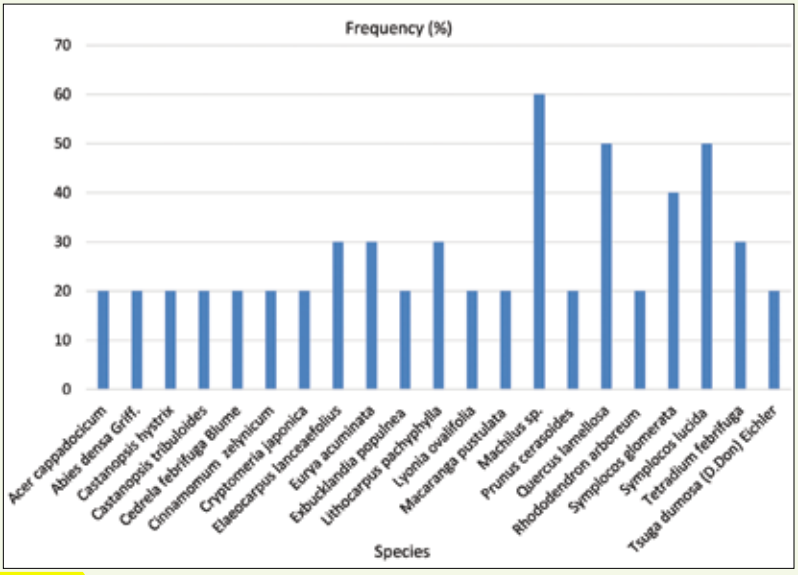


Figure 2: Frequency of tree species (adult individuals) along Tendong RF sampling path

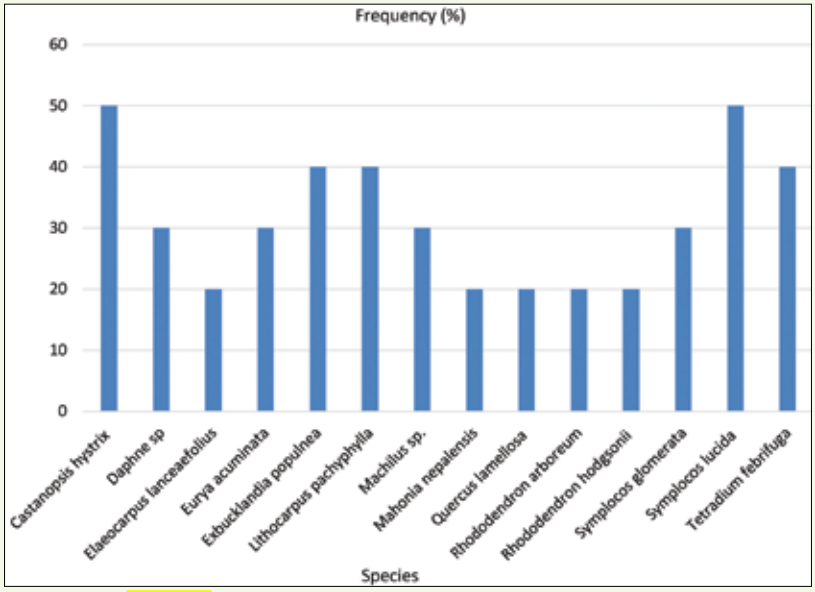


Figure 3: **Frequency of saplings along Tendong sampling path**

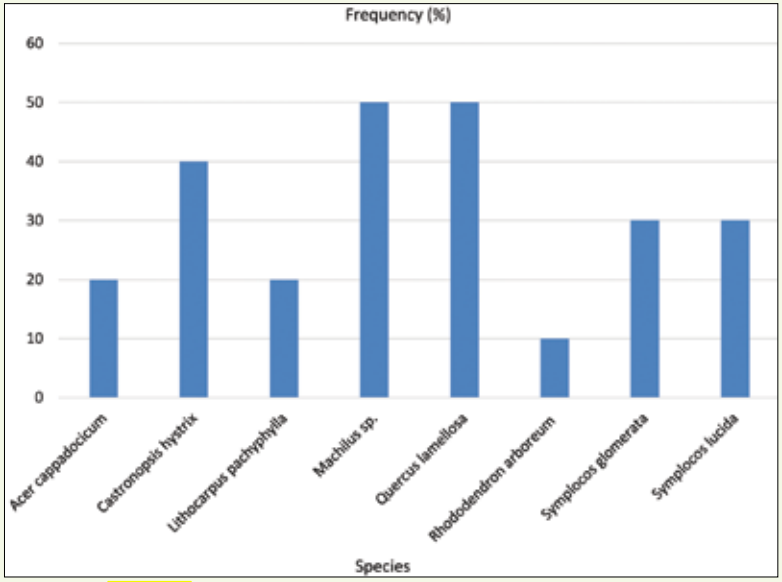


Figure 4: **Frequency of seedling along Tendong RF sampling path**

Based on diameter class, the tree was measured under different girth class for precise determination of stand structure with the gradient of 10 cm rise starting from 30 cm at gbh. The intervals started from 20-30 cm and ended at 671-680 cm at gbh. Dominant species as well as a few major tree species of the study site was measured to understand the community structure. The diameter size classes were as follows:

20-30=1; 31-40=2; 41-50=3; 51-60=4; 61-70=5; 71-80=6; 81-90=7; 91-100=8; 101-110=9; 111-120=10; 121-130=11; 131-140=12; 141-150=13; 151-160=14; 161-170=15; 171-180=16; 181-190=17; 191-200=18; 201-210=19; 211-220=20; 221-230=21; 231-240=22; 241-250=23; 251-260=24; 261-270=25; 271-280=26; 281-290=27; 291-300=28; 301-310=29; 311-320=30; 321-330=31; 331-340=33; 341-350=34; 351-360=35; 361-370=36; 371-380=37; 381-390=38; 391-400=39; 401-410=40; 411-420=41; 421-430=42; 431-440=43; 441-450=44; 451-460=45; 461-470=46; 471-480=47; 481-490=48; 491-500=49; 501-510=50; 511-520=51; 521-530=52; 531-540=53; 541-550=54; 551-560=55; 561-570=56; 571-580=57; 581-590=58; 591-600=59; 601-610=60; 611-620=61; 621-630=62; 631-640=63; 641-650=64; 651-660=65; 661-670=66; 671-680=67

Similarly, based on the diameter class, the individuals falling in E diameter class had the highest density (20 ind/ha) followed by F (11 ind/ha) **[Figure 5].** While the I and N diameter class had the lowest density (1 ind/ha) **[Figure 5]**.

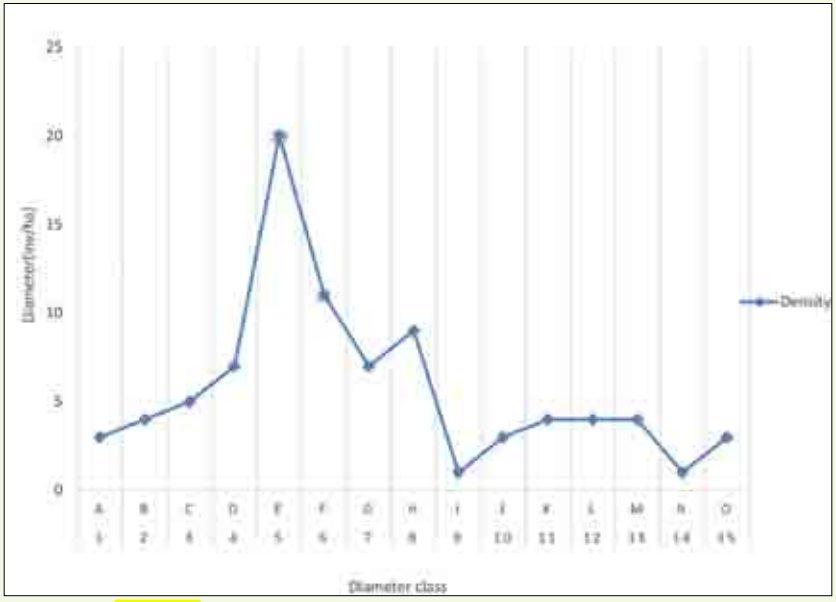


Figure 5: Class-wise availability of tree species in the sampling site

Among the tree species, *Lithocarpus pachyphyllus* recorded the highest diameter in the diameter class 67 (1 no. of species), followed by *Machilus edulis* falling under diameter class 59 (1 no. of species). While *Rhododendron arboreum* (2 no. of species) and *Machilus edulis* (1 no. of species) were recorded the lowest diameter in diameter class 1 **(Figure 5)**. While, *Symplocos glomerata* was recorded with maximum number species in girth class 5 (8 no. of species) followed by *Symplocos lucida* (4 no. of species) in girth class 5 and *Quercus lamellosa* in girth class 3 (3 no. of species) and girth class 5 (3 no. of species)**[Figure 5]**. Similarly, diameter class distribution for some of the dominant species in Tendong Reserve Forest is depicted in **Figure 6**, which reveals that, for no species, individuals falling in all the diameter class were recorded from the study sites.

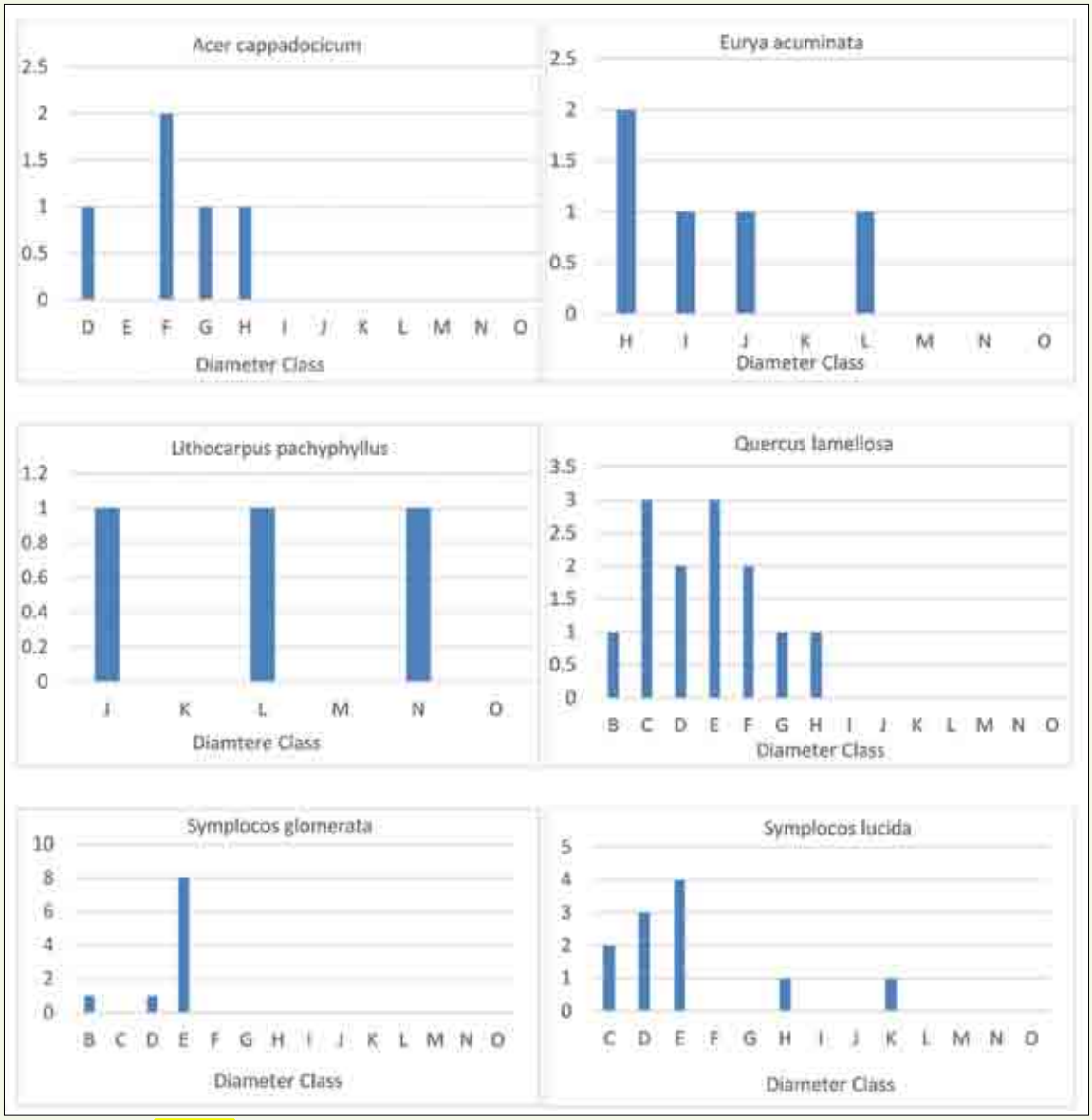


Figure 6: Diameter class distributions for some of the dominant tree species in Tendong RF

A total of 6 species of shrubs belonging to 5 genera and 5 families were recorded. The highest percent cover was recorded for *Rubus ellipticus* Sm. (8.1%) followed by the *Viburnum erubescencs* (7%) and *Rubus splendidissimus* (5.1%) **[Figure 7].** While the lowest percentage was recorded for *Azelea* species (1.2%) followed by *Osbeckia stellata* Buch.-Ham. ex Ker Gawl. (1.1%) **[Figure 7].**

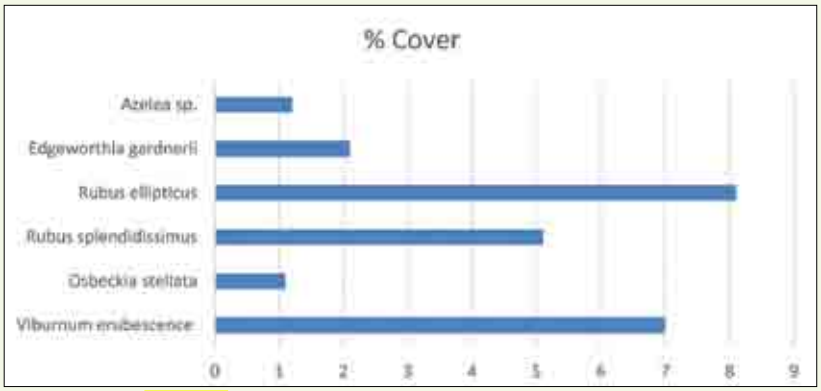


Figure 7: % cover of shrubs in Tendong RF Sampling path

Similarly, a total of 21 species of herbs with 20 genera and 12 families were recorded. The highest percentage cover was recorded for *Eragrostis* species (19%) followed by *Laportea bulbifera* (Siebold & Zucc.) Wedd. (14%), *Polygonum molle* D. Don (9.5%), *Pilea umbrosa* Blume (9%) and *Centella asiatica* (L.) Urb. (7.5%) **[Figure 8]**; while the lowest percentage was recorded for *Fragaria nubicola (*Lindl. ex Hook.f.) Lacaita, *Rubia manjith* Roxb. ex Fleming, *Astilbe rivularis* Buch.-Ham. ex D.Don and *Hedychium gardnerianum* Sheppard ex Ker Gawl. (0.5%) **[Figure 8]**. If we go according to the family-wise composition, the highest number of taxa was recorded for Urticaceae (4) followed by Asteraceae (3), Polygonaceae (3) and Zingiberaceae (2) **[Figure 9]**. Apart from the above species, the commonly found herbs are represented by *Carex* sp., *Cautleya* sp., *Elastotema platyphyllum*, *Persicaria capitata*, *Hedychium spicatum*, *Hedychium gardnerianum*, etc.

However, many species of fern and fern-allies such as *Gleichenia longissima*, *Pteridium revolutum*, *Cyathea chinensis* and *Nephrolepis cordifolia* cover the forest floor in clusters and some grow as epiphytes as well. The trees also support epiphytic orchids and climbers of various species like *Crawfurdia speciosa*, *Piper boehmeriifolium*, *Pleione praecox* and *Tetrastigma serrulatum*.

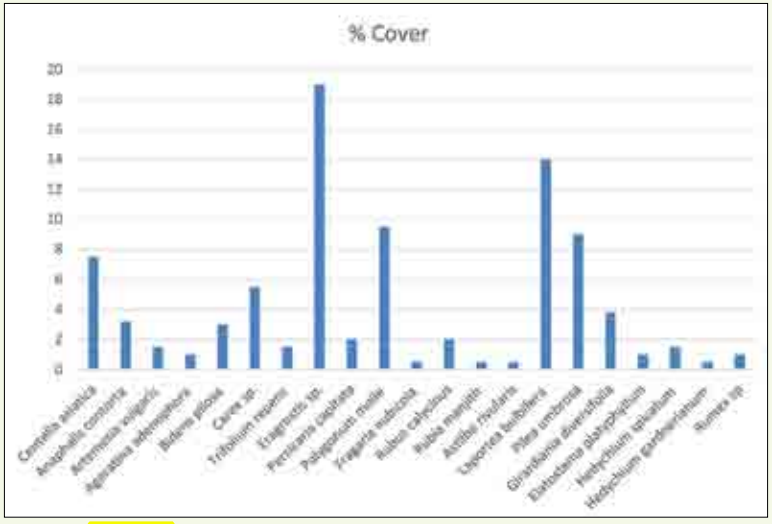


Figure 8: % Cover of Herb species in Tendong RF Sampling path

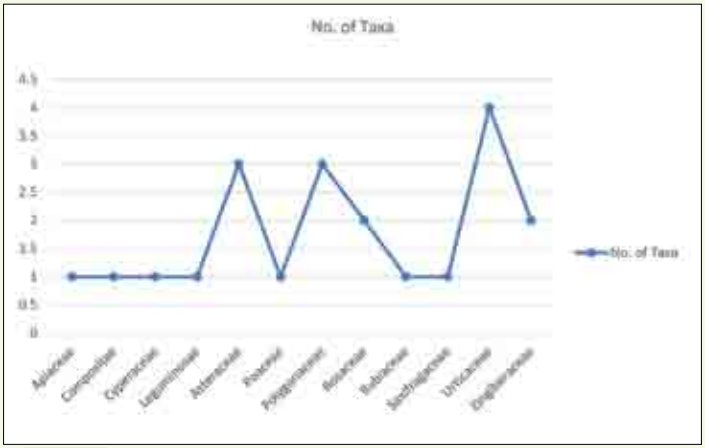


Figure 9: Family-wise species composition of herb species in Tendong RF

FAUNA

During the trail sampling, a total of 7 species of mammals and 18 bird species were recorded along Tendong trail (**Table 6 & 7**). Amongst the mammalian species, Assamese Macaque, Himalayan Serow have been assessed as near threatened by the IUCN whereas Himalayan black bear as Vulnerable.

Table 6 Mammal species encountered in the trail sampling along Tendong RF transect

Common Name	Zoological Name	Local Name	Evidences[1]	IUCN Status[2]
Barking Deer	*Muntiacus muntjak*	Mirga	P	LC
Squirrel	*Dremomys lokriah*	Lottherkey	S	LC
Assamese Macaque	*Macaca assamensis*	Bandar	C	NT
Serow	*Capricornis thar*	Thar	P	NT
Wild boar	*Sus scrofa*	Badel	DS	LC
Yellow Throated Marten	*Martes flavigula*	Malsapra		LC
Himalayan Black Bear	*Ursus thibetanus*	Bhalu	DS, FS	V

[1]**C**: Call, **DS**: Digging sign, **FS**: Foraging sign, **P**: Pellet, **PM**: Pug mark, **S**: Sighting [2]**LC**: Least concern, **NT**: Near threatened, **VU**: Vulnerable

Table 7 Checklist of bird species encountered along Tendong RF transect

Species	Zoological Name	Local Name	Evidences[1]	IUCN Status[2]
Blue Whistling Thrush	*Myophonus caeruleus*	Kalchura	S	LC
Common Green Magpie	*Cassa chinensis*	Dhodey Koiley	S	LC
Common Myna	*Acridotheres tristis*	Ruppi	S	LC
Great Barbet	*Megalaima virens*	Neol	S	LC
Green Backed Tit	*Parus monticolus*	Chi chink Kotey	S	LC
Green Tailed Sunbird	*Aethopyga nipalensis*	Balchi	S	LC
Himalayan Bulbull	*Pycnonotus leucogenys*	Jureli	S	LC
House Crow	*Corvus splendens*	Kag	S	LC
House Sparrow	*Passer domesticus*	Bhangera	S	LC
Kaleej Pheasant	*Lophura leucomelanos*	Kalij	S	NA

Red Tailed Minla	*Minla ignotincta*		S	LC
Red Vented Bulbull	*Pycnonotus cafer*	Jureli	S	LC
Rufous Sibia	*Malacias capistratus*		S	LC
Scaly Thrush	*Zoothera duma*		S	LC
Striated Laughingthrush	*Garrulax striatus*	Kolkoley	S	LC
Velvet Fronted Nuthatch	*Sitta frontalis*	Sulsuley	S	LC
Verditer Flycatcher	*Eumyias thalassinus*	Harini	S	LC
Whiskered Yuhina	*Yuhina flavicollis*	Sano Jureli	S	LC
[1]**S**: Sighting; **LC**: Least concern; **NA**: Not assessed				

DISCUSSION

Tendong Reserve Forest, located in Tendong hill above Damthang is a famous tourist destination. The top of the hill goes upto the elevation of 8660 ft which provide serene environment and the breathtaking panoramic views of the Eastern Himalayas. It can be approached only by trekking which starts from Damthang. The length of the trek route is around 6 kms which passes through lush green forest, rich in Spectacular Flora and Fauna.

Historically, this has been a place of solitary for Buddhist monk who spend years in meditation amidst the silent scenic grandeur. As per the Lepcha folklore Tendong Hill gets its name, meaning "the land of the horn" and the myths of Lepchas which passed on through generation are that, Tendong saved them from the great flood, which submerged the entire world. This lore is an amazing resemblance with Noah's Ark as Mount Ararat become the savour like Tendong Hill. It is a sacred place. Even today Lepchas pay homage to Tendong Hill on Lho Rham Faat.

A small monastery and a three storied watch towers are on the top.The massive earthquake of September 2011 has left the tower and monastery with cracks. From this tower we get a magnificent 360° view of the entire mountain ranges of Sikkim viz. Singalila range in the west and Chola range in the east.

Sikkim harbours 11 oak species viz. *Quercus lamellosa* Sm., *Quercus serrata* Murray, *Quercus lineata* Blume, *Quercus glauca* Thunb., *Quercus laurina* Bonpl., *Lithocarpus fenestratus* (Roxburgh) Rehder, *Lithocarpus pachyphylla* (Kurtz) Rehder, *Castanopsis hystrix* Hook. f. & Thomson ex A. DC., *Castanopsis tribuloides* (Sm.) A.DC, *Castanopsis indica* (Roxb. ex Lindl.) A. DC. and *Castanopsis lanceifolia* (Oerst.) Hickel & A. Camus. During our field survey in the Tendong reserve forest, we came across 4 types of oak species viz. *Castanopsis tribuloides, Castanopsis hystrix, Lithocarpus pachyphyllus* and Quercus lamellosa all belonging to Fagaceae family. Quercus lamellosa (130±0.68 ind/ha) had the highest density followed by the *Lithocarpus pachyphyllus* (70±0.33 ind/ha), *Castanopsis hystrix* and *Castanopsis tribuloides* (30±0.50 ind/ha) each.

0aks are considered Keystone species because it plays a critical role in maintaining the structure of an ecological community and whose impact on the community is greater than would be expected based on its relative abundance or total biomass[(3)]. Many species of oaks are under threat of extinction in the wild, largely due to land use changes, livestock grazing and unsustainable harvesting[(4)].

The present study of the forest was dominated by Rosaceae (7 species) followed by Urticaceae (4 species), Compositae (4 species), Ericaceae (4 species), Fagaceae (4 species), Polygonaceae (3 species) and Zingiberaceae (3 species) in the entire plots. Rosaceae is major dominant family as compared to other family in present study. The family included several species belonging to the genus *Fragaria, Prunus, Rubus* etc.

The tree density was recorded higher for *Quercus lamellosa* followed by *Machilus edulis, Symplocos glomerate* and *Symplocos lucida.* Whereas in the seedling category, the higher density was recorded for *Rhododendron arboreum* followed by *Lithocarpus pachyphyllus*, *Symplocos lucida, Rhododendron hodgsonii*, *Tetradium febrifuga* and *Symplocos glomerate.* In saplings highest was recorded for Symplocos lucida, Quercus lamellose, *Machilus edulis* and *Rhododendron arboreum*.

Similarly, the higher frequency was recorded for *Machilus edulis*, *Quercus lamellosa*, *Symplocos lucida* and *Symplocos glomerate.* While, in the seedling higher frequency was recorded for Quercus lamellosa, *Machilus edulis, Castronopsis hystrix* and *Rhododendron arboreum*. Whereas, the higher frequency in sapling was recorded in *Symplocos lucida, Castronopsis hystrix, Lithocarpus pachyphylla* and *Tetradium febrifuga.*

In terms of Important Value Index (IVI) in Tendong Reserve Forest, the dominant tree species where *Lithocarpus pachyphyllus* (46.26) followed by *Machilus edulis* (45.68), *Castronopsis hystrix* (26.61) and *Symplocos lucida* (21.99), were dominant tree species in the entire sampling plots. According to Subba et al, 2014 the broad-leaved hill forest temperate region mostly comprises mostly Oak forest. Similarly in Sikkim Himalayas, the Oak species viz.*Lithocarpus pachyphyllus*, *Quercus lamellose, Castronopsis hystrix and Castanopsis tribuloides* were highly dominated in the forest, which has water holding capacity in the ground. This is evident in the present study area where *Lithocarpus pachyphyllus*, Quercus lamellose, *Castronopsis hystrix and Castanopsis tribuloides* has been found to be the dominant Oak species. These Oak species is also indicator of faunal species presence especially; the fruits are eaten by Wild boar, Red Panda and which directly relates to the growth of predator species like leopard (Subba et al, 2014).

When further analysed with girth classes, the intervals started from 20-30 cm and ended at 671-680 cm at ghb. The dominant species as well as a few major tree species of the study site was measured to understand the community structure. Among the Oak species *Lithocarpus pachyphyllus and Machilus edulis* followed almost a normal distribution curve with increasing the girth classes suggesting stable population. In case of *Quercus lamellose, Symplocos glomerate* and *Symplocos lucida,* there is larger proportion of small girth classes to moderate girth classes than fairly big trees. This study suggested that the population of these trees is more stable and is capable of regenerating to mature trees under favourable conditions.

The highest percent cover of shrubs/Scrub species were recorded in diminishing order of *Viburnum erubescens, Rubus ellipticus, Rubus splendidissimus, Edgeworthia gardnerii, Azelea* sp. and *Osbeckia stellate* in the entire sampling plots. Similarly, the highest herb percent cover was recorded as *Eragrostis* sp. (19), *Laportea bulbifera* (14), *Polygonum molle* (9.5), *Pilea umbrosa* (9), *Centella asiatica* (7.5), *Carex* sp. (5.5), *Girardiania diversifolia* (3.8), *Anaphalis contorta* (3.2), *Bidens pilosa* (3), *Persicaria capitata* (2), *Rubus calycinus* (2)., etc. Similarly, in the family-wise species composition the maximum family of herbs species were recorded Urticaceae (4 species), Zingiberaceae, Compositae, Polygonaceae and Rosaceae (2 no. of taxa each) respectively. Highest family Zingiberaceae included several species belonging to the taxa of *Laportea bulbifera, Pilea umbrosa, Girardiania diversifolia and Elatostema platyphyllum* (Urticaceae) and the taxa belonging to *Hedychium spicatum and Hedychium gardnerianum* (Zingiberaceae). While the taxa belonging *Anaphalis contorta* and *Ageratina adenophora* (Compositae) and the taxa belonging *Persicaria capitata* and *Polygonum molle* (Polygonaceae) and the taxa belonging *Fragaria nubicola and Rubus calycinus* (Rosaceae) were recorded. Apart from these plant species, one bamboo species *Yushania maling* (locally called as "Maling") is widely distributed in Tendong Reserve Forest trekking trail. The bamboo is used to in house construction and for matting. When growing vigorously, the bamboo can be used for weaving baskets or making fencing, more usually though the growth is smaller and is used for making brushes and straws.

Barsey Rhododendron Sanctuary
West Sikkim

Anjana Pradhan, Sanjyoti Subba, Nimesh Chamling and Sumitra Nepal

Photo 1: Survey team at Barsey Rhododendron Sanctuary at Hilley in West Sikkim

INTRODUCTION

Barsey Rhododendron Sanctuary, located in the West District of Sikkim, is nestled in the Singalila Range sharing its border with Nepal in the west and West Bengal in the south over the Rambong Khola. Occupying an area of 104km^2, the sanctuary is a trans-boundary protected area bounded by 27°14′01″ N latitude and 88°14′26″ E longitude towards east, 27°12′47″ N latitude and 88°01′05″E longitude towards west, 27°17′21″ N latitude and 88°02′31″ E longitude towards north, and 27°09′05″N latitude and 88°08′00″E longitude towards south. The sanctuary being a rich store house of flora especially the rhododendrons and fauna, this sanctuary was created and notified in the year 1998 under the Notification No.50/WL/F/95/269/F & WL dated 08.06.96 (**Photo 1**).

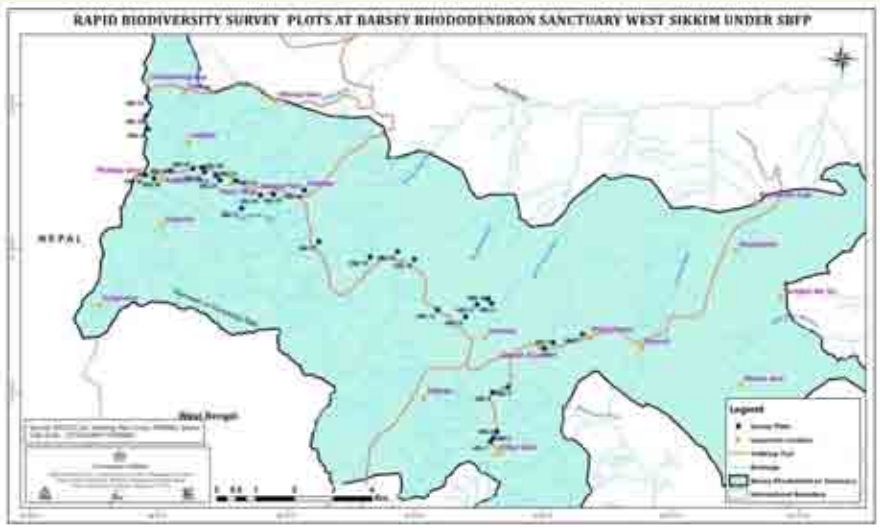
The altitudinal gradient of 2200-4100 m above sea level has a diverse topography providing a range of climate leading to a vast floral and faunal diversity right from the sub-tropical forest to the alpine meadows. These forests are mainly dominated by species of rhododendron favored by the wet and cold climate along with varieties of tree and medicinal plant species of economic value. The splendid sight of rhododendron flowers with a grandiose view of the Mount Kangchendzonga at the back drop and the region being a home to the state animal, Red Panda (*Ailurus fulgens*), makes the sanctuary an attractive paradise for nature lovers.

The sanctuary is flourished with trees of *Rhododendron arboreum*, *R. barbatum*, *R. falconeri*, *R. grande*, *R. griffithianum* and *R. hodgsonii* and shrubs such as *R. campanulatum*, *R. dalhousieae* and *R. lepidotum* giving the forest a beautiful look at the time of blooming. Other commonly available tree species are *Abies densa*, *Acer campbellii*, *A. caudatum*, *A. palmatum*, *A. pectinatum*, *Lithocarpus pachyphyllus*, *Maddenia himalaica*, *Magnolia campbellii*, *Prunus* sp., *Symplocos lucida* and *Tsuga dumosa*. While many epiphytic species such as orchids, mosses and lichens are seen growing on trees, shrubs such as *Berberis insignis*, *Daphne cannabina*, *Gaultheria nummularioides*, *Gaultheria trichophylla*, *Piptanthus nepalensis*, *Rosa sericea*, *Rubus* sp. *and Viburnum erubescens* are frequently seen throughout the forest. The forest floor is covered by various species of herbs such as *Arisaema* sp., *Frageria nubicola*, *Hemiphragma heterophyllum*, *Oxalis* sp., *Potentila* sp., *Primula* sp., *Rubus* sp., *Swertia* sp. and *Viola* sp. The sanctuary is also rich in medicinal herbs such as *Swertia* sp., *Paris polyphylla*, *Oxalis corniculata*, *Meconopsis paniculata*, *Heracleum wallichii* and *Rumex nepalensis*. Thick growth of bamboo such as *Bambusa* sp. and *Sinarundinaria microphylla* is encountered habitually along the trial serving a habitat for Red Panda.

The sanctuary, renowned for harboring varieties of rhododendron, is also known for sheltering a wide range of faunal species viz., Red Panda, Himalayan Black Bear, Barking Deer, Yellow-throated Marten, Goral, Common Leopard, Leopard Cat, Marbled Cat, Himalayan Palm Civet, Wild dog, Fox, Wild Boar, Serow, Monal Pheasant, Kaleej Pheasant, Crestless Porcupine, Rufous-tailed Hare, Flying Squirrel and Himalayan Mouse Hare. Birds such as Verditer Flycatcher, Large-billed Crow, Plain mountain finch, Spotted laughing thrush, Grey-backed shrike, Green-tailed sunbird, Green-backed tit and Blood Pheasant.

SURVEY AREA

The Rapid Biodiversity Survey was conducted along the trekking route of Barsey Rhododendron Sanctuary starting from Hilley to Chewabhanjyang (April-May 2017) covering 40 km approx. distance. The altitude of the surveyed path ranged from 2737m to 3610m asl lying between 27º11'14.9''N-27º15'0.0''N latitude and 88º07'11.7''E -88º01'50.5''E longitude covering temperate rhododendron forest, temperate coniferous forest and sub-alpine forest. A total of 33 plots were laid along the transect (**Map**).



Map of the Rapid Biodiversity Survey along the Barsey Rhododendron Sanctuary sampling path

MATERAILS AND METHODS

FLORA: The sampling plot of 10 X 10 m was laid, depending upon the site feasibility. Within the main plot, all the standing tree species were enumerated and measured (cbh) at 1.37 m from the ground by using measuring tape. Circumference at breast height (1.37 m) was taken for the determination of tree basal area. Total basal area is the sum of basal area of all species present in the forest. Basal area (m2 / ha) was used to determine the relative dominance of a tree species. Within the subplots, 5 m X 5m were laid for recording the sapling (no. of species & its height) & shrub for the percent cover was recorded. Within this, 1 m X 1m were laid in 4 corner and 1 point at centre for seedling species were enumerated, in the same plot was used for recording the herb percentage in the area. The location and altitude of the plots were recorded by calibrate the global positioning system (GPS; Garmin eTrex) and the humus depth was measured with the help of measuring scale. Plant species were identified through herbarium record and flora published (Hooker JD, 1888-1890, Hooker JD 1849, Pradhan & Lachungpa, 1990, Kholia, 2010). The unidentified plants species in the field were photographed, and later identified by consulting plant taxonomist), & BSI and web references (www.efloras.org; www.flowersofindia.net & www.floraofchina.org) were made and by referring to local people too. All the sampling plots were geo-tagged for reference under long-term monitoring.

FAUNA

The presence and relative abundance of most small and large species of animals has been studied using methods based on indirect evidence, such as animal pits, manure, pellets, fossils, feeding signs & tracks. The birds and butterflies were inventoried along the sampling paths.

Photo 2: Laying sampling plots and enumerating floral species

Table 1: Site characteristics of the sampling plots along Barsey Rhododendron Sanctuary path

Site Code	Area Name	Forest Type	Altitude (m)	GPS Coordinate		Slope Angle	Slope Aspect	Canopy Cover (%)	Disturbance
				Latitude (N)	Longitude (E)				
BRS 1	Hilley	Temperate Rhododendron Mixed Forest	2737	27°11′14.9”	88°07′11.7”	70	N	30	Natural
BRS 2	Hilley	Temperate Rhododendron Mixed Forest	2774	27°11′18.3”	88°07′14.2”	80	NE	20	Natural
BRS 3	Hilley	Temperate Rhododendron Mixed Forest	2797	27°11′23.5”	88°07′17.7”	80	NE	10	Natural
BRS 4	Hilley	Temperate Rhododendron Mixed Forest	2842	27°11′56.09”	88°07′14.4”	50	E	20	Natural
BRS 5	Hilley	Temperate Rhododendron Mixed Forest	2811	27°12′0.6”	88°07′28.6”	60	NW	10	Natural
BRS 6	Hilley	Temperate Rhododendron Mixed Forest	2865	27°12′32.5”	88°08′2.8”	10	E	25	Natural
BRS 7	Barsey	Temperate Rhododendron Mixed Forest	2823	27°12′37.2”	88°08′11.3”	10	SE	30	Natural
BRS 8	Barsey	Temperate Rhododendron Mixed Forest	2797	27°12′44.1”	88°08′38.7”	40	NE	15	Natural
BRS 9	Barsey	Temperate Rhododendron Mixed Forest	2835	27°13′10.3”	88°07′13.8”	70	NE	20	Natural
BRS 10	Barsey	Temperate Rhododendron Mixed Forest	2845	27°13′14.5”	88°07′10.7”	25	E	45	Natural
BRS 11	Barsey	Temperate Rhododendron Mixed Forest	2871	27°13′9.7”	88°07′0.1”	40	NE	10	Natural
BRS 12	Lasuney	Temperate Rhododendron Mixed Forest	2826	27°12′59.7”	88°06′49.5”	40	N	10	Natural
BRS 13	Above Lasuney	Temperate Rhododendron Mixed Forest	2853	27°13′5.4”	88°06′23.4”	35	E	60	Natural
BRS 14	Below DeonigaloDhaap	Temperate Rhododendron Mixed Forest	2808	27°13′47.8”	88°06′2.2”	60	SE	0	Natural
BRS 15	DeonigaloDhaap	Temperate Rhododendron Mixed Forest	2787	27°13′54.5”	88°05′46.4”	45	E	60	Natural

BRS 16	Above DeonigaloDhaap	Temperate Rhododendron Mixed Forest	2813	27°13′50.2”	88°05′20.6”	10	E	40	Natural
BRS 17	Above Duck Pokhari	Temperate Rhododendron Mixed Forest	2872	27°14′3.3”	88°04′32.9”	mild	NE	10	
BRS 18	Achallay	Temperate Rhododendron Mixed Forest	2885	27°14′46.5”	88°04′19.6”	mild	NE	0	Anthropogenic
BRS 19	Above Achallay	Temperate Rhododendron Mixed Forest	2885	27°14′43.1”	88°03′50.6”	30	NE	20	Natural
BRS 20		Temperate Rhododendron Mixed Forest	2968	27°14′42.4”	88°03′38.6”	15	NE	20	Natural
BRS 21		Temperate Rhododendron Mixed Forest	2947	27°14′31.6”	88°03′20.6”	10	NE	0	Natural
BRS 22	Thulo Dhaap	Temperate Rhododendron Mixed Forest	2877	27°14′54.9”	88°03′15.5”	mild	NE	10	Natural
BRS 23	Above Thulo Dhaap	Temperate Coniferous	3002	27°14′55.6”	88°03′0.5”	40	NE	30	Natural
BRS 24		Temperate Coniferous	3069	27°14′59.3”	88°02′56.7”	30	NE	20	Natural
BRS 25		Temperate Coniferous	3177	27°15′2.3”	88°02′46.3”	mild	NE	20	Natural
BRS 26		Temperate Coniferous	3250	27°15′6.0”	88°02′44.1”	60	NE	35	Natural
BRS 27	Chipchipey	Temperate Coniferous	3352	27°15′5.2”	88°02′35.5”	10	NE	0	Natural
BRS 28	Kalijhar	Sub-Alpine	3412	27°15′3.5”	88°02′14.8”	90	SW	0	Natural
BRS 29	Above Kalijhar	Sub-Alpine	3509	27°14′57.2”	88°01′59.1”	90	NE	0	Natural
BRS 30	Phoktey Dara	Alpine	3610	27°15′0.0”	88°01′50.5”	mild	NE	0	Natural
BRS 31		Temperate Coniferous	3251	27°15′38.5”	88°01′53.9”	60	NE	10	Natural
BRS 32	Before Chewa-bhanjyang	Temperate Coniferous	3157	27°15′50.0”	88°01′52.2”	45	E	15	Natural
BRS 33	Chewa-bhanjyang	Temperate Coniferous	3119	27°16′5.3”	88°01′52.6”	25	S	10	Natural
Note: N, North; S, South; E, East; NE, North-East; NW, North-West; SW, South-West; SE, South-East.									

FINDINGS AND DISCUSSION

FLORA

A total of 109 floral species belonging to 45 families were recorded during the survey and covering an area 0.33 ha. Herbs represented the highest 50 number of species belonging to 39 genera in 26 families. This was followed by shrubs with 26 species belonging to 18 genera in 12 families. Trees characterized 21 species including 1 unidentified species belonging to 13 genera in 9 families. Whereas, 4 epiphytes species 3 genera belonging to 2 families, climbers represented 6 species with 5 genera belonging to 5 families were recorded. The highest species was documented from Ericaceae family representing *rhododendron* species along with other species such as *Gaultheria* sp., and *Vaccinium* species.

The vegetation of the surveyed path from Hilley to Barsey comprises of trees viz., *Abies densa*, *Lithocarpus pachyphyllus*, *Symplocos lucida* and *Tsuga dumosa* giving a moderate canopy cover. A rhododendron tree species of *R. arboreum* of rosy-red form is seen flourishing along the trail. *Rhododendron barbatum* which is categorized as vulnerable in Sikkim is found at large scale at an elevation of 2823m asl just before reaching Barsey which can also be observed at higher elevation of the sanctuary. A pure stand of *Rhododendron falconeri* is found at an elevation of 2865m asl. The forest floor is densely covered with shrubs and herbs. The commonly occurring shrubs are *Polygonum molle*, *Berberis insignis*, *Cotonaester microphyllus*, *Daphne cannabina*, *Gaultheria nummuloroides*, *Ilex* sp., *Piptanthus nepalensis*, *Rubus ellipticus* and *Viburnum erubescens*. While *Gaultheria nummuloroides* was recorded with herbs such as *Arisaema griffithii*, *Viola* sp., *Fragaria nubicola*, *Paris polyphylla*, *Impatiens* sp., *Astilbe* sp., *Hypericum* sp., *Lycopdium* sp., *Primula* sp., *Rumex nepalensis*, *Anaphalis* sp., *Heracleum wallichii*, *Centella asiatica*, *Oxalis corniculata* and *Elatostema platyphyllum* are found covering the forest floor. Epiphytes and climbers such as *Holboellia latifolia, Rubia manjith*, *Smilax* sp. and *Vaccinium nummularia* and mosses are commonly seen growing on trees.

Photo 3a, b: *Rhododendron arboreum* and *Rhododendron dalhousieae* in full bloom

The flora along the trekking route from Barsey to Sano Dhaap to Thulo Dhaap was dominated by *Tsuga dumosa*, *Lithocarpus pachyphyllus*, *Rhododendron arboreum* and *R. falconeri* with shrub species such as *Berberis insignis*, *Daphne cannabina*, *Gaultheria nummularioides*, *Rosa sericea* and *Viburnum erubescens* which are most prominent at 2835 m asl **(Photo 3a)**. Saplings and seedlings of *R. barbatum*, *R. hodgsonii* and *Acer* species were recorded abundantly. Trees are mostly covered with an epiphyte speices such as *Vaccinium nummularia*, and climbers such as *Holboellia latifolia* and *Clematis montana* are seen clinging on them. However, an epiphytic shrub, *R. dalhousieae*, was spotted along 2810 m asl at latitude

27°13′48.5″ N and longitude 88°05′17.8″ E growing on the common shrub *Viburnum erubescens* **(Photo 3b)**. The commonly found herbs are *Fragaria nubicola*, *Geranium* sp., *Hemiphragma heterophyllum*, *Primula* sp., *Potentila* sp. and *Viola pilosa*. A herb named *Ligularia* sp. (locally called Barsey jhar), is found only along the Barsey trekking route. Though *Arisaema griffithii* is distributed along this trekking route, *Arisaema nepenthoides* and *Arisaema speciosum* were recorded. The reed-bamboo, *Sinarundinaria microphylla*, is largely distributed along 2787 m asl at Sano Dhaap (locally called Deonigalo Dhaap; **Photo 4**). It is a rare species recorded only in West district of Sikkim so far.

Photo 4: *Sinarundinaria microphylla* at Sano Dhaap

Along Thulo Dhaap-Kalijhar trail (2877-3412 m asl), the temperate rhododendron mixed forest is slowly replaced by temperate coniferous forest dominating with *Rhododendron falconeri* and *R. barbatum* **(Photo 5a, b)**. Another species of rhododendron, *R. hodgsonii*, is available in the area along with *Magnolia campbellii* is in full bloom stage **(Photo 6)**. The shrubs are also replaced by *Berberis mucrifolia*, *Cotonaester microphyllus*, *Enkianthus deflexus*, *Gaultheria trichophylla*, *Piptanthus nepalensis* and *Viburnum nervosum* while *Rosa sericea* and *Daphne cannabina* are the existing shrubs found upto Kalijhar. Even the floor of the temperate coniferous forest is covered with *Gentiana pedicellata*, *Primula* sp., *Potentila* sp., *Frageria nubicola*, *Meconopsis paniculata* and *Cirsium* sp., *Arisaema griffithii* and *A. nepenthoides* are found amongst the *Arisaema* species.

Photo 5a: ***Rhododendron falconeri*** **habitat along Hilley-Barsey sampling path**

Photo 5b: ***Rhododendron barbatum*** **habitat and its blooming along Hilley-Barsey sampling path**

Photo 6: ***Rhododendron hodgsonii***

However, on reaching Kalijhar, the forest is substituted with an open scrubland with herb vegetation viz., *Cirsium* sp., *Frageria nubicola* and *Potentila* sp. Above this zone, the forest is again flourished with *R. arboreum* (rosy and pinkish-red form) covering the entire forest; and huge trees of *Abies densa* were recorded along Kalijhar. A large portion of ground is largely distributed with scrubs of *R. lepidotum* in its vegetative stage on the way upto Kalijhar (**Photo 7**). Scrubs such as *Cotonaester microphyllus*, *Rosa sericea* and *Berberis* sp. are widely distributed and herbs of *Potentila* sp., *Cirsium* sp. and *Anaphalis* sp. cover the floor.

Photo 7: ***Rhododendron lepidotum*** **along Kalijhar – Phoktey Dara**

Phoktey Dara, standing at 3610 m altitude, is a small hillock which is a viewpoint for the Singalila Range (**Photo 8**). The alpine vegetation such as *Berberis* sp. and *Cirsium* sp were recorded. Below this zone is the sub-alpine zone representing the vegetation of *R. barbatum, R. falconeri* and *Machilus* sp. The prevailing shrubs along this trekking route upto Chewabhanjyang are *Berberis* sp., *Daphne cannabina, Rosa sericea* and *Viburnum nervosum* while herbs species such as *Potentila* sp., *Meconopsis* sp., *Frageria nubicola*, *Hemiphragma heterophyllum*, *Viola serpens*, *V. pilosa* and *Geranium* sp. are commonly found and recorded.

Apart from the above-mentioned species, the checklist of the floral diversity recorded along the Barsey Rhododendron Sanctuary is listed in **Table 2**.

Table 2: Checklist of floral species encountered along the Barsey Rhododendron Sanctuary

Sl. No.	Botanical Name	Common Name	Local Name	Family	Altitudinal ranges (m) asl	IUCN/ Regional Status
TREES						
1	*Abies densa* Griffith. ex Parker	Silver Fir	GobreySalla	Pinaceae	2800 – 3700	LC
2	*Acer campbellii* Hook. & Thom. ex Hiern	Campbell's Maple	Kapasay	Aceraceae	1800 – 2700	NA
3	*Acer palmatum*	Palmate Maple	Kapasay	Aceraceae	2500 – 3000	NA
4	*Acer pectinatum* Wall. ex Nicholson	Maple	LekhKapasay	Aceraceae	2300 – 3700	NA
5	*Betula utilis* Don	Himalayan Birch	Bhojpatra	Betulaceae	2500 – 3800	LC
6	*Lithocarpus pachyphyllus* (Kurtz.) Rehder	Thick-leaved Oak	SungureyKatus, Bante	Fagaceae	1800 – 2700	NA
7	*Lyoniaovalifolia*	Oval-leaved Lyonia	Angeri	Ericaceae	1500 – 3000	NA
8	*Machilus*sp.		Kawlo	Lauraceae	1500 – 2100	NA
9	*Maddenia himalaica Hook. f. & Thom.*			Rosaceae	2400 – 3000	NA
10	*Magnolia campbellii* Hook. f. & Thom.	Campbell's Magnolia	Ghogey Champ	Magnoliaceae	2400 – 3100	LC
11	*Magnolia doltsopa* (Buch.-Ham. ex DC.) Figlar	Doltsopa	Rani Champ	Magnoliaceae	2100 – 2500	NA
11	*Prunus sp.*					

Photo 8: Phoktey Dara at 3610 m asl

12	*Rhododendron arboretum* (CB Clarke) Ridley.	Arborescent Rhododendron	LaliGurans	Ericaceae	1700 – 3400	IUCN: NA; Sikkim: VUL[5]
13	*Rhododendron barbatum* Wall. ex G. Don	Bristly Rhododendron	LalChimal	Ericaceae	3000 – 3700	IUCN: NA; Sikkim: VUL
14	*Rhododendron falconeri* Hook. f	Dr. Falconer's Rhododendron	Korlinga	Ericaceae	2700 – 3000	IUCN: NA; Sikkim: Threatened
15	*Rhododendron grande* Wight	Large Silvery Rhododendron	PatleKorlinga	Ericaceae	2000 – 3000	IUCN: NA; Sikkim: Threatened
16	*Rhododendron griffithianum* Wight	Lord Auckland's Rhododendron	SetoChimal	Ericaceae	1800 – 3200	IUCN: NA; Sikkim: Out of danger
17	*Rhododendron hodgsonii* Hook. f.	Hodgson's Rhododendron	Khorlinga	Ericaceae	3000 – 4000	IUCN: NA; Sikkim: Out of danger
18	*Sorbus* sp.		Lekpasi	Rosaceae	2700 – 5400	NA
19	*Symplocos lucida*		Kharanay	Symplocaceae	1900 – 2500	NA
20	*Tsuga dumosa* (D. Don) Eichler	Himalayan Hemlock	TengreSalla	Pinaceae	2500 – 3000	LC
21	Unidentified					
SHRUBS/SCRUBS						
1	*Acanthopanax cissifolius* (Griff. ex C.B.Clarke) Harms	Grape-Leaf Eleuthero	Dangdinge	Araliaceae	2500 – 3600	NA
2	*Polygonum molle* (D. Don) H. Hara	Sikkim Knotweed	Thotne	Polygonaceae	1300 – 3200	NA
3	*Alstonia* sp.			Apocynaceae		
4	*Berberisi nsignis* Hook. F. &Thoms.		Chutro	Berberidaceae	2000 – 3400	NA
5	*Berberis mucrifolia*Ahrendt	Box-leaved Barberry		Berberidaceae		
6	*Cotoneaster microphyllus* Lindley	Rockspray Cotoneaster		Rosaceae	2400 – 4000	NA
7	*Daphne cannabina* Lour.	Indian Paper Plant	Baruvaa, Lokta	Thymelaeaceae		
8	*Elatostema platyphyllum Wedd.*		Sano Gangleto	Urticaceae	700 – 1900	NA
9	*Enkianthus deflexus* (Griff.) C.K. Schneid.	Himalayan Red Bells, Himalayan Enkianthus	RatoAngeri	Ericaceae	2500 – 3300	NA

10	*Gaultheria nummularioides* D.Don	Coinwort Snowberry	KaaliGedi	Ericaceae	2100 – 4100	NA
11	*Gaultheria trichophylla* Royle	Himalayan Snowberry	KaaliGedi	Ericaceae	2700 – 4500	NA
12	*Ilex* sp.			Aquifoliaceae		
13	*Mahonia napaulensis* DC.	Nepal Mahonia, Indian barberry	JamaneMandro	Berberidaceae	1200 – 3000	NA
14	*Piptanthus nepalensis* (Hook.) D. Don	Evergreen Laburnum		Fabaceae	2100 – 3600	NA
15	*Rhododendron campanulatum* D.Don	Bell-flowered Rhododendron	NiloChimal	Ericaceae	3000 – 4500	IUCN: NA; Sikkim: Threatened
16	*Rhododendron dalhousieae* Hook. f. & Thom.	Lady Dalhousie's Rhododendron	LahareChimal	Ericaceae	2000 – 2600	IUCN: NA; Sikkim: Out of danger
17	*Rhododendron lepidotum* Wall. ex G. Don	Scaly Rhododendron	BhaleSunpate	Ericaceae	2500 – 5000	IUCN: NA; Sikkim: Out of danger
18	*Ribes* sp.			Grossulariaceae		
19	*Rosa sericea* Lindl.	Silky Rose	BhoteyGulab	Rosaceae	2100 – 4500	NA
20	*Rubus ellipticus* Sm.	Yellow Himalayan Raspberry	Ainselu	Rosaceae	1700 – 2300	NA
21	*Rubus nepalensis* (Hook.f.) Kuntze	Nepalese Raspberry	BhuiAinselu	Rosaceae	2100 – 3200	NA
22	*Rubus niveus*Thunb.	Mysore Raspberry	Ainselu	Rosaceae	500 – 2800	NA
23	*Spiraea* sp.	Arching Spirea	Panda, Pans	Rosaceae	3000 – 4200	NA
24	*Spiraea bella*Sims.	Pretty Spirea, Himalayan Spirea		Rosaceae	2100 – 3600	NA
25	*Viburnum erubescens* Wall.	Reddish Viburnum	Asare	Adoxaceae	1500 – 2700	NA
26	*Viburnum nervosum* D. Don		Asare	Adoxaceae	2600 – 3500	NA
HERBS						
1	*Acanthus* sp.			Acanthaceae		
2	*Ainsliaea aptera* DC.			Asteraceae	1200 – 3600	NA
3	*Ajuga lobata*D.Don			Lamiaceae	1500 – 3300	NA
4	*Amorphophallus* sp.			Araceae	1400 – 2700	
5	*Anaphalis* sp.			Asteraceae		
6	*Arisaema consanguineum* Schott			Araceae	2200 – 2700	NA
7	*Arisaema griffithii* Schott			Araceae	2400 – 3600	NA

8	*Arisaema nepenthoides* (Wall.) Mart.			Araceae	2000 – 3300	NA
9	*Arisaema speciosum* (Wall.) Mart.			Araceae	2400 – 2800	NA
10	*Arisaema* sp.			Araceae		
11	*Astilbe* sp.			Saxifragaceae		
12	*Carex* sp.			Cyperaceae		
13	*Centella asiatica* (L.) Urb.			Apiaceae	500 – 2100	LC
14	*Cirsium* sp.			Asteraceae		
15	*Clintonia udensis* Trautv. &C.A.Mey.			Liliaceae	1600 – 4000	NA
16	*Conium maculatum* L.			Apiaceae		NA
17	*Fragaria nubicola* Lindl.			Rosaceae	2000 – 3600	NA
18	*Gentiana pedicellata* (D. Don) Wall			Gentianaceae	2100 – 3400	NA
19	*Gentiana* sp.			Gentianaceae		
20	*Geranium* sp.			Geraniaceae		
21	*Hemiphragma heterophyllum* Wall.			Scrophulariaceae	1800 – 3600	NA
22	*Heracleum wallichii* DC			Apiaceae	3600 – 4100	NA
23	*Hypericum* sp.			Hypericaceae		
24	*Impatiens* sp.			Balsaminaceae		
25	*Juncus* sp.			Juncaceae		
26	*Lecanthus peduncularis* (Wall. ex Royle) Wedd.			Urticaceae	1200 – 3200	NA
27	*Ligularia* sp.			Asteraceae	1200 – 3200	
28	*Lycopdium* sp.			Lycopodiaceae		
29	*Meconopsis paniculata* (D. Don) Prain			Papaveraceae	3000 – 4100	NA
30	*Meconopsis* sp.			Papaveraceae		
31	*Mimulus nepalensis* Benth.			Scrophulariaceae	1200 – 3000	NA
32	*Oxalis corniculata* L.			Oxalidaceae	250 – 2450	NA
33	*Oxalis* sp.			Oxalidaceae		
34	*Paris polyphylla* Sm.			Melanthiaceae	2000 – 3000	NA
35	*Pedicularis* sp.			Orobanchaceae		
36	*Persicaria capitata* (Buch.-Ham. ex D.Don) H.Gross			Polygonaceae	600 – 2400	NA
37	*Persicaria runcinata* (Buch.-Ham. ex D. Don) H. Gross			Polygonaceae	1600 – 3800	

38	*Potentilla peduncularis* D. Don			Rosaceae	3000 – 4500	NA
39	*Primula gracilipes*Craib			Primulaceae	3500 – 4000	NA
40	*Rumex nepalensis*Spreng.			Polygonaceae	1200 – 4300	NA
41	*Sambucus* sp.			Adoxaceae		
42	*Streptopus simplex*			Liliaceae	2400 – 4000	NA
43	*Swertia bimaculata* (Siebold&Zucc.) Hook. f. & Thomson ex C.B. Clarke			Gentianaceae	200 – 3000	NA
44	*Swertia chirayita* (Roxb.) Buch.-Ham. ex C.B.Clarke			Gentianaceae	1500 – 2500	NA
45	*Taraxacum officinale*			Asteraceae	3350 – 5500	NA
46	*Thalictrum foliolosum* DC.			Ranunculaceae	1300 – 3400	NA
47	*Trillium govanianum* Wall. ex D.Don			Melanthiaceae	2700 – 4000	NA
48	Unidentified					
49	*Viola serpens* Wall. ex Ging.			Violaceae	1400 – 3500	NA
50	*Viola pilosa* Blume			Violaceae	1200 – 3000	NA
EPIPHYTES						
1	*Agapetes serpens* (Wight) Sleumer	Himalayan Lantern, Creeping Agapetes	Khursani		1720 – 2130	NA
2	*Gastrochilus calceolaris* (Buch.-Ham. ex Sm.) D.Don	Shoe-shaped Gastrochilus			1500 – 2200	CR
3	*Vaccinium nummularia* Hook. f &Thoms. ex. C. B. Cl.	Coin Whortleberry			2400 – 4000	NA
4	*Vaccinium retusum* (Griff.) Hook. f. ex C. B. Cl.	Himalayan Blueberry	Mussikane		2130 – 3050	NA
CLIMBERS						
1	*Clematis acuminata* DC.		Ransag		500 – 2400	NA
2	*Clematis Montana* Buch.-Ham. ex DC.		JungeLaharo		2100 – 4100	NA
3	*Crawfurdia speciosa* Wall.				2400 – 3000	NA
4	*Holboellia latifolia* Wall.		Bagul, Guphala, Malkati		1500 – 4000	NA
5	*Rubia manjith* Roxb. ex Fleming		Majitho		700 – 3600	NA
6	*Smilax* sp.					
BAMBOO						
1	*Bambusa* sp.					
2	*Sinarundinaria macrophylla*		Deonigalo		1800 – 3300	Rare in Sikkim

Note: NA, Not Assessed; CR, Critically Endangered; LC, Least Concern.

Magnolia campbellii

Rhododendron griffithianum

Berberis insignis

Cotoneaster microphyllus

Daphne cannabina

Mahonia nepaulensis (Fruiting)

Piptanthus nepalensis

Rosa sericea

Spiraea bella

Viburnum nervosum

Ajuga lobata

Ainsliaea aptera

Anaphalis sp.

Arisaema griffithii

Arisaema nepenthoides

Arisaema consanguineum

Arisaema speciosum

Arisaema sp.

Clintonia udensis

Conium maculatum

Gentiana pedicellata

Meconopsis sp.

Mimulus nepalensis

Paris polyphylla

Swertia chirayata

Trillium govanianum

Amorphophallus sp.

Viola serpens

Agapetes serpens

Vaccinium numaalaria

Holboellia latifolia

Gastrochilus calceolaris

FAUNA

To record faunal and avi-faunal species, direct and indirect signs were taken into considerations while walking along the sampling path. Recording of digging signs of wild boar, pellets, scats, calls and feathers were mostly seen along the trekking trial, and photo capture was done depending upon the feasibility. Some of the common butterfly species were also recorded during the trail sampling.

During the trekking route along the sampling paths, a number of faunal and avi-faunal species were sighted and some were recorded based on their calls. A total of 34 bird species were recorded belonging to 31 genera and 20 families out of which 10 were sighted from Hilley to Chewabhanjyang trekking route. Amongst fauna, a Barking Deer (*Muntiacus muntjak*) belonging to Cervidae family was sighted at Sano Dhaap. Birds such as Verditer Flycatcher, Large-billed Crow, Plain mountain finch, Spotted laughingthrush, Grey-backed shrike, Green-tailed sunbird and Green-backed tit were spotted and recorded. The male and female Blood Pheasant were spotted at 3352m asl in *R. hodgsonii* forest**.** Many beautiful avians were encountered in the sanctuary out of which Indian Common Crow (*Euploea core* Cramer) was recorded at around 3000 m asl, Indian Tortoiseshell (*Aglais caschmirensis*) recorded at around 2800 m asl and Painted Lady (*Vanessa cardui* recorded at around 2700 – 2800 m asl) butterflies were sighted (**Photo 9**, **Table 3**).

Table 3: Checklist of faunal and avi-faunal species recorded along the Barsey Rhododendron Sanctuary

Sl. No.	Scientific Name	Common Name	Local Name	Family	Evidences (Direct & indirect)	Altitudinal Range (m)	IUCN Status
AVI-FAUNA							
1	*Aethopyga ignicauda*	Fire-tailed Sunbird	Balchey	Nectarinidae	Sighted	1500 – 2700	NA
2	*Aethopyga nepalensis*	Green-tailed Sunbird	Kalobalchey	Nectarinidae	Sighted	1500 – 2000	LC
3	*Alcippe sp.*	White-throated Fulvetta		Sylviidae		1500 – 2700	NA
4	*Arborophila torqueola*	Hill Partridge	Peura	Phasinidae	Call	1500 – 2700	LC
5	*Blythipicus pyrrhotis*	Bay Wood Pecker		Picidae		1500 – 1950	NA
6	*Carpodacus rodochroa*	Rose Finch	Tuti	Fringillidae	Sighted	1500 – 4500	NA
7	*Cinclus cinclus*	White-throated Dipper		Cinclidae		1500 – 2300	LC
8	*Corvus macrorhyncus*	Large-billed Crow	Kaag	Corvidae	Sighted	1500 – 4500	LC
9	*Dendrocopos darjellensis*	Darjeeling Wood Pecker	Laachey	Picidae		1500 – 2300	NA
10	*Dicrurus macrocerus*	Black Drongo	Chibey	Dicaeidae		1500 – 1900	LC
11	*Enicurus maculatus*	Spotted Forktail		Muscicapidae		1500 – 1330	LC
12	*Eumyias thalassinus*	Verditer Flycatcher	Hariney	Muscicapidae	Sighted	1500 – 4500	LC
13	*Garrulax ocellatus*	Spotted Laughingthrush	Kolkoley	Turdidae	Sighted	1500 – 2700	LC
14	*Garrulax striatus*	Straited Laughingthrush	Kolkoley	Turdidae		1500 – 2300	NA
15	*Hierococcyx sparverioides*	Large Hawk Cuckoo		Cuculidae		1500 – 2300	LC
16	*Ithaginis cruentus*	Blood Pheasant		Phasinidae	Sighted	1500 – 4500	LC
17	*Lanius tephronotus*	Grey-backed Shrike		Laniidae	Sighted		LC
18	*Leucosticte nemoricola*	Plain Mountain Finch		Fringillidae	Sighted		LC
19	*Lophura leucomelana*	Kalij Pheasant	Kaleej	Phasinida		1850 – 2700	LC
20	*Lophophorus impejanus*	Himalayan Monal,		Phasianid		2000 – 4500	LC
		Monal Pheasant					
	alacias capistratus	Rufous Sibia		Leiotrichidae			LC
23	*Minnla strigula*	Bar-throated Minla		Leiotrichidae		1500 – 2700	LC

24	*Motacilla flava*	Yellow Wag Tail		Motacillidae			NA
25	*Myophonus caeruleus*	Blue Whishing Thrush	Kalchura	Turdidae		1100 – 2700	NA
26	*Parus monticolus*	Green-backed Tit	Fista	Paridae		2400 – 2700	LC
27	*Pericrocotus ethologus*	Long-tailed Minivet		Campephagidae			LC
28	*Pomatorhinus superciliaris*	Splender Bill Scimeter Babbler		Timaliidae		540 – 2464	NA
29	*Porphyrospiza caerulescens*	Finch	Tuti	Fringillidae			NT
30	*Scolopax rusticola*	Wood Cock		Scolopacidae			NA
31	*Streptopelia orientalis*	Oriental Turtle Dove	Dhukur	Columbidae			LC
32	*Tragopan satyra*	Satyr Tragopan	Mudal	Phasinidae		2700 – 4000	NT
33	*Turdus boulboul*	Grey-winged Black Bird		Turdidae		1800 – 2700	NA
34	*Upupa epops*	Common Hoope	Fafarey	Upupidae	Sighted		NA
35	*Urocissa flevirostris*	Yellow-billed Blue Magpie		Corvidae	Sighted	1500 – 2000	LC
FAUNA							
1	*Ailurus fulgens*	Red Panda		Ailuridae		2200 – 4800	EN
2	*Capricornis thar*	Himalayan Serow		Bovidae		300 – 3000	NT
3	*Hystrix brachyura* Linnaeus	Himalayan Crestless Porcupine		Hystricidae		upto 1500	LC
4	*Lepus nigricollis ruficaudatus*	Rufous-tailed Hare	Jarayo	Leporidae		upto 2700	LC
5	*Martes flavigula*	Yellow-throated Marten		Mustelidae		upto 4500	LC
6	*Muntiacus muntjak*	Barking Deer	Mirga	Cervidae	Photo captured		LC
7	*Nemorhaedus* sp.	Goral		Bovidae			
8	Ochotona roylei	Himalayan Mouse Hare, Royle's Pika		Ochotonidae		2400 – 5200	LC
9	*Paguma larvata*	Himalayan Palm Civet		Viverridae			LC
10	*Panthera pardus*	Common Leopard		Felidae		upto 5200	VUL
11	*Pardofelis marmorata*	Marbled Cat		Felidae		upto 2500	NT
12	*Prionailurus bengalensis*	Leopard Cat		Felidae		upto 4000	LC
13	*Sus scrofa*	Wild Boar		Suidae			LC
14	*Ursus thibetanus*	Himalayan Black Bear	Bhalu	Ursidae		upto 4300	VUL
15	*Vulpes bengalensis*	Bengal Fox, Indian Fox		Canidae		upto 1500	LC
16		Flying Squirrel		Sciuridae		upto 2300	
17		Giant Squirr		Sciuridae			
BUTTERFLY							
1	*Aglais caschmirensis*	Indian Tortoiseshell		Nymphalidae	Sighted	600 – 5500; encountered at 2800	NA
2	*Euploea core* Cramer	Indian Common Crow		Nymphalidae	Sighted	encountered at 3000	LC
3	*Vanessa cardui*	Painted Lady		Nymphalidae	Sighted	encountered at 2700	NA

Note: LC, Least Concern; VUL, Vulnerable; NT, Near Threatened; NA, Not Assessed.

Photo 9: Faunal and avi-faunal species recorded along the trekking trail

Barking Deer sighted at Sano Dhaap

Spotted Laughingthrush

Grey-backed Shrike

Plain Mountain Finch

Verditer Flycatcher

Indian Tortoiseshell butterfly on the petals of *R. falconeri*

Blood Pheasant (male and female) spotted at 3352m asl in *R. hodgsonii* forest

OBSERVATIONS

Barsey Rhododendron Sanctuary comprises of a flat, hilly and mountainous terrain interspersed with lakes and winding streams providing a varied forest ranging from sub-tropical to temperate rhododendron mixed forest to temperate coniferous to alpine meadows, thereby leading to a vast floral and faunal diversity. The climate is wet and cold which is highly favourable for the growth of various species of rhododendron.The sanctuary is flourished with rhododendron trees viz., *Rhododendron arboreum*, *R. barbatum*, *R. falconeri*, *R. grande*, *R. griffithianum* and *R. hodgsonii* and some rhododendron shrubs such as *R. campanulatum*, *R. dalhousieae* and *R. lepidotum* giving the forest a beautiful look at the time of blooming.

During the survey, we came across two vulnerable rhododendron species of Sikkim i.e. *Rhododendron arboreum* and *R. barbatum* which were found regenerating vibrantly in the area. With an increase in elevation, *R. arboretum* having a high medicinal value (in both pinkish-rose and rosy-red forms) are in full bloom which is largely distributed upto 3400 m asl at Phoktay Dara. A threatened species, *Rhododendron falconeri* habitat was observed at an elevation of 2823 m asl which was also observed at higher elevation from 3177 - 3352 m asl. Where *R. grande* was observed at lower elevation of the area, *R. barbatum* habitat was observed at higher elevation. An epiphytic rhododendron shrub, *R. dalhousieae* was recorded along 2810 m asl at latitude 27°13′48.5″ N and longitude 88°05′17.8″ E growing on the common shrub *Viburnum erubescens*. An epiphytic orchid, *Gastrochilus calceolaris*, which is categorized as Critically Endangered species by IUCN, was also observed in the trekking route of Barsey Rhododendron Sanctuary.

Other commonly available tree species are *Abies densa*, *Tsuga dumosa, Acer campbellii*, *A. caudatum*, *Lithocarpus pachyphylla*, *Maddenia himalaica*, *Magnolia campbellii*, *Prunus* sp. and *Symplocos lucida*. While many epiphytic species such as orchids, pteridophytes, mosses and lichens are growing on trees, shrubs such as *Berberis insignis*, *Daphne cannabina*, *Gaultheria nummularioides*, *Gaultheria trichophylla*, *Piptanthus nepalensis*, *Rosa sericea*, *Rubus* sp., *Viburnum erubescens* and *Viburnum nervosum* are frequently observed throughout the forest. The forest floor is covered mostly by various species of herbs such as *Arisaema* sp., *Frageria nubicola*, *Hemiphragma heterophyllum*, *Oxalis* sp., *Potentila* sp., *Primula* sp., *Rubus* sp., *Swertia* sp., *Viola pilosa* and *Viola serpens*. The sanctuary is also rich in medicinal herbs such as *Swertia* sp., *Paris polyphylla*, *Oxalis corniculata*, *Meconopsis paniculata*, *Heracleum wallichii* and *Rumex nepalensis*.

Another importance of the sanctuary is the availability of a rare bamboo, *Sinarundinaria macrophylla*, along 2787 m asl at Sano Dhaap which has been recorded only in West district of Sikkim so far. The presence of the bamboo in the sanctuary serves as a habitat for Red Panda. The bamboo has a medicinal property where the smoke of leaves is used during headache and common cold. It is said that this dhaap was once a huge sacred lake which is now a marshy land making it a habitat for *Sinarundinaria macrophylla*.

An evident character of the forest is the availability of a vast seedling emergence of many floral species of *Acer campbellii*, *A. palmatum*, *A. pectinatum*, *Lithocarpus pachyphylla*, *Magnolia campbellii*, *R. arboreum*, *R. barbatum*, *R. falconeri*, *R. grande*, *R. hodgsonii*, *Symplocos lucida* and *Tsuga dumosa* which is very high along the sampling path indicating a vibrant regeneration potential.

Quantitative Analysis of vegetation in different forest types of Barsey Rhododendron Sanctuary in West Sikkim, India

Sanjyoti Subba, Sumitra Nepal, Anjana Pradhan, Nimesh Chamling

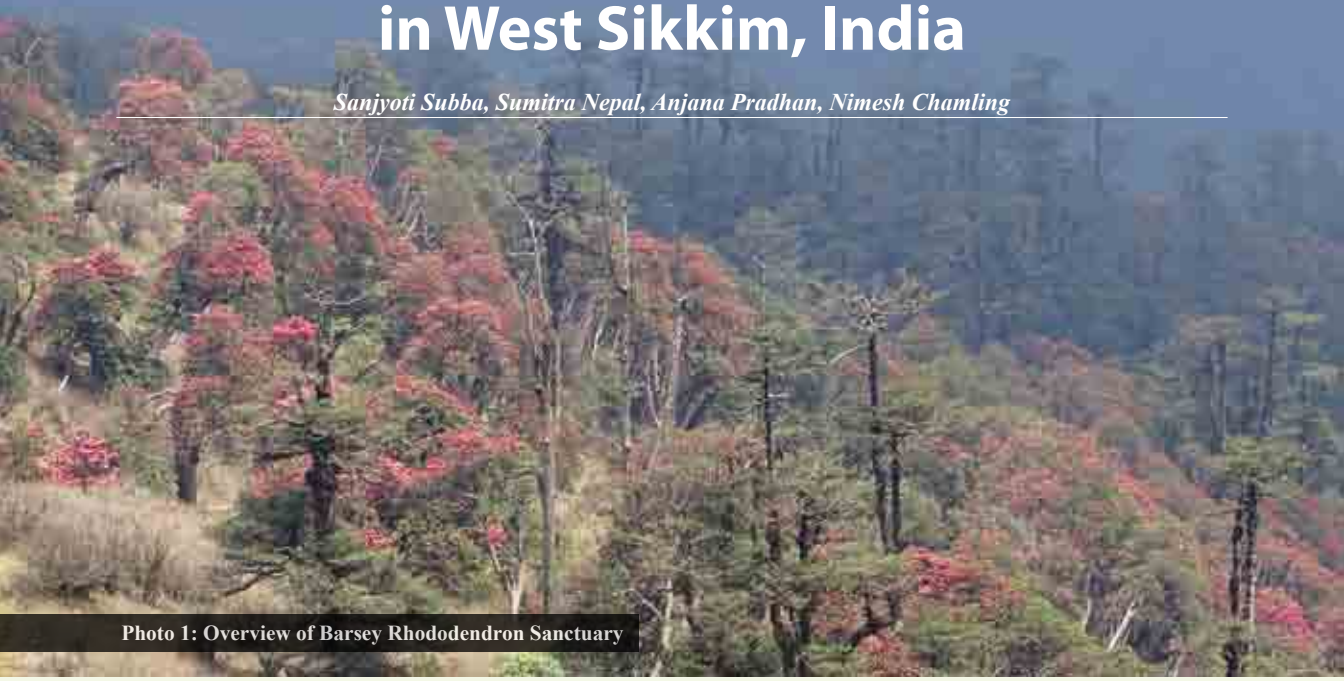


Photo 1: Overview of Barsey Rhododendron Sanctuary

ABSTRACT

A total of 98 species were recorded of which 34 herb species followed by 26 tree species, 20 shrub/scrub species, 6 climber, 6 fern and fern-allies, 4 epiphyte and orchid species and 2 bamboo species were recorded by laying 33 sampling plots in Barsey Rhododendron Sanctuary. Raunkiaer's life form assessments revealed the Hemicryptophytes (40.86%) representing the highest, which is ground vegetation of herbaceous plant species followed by Phanerophytes (34.41%) representing the canopy forming plant. The highest tree individuals were recorded is *Rhododendron falconeri* (351.52 Ind/ha) followed by *Rhododendron arboreum* var. *arboreum* (CB Clarke) Ridley (315.15 Ind/ha), and *Lithocarpus pachyphyllus* (124.24 Ind/ha). The lowest adult tree individual were recorded from *Acer campbellii* (6.06 Ind/ha), *Magnolia doltsopa, Prunus* sp. *Sorbus* sp (each having 9.09 Ind/ha) respectively. The highest important Value index (IVI) value was recorded for *Lithocarpus pachyphyllus* (58.70) followed by *Rhododendron arboreum* var. *arboreum* (50.17) etc. The lowest IVI value was recorded for *Acer campbellii* (2.48). In general, the species diversity (H') and richness of trees (adult, sapling & seedling) in the site were found as highest in concentration for the seedlings (H'=2.530) followed by trees H'=2.368 and the saplings

(H'=1.888) in the area of 0.33 ha. The abundance to frequency ratio revealed all the adult individuals of tree species showing contagious distribution and not exhibiting any random or regular distribution. The maximum abundance of the species of tree species were recorded for *Rhododendron arboreum* var. *arboreum* (16), followed by *Lithocarpus pachyphyllus* & *Rhododendron falconeri* (15 each species), respectively. The study suggests that there was rich biodiversity in the different forest types in Barsey Rhododendron Sanctuary need to be conserving for future generation.

KEYWORDS

Barsey Rhododendron Sanctuary; Plant diversity; life-forms; Species richness; distribution patterns

INTRODUCTION

Different forest types play significant role in preserving the ecosystem especially related to soil, water and the biota. The appearance of similar biological spectra in different regions shows similar climatic conditions. However, differing in the life form distribution between the normal spectrum and a biological spectrum would indicate which form of life characterizes the phyto-climate or the vegetation under study. As because vegetation is also part of ecosystem, ecosystem one can learn about plants before understanding specific ecosystem. Monitoring ecosystem health and changes in biodiversity can be achieved to a significant degree by monitoring changes in vegetation (Subba et al. 2017).

A life form of a plant is the sum of its all life processes and evolved directly in response to the environment (Cain 1950). It is descriptive tool for classifying plant life forms based on the structure and function of forest by (Raunkiaer 1934). Under the Raunkiaer's systems, the plant species can be grouped into five main classes, viz., Phanerophytes, Chamaephytes, Hemicryptophytes, Cryptophytes and Therophytes. The Raunkiaer's life forms spectrum is an indication of phytoclimate of the habitats and micro and macro-climate and human disturbance of particular area by (Cain & Castro 1959).

Many studies have been done on variety and variability of plant species diversity in different forests types in north- eastern India (Bhuyan et al. 2003; Devi & Yadava 2006; Majumdar & Datta 2015; Upadhaya et al. 2015) and study of life-form in north east vegetation by (Singh & Gupta, 2015). The plant species diversity in Sikkim Himalayan Region, by many researches has been done and recorded by (Cowan & Cowan 1929; Pradhan & Lachungpa 1990; Rai & Rai 1993; Singh & Chauhan 1998; Sanjyoti Subba, 2017) and vegetation studies were done by (Chettri & Sharma 2006; Subba et al. 2015; Subba et al. 2016; Subba et al. 2017; Subba & Lachungpa 2016; Pradhan & Lachungpa 2015) and life-form spectrum study by (Subba et al. 2017). The present study on Barsey Rhododendron Sanctuary was carried out with the objective to quantify and analyze the vegetation pattern and plant species diversity along with distribution patterns in that area.

STUDY AREA

The Barsey Rhododendron Sanctuary is located in the western district of Sikkim, established in 1998, occupies an area of 104 km^2 sharing its border with Nepal to the west and West Bengal to the south over the Rambong Khola in the Singalila Range. The altitudinal gradient of 2200–4100 m asl provides a wide range of topography leading to various forest types, viz., sub-tropical moist deciduous forest (2200–2400 m), wet temperate forest (2400–2700 m), moist temperate forest (2700–3250 m), sub-alpine forest (3200–4000 m) and alpine meadows (>4000 m) as mentioned by (Sharma 2001).

Rapid biodiversity survey was conducted during April-May 2017, along Hilley-Barsey-Sano Dhaap-Thulo Dhaap-Kalijhar-Phoktay Dara-Chitray-Chewabhanjyang-Uttarey trekking route (ca. 40 km) of BRS in proximity to the Singalila Ridge. From Hilley to Chewabhanjyang, 33 random sampling plots were laid, covered an area 0.33 ha. We covered the temperate rhododendron forest, temperate coniferous forest and sub-alpine zone between 2700-3600 m asl. The sanctuary harbors over dozen of rhododendron species, pure patches of *Lithocarpus pachyphyllus* and epiphytes, climbers, ferns and fern-allies, moss and lichens. BRS is a biologically diverse sanctuary and famous for its rhododendron stand which blooms usually between April and May. The climate is wet and cold which is highly favorable for the growth of rhododendrons. July is the wettest month of the year and temperature is not less than 17°C. There is Hilley enter point of BRS, Hilley gives the best view of sunrise while Barsey gives a splendid view of Mt. Khangchendzonga, Mt. Pandim and Mt. Sinolchu, etc., which becomes more picturesque between October and November. The sanctuary is also home to many faunal species, viz., Red Panda, Wild Boar, Himalayan Black Bear, Barking Deer and Serow, etc. BRS is also notable for habitat of Red Panda (*Ailurus fulgens*) which is the State Animal of Sikkim. The dense forests of *Lithocarpus pachyphyllus* provides shelter as well as abundant fruits and as such are good indicators of faunal presence and richness.

MATERIAL AND METHODS

From Hilley to Chewabhanjyang, 33 random sampling plots were laid, covered an area 0.33 ha. We covered the temperate rhododendron forest, temperate coniferous forest and sub-alpine zone between 2700-3600 m asl. In April-May 2017, random quadrate method was done by laying 33 sampling plots. The plot of 10 x 10 m was laid, depending upon the site feasibility. Within the main plot, all the standing tree species were enumerated and measured (cbh) at 1.37 m from the ground. Circumference at breast height (1.37 m) was taken for the determination of tree basal area. Total basal area is the sum of basal area of all species present in the forest. Basal area (m^2 / ha) was used to determine the relative dominance of a tree species. Within the subplots, 5 m x 5m were laid for recording the sapling (no. of species & its height) & shrub for the percent cover was recorded. 1 m x 1m were laid 4 corners and 1plot at centre point for seedling species were enumerated, in the same plot was used for recording the herb percentage in the area. Plant species were identified through herbarium record and flora (Polunin & Stainton 1984; Hooker JD 1872-1897; Hooker JD 1888-1890; Hooker JD 1849; Pradhan & Lachungpa 1990; Kholia, BS 2010). The unidentified plants species in the field were photographed, and later identified by consulting plant taxonomist at G.B. Pant Institute (Sikkim Unit), & BSI and web references (www.efloras.org; www.flowersofindia.net), www.floraofchina were made and by referring to local people from the nearby villages. All the sampling plots were geotagged for reference under long-term monitoring and altitude was recorded.

QUANTITATIVE ANALYSIS

The quantitative analysis such as frequency, density, and abundance of the recorded species were determined as per (Curtis & McIntosh 1950).

1. Frequency (%) (F) = $\frac{\text{Total no. of quadrates in which the species occurred}}{\text{1. Total no. of quadrates studied}} \times 100$

2. Relative frequency (RF) = $\frac{\text{Frequency of a species}}{\text{a. Frequency of all species}} \times 100$

3. Density (D) = $\frac{\text{Total no. of individual in all the quadrates}}{\text{1. Total no. of quadrates studied}} \times 100$

4. Relative Density (RD) = $\frac{\text{Number of Individual of a species}}{\text{a. Total number of individual of all species}} \times 100$

5. Abundance (A) = $\frac{\text{Total number of individuals of a species}}{\text{1. Total number of quadrates in which the species occurred}} \times 100$

6. Relative Dominance (RDo) = $\frac{\text{Total basal cover of individual species}}{\text{i. Total basal cover of all species}} \times 100$

7. Basal cover = Pi *r2

8. Importance Value Index (IVI) = RD + RF + RDo

9. Species Diversity Index:

   The Shannon-Weiner diversity index (Shannon & Weiner 1963) is calculated using the species diversity in a community

   S

   H'=-"(ni/N)log2 ni/N)

   i. i=1

   Where, 'ni' represents total number of individuals of particular species, and 'N' represents the total number of individuals of all species

10. Species Richness

    It is simply the number of species per unit area. (Margalef's index of species richness 1958) was calculated by using formula.

    D= (S-1)/ln(N)

    Where, 'S' = the number of species in the sample and 'N'= the total number of individual in the sample.

11. Pearson Correlation Coefficient was calculated.

RESULTS

1. VEGETATION STRUCTURE

The study revealed a total of 98 species were recorded of which 34 herb species followed by 26 tree species, 20 shrub/scrub species, 6 climber, 6 fern and fern-allies, 4 epiphyte and orchid species and 2 bamboo species were recorded within 33 sampling plots and other remaining shown in **(Table 1)**.

Table 1: Plant Taxa recorded in Barsey Rhododendron Sanctuary, West Sikkim

Habitat	Species	Genera	Family	Unidentified
Tree	26	17	10	1
Shrubs/scrub	20	15	10	1
Herb	34	30	21	1
Fern & fern-allies	6	6	5	1
Epiphytes/orchids	4	4	2	0
Climber	6	5	5	0
Bamboo	2	2	1	0
Total	**98**	**79**	**54**	**4**

2. LIFE FORM SPECTRUM

Raunkiaer's life-form assessments revealed 5 spectra represented by Phanerophytes, Chamaephytes, Geophytes, Hemicrytophytes, and Epiphytes. The missing life-forms in the site were Geophytes, Aerophytes, Helophytes, Hydrophytes and Therophytes. Highest percent among the life-forms was of the Hemicryptophytes (40.86%) representing the ground vegetation of herbaceous plant species followed by Phanerophytes (34.41%) representing the canopy forming plant. Between the ground flora and canopy-forming species other life-forms like Chamaeophytes (16.13 %) and Epiphytes (8.60 %) were recorded **(Figure** 1).

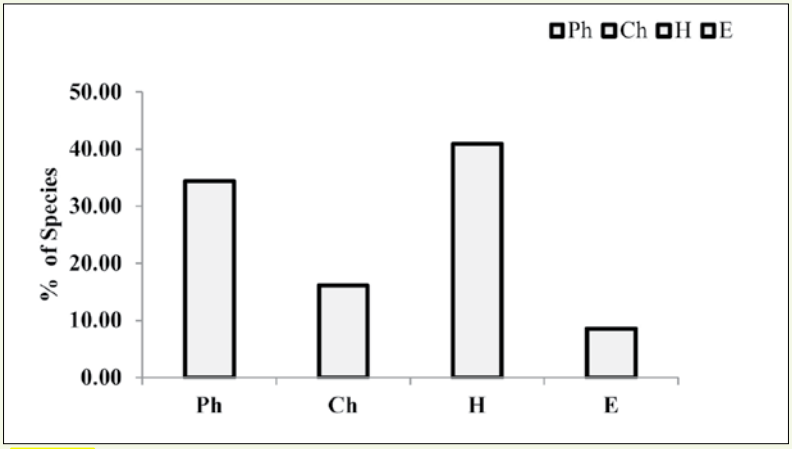


Figure 1: Life form Spectrum of different forest types of Barsey Rhododendron Sanctuary

Diversity of vegetation was found most in case of the ground flora in comparison to trees and shrubs/ scrubs. Trees recorded the highest diversity on a species to family ratio (2:6). Overall species to family ration was found to be (1.7) for the study site. A total of 54 plant families containing 98 number of plant species represented the floral face of the study site. For the phanerogamic flora maximum species recorded for any family was that of Ericaceae (21 species), and this was followed by Rosaceae (11 species), and Sapindaceae (9 species), Asteraceae (8 species), Papaveraceae (7), Apicaceae (4 species), respectively. The correlation between the elevation and total number of individuals showed the maximum of 27 of plant species being recorded at 2811 m elevation at plot 5 followed by 25 plant species at 2865-3069 m asl at plot 6 and 24 **(Figure** 2).

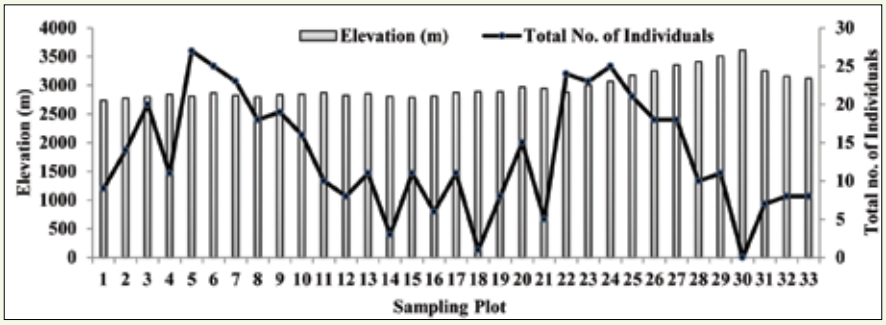


Figure 2: Correlation between the elevation and total number of individuals

Site characteristics including the geographic location of sampling plots, species richness, humus depth, slope angle, etc., in the study area is presented in **(Table 2).**

Pearson Correlation Coefficient was calculated between the humus depth (cm) and species richness, where positively significant correlation between those and the value of (+1.00) was obtained which is significantly higher.

Table 2: Site Characteristics and Species richness of the sampling plots in the Barsey Rhododendron Sanctuary, West Sikkim (between Lat: 27°11´14.9" & 27°15´38.5 " and Long: 88°07´11.7" & 88°01´53.9")

Site code	Forest Type	Elevation (m)	Slope Angle (°)	Slope Aspect	Humus depth (cm)	Canopy Cover (%)	Species Richness	Disturbance
P1	Temperate broadleaved Forest	2737	70	N	0.5	30	32.54	Natural
P2	Temperate broadleaved Forest	2774	80	NE	1.5	20	32.62	Natural
P3	Temperate broadleaved Forest	2797	80	NE	1.5	10	32.67	Natural
P4	Temperate broadleaved Forest	2842	50	E	1	20	32.58	Natural
P5	Temperate broadleaved Forest	2811	60	N	1.6	10	32.70	Natural
P6	Temperate broadleaved Forest	2865	10	E	1.5	25	32.69	Natural
P7	Temperate broadleaved Forest	2823	10	SE	1	30	32.68	Natural
P8	Temperate broadleaved Forest	2797	40	NE	3	15	32.65	Natural
P9	Temperate broadleaved Forest	2835	70	NE	1	20	32.66	Natural
P10	Temperate broadleaved Forest	2845	25	E	2	45	32.64	Natural
P11	Temperate broadleaved Forest	2871	40	NE	1	10	32.57	Natural
P12	Temperate broadleaved Forest	2826	40	N	1	10	32.52	Natural
P13	Temperate broadleaved Forest	2853	35	E	1	60	32.58	Natural

P14	Temperate broadleaved Forest	2808	60	SE	1	0	32.09	Natural
P15	Temperate broadleaved Forest	2787	45	E	1	60	32.58	Natural
P16	Temperate broadleaved Forest	2813	10	E	3	40	32.44	Natural
P17	Temperate broadleaved Forest	2872	0	NE	0.5	10	32.58	Natural
P18	Temperate broadleaved Forest	2885	0	NE	0.2	0	0.00	Anthropogenic
P19	Temperate broadleaved Forest	2885	30	NE	1	20	32.52	Natural
P20	Temperate broadleaved Forest	2968	15	NE	0.5	20	32.63	Natural
P21	Temperate broadleaved Forest	2947	10	NE	1	0	32.38	Natural
P22	Temperate broadleaved Forest	2877	0	NE	1	10	32.69	Natural
P23	Temperate Coniferous Forest	3002	40	NE	0.5	30	32.68	Natural
P24	Temperate Coniferous Forest	3069	30	NE	2.0	20	32.69	Natural
P25	Temperate Coniferous Forest	3177	30	NE	1.5	20	32.67	Natural
P26	Temperate Coniferous Forest	3250	60	NE	1.2	35	32.65	Natural
P27	Temperate Coniferous Forest	3352	10	NE	1.3	0	32.65	Natural
P28	Sub-Alpine	3412	90	SW	1.0	0	32.57	Natural
P29	Sub-Alpine	3509	90	NE	1.0	0	32.58	Natural
P30	Alpine	3610	0	NE	2.0	0	0.00	Anthropogenic
P31	Temperate broadleaved Forest	3251	60	NE	0.5	10	32.49	Natural
P32	Temperate broadleaved Forest	3157	45	E	0.5	15	32.52	Natural
P33	Temperate broadleaved Forest	3119	25	S	0.3	10	32.52	Natural

3. TREE DENSITY AND FREQUENCY

The tree species were recorded cumulatively, viz., adult, sapling and seedling from 33 sampling plots, the highest adult individuals were recorded is *Rhododendron falconeri* (351.52 Ind/ha) followed by *Rhododendron arboreum* var. *arboreum* (CB Clarke) Ridley (315.15 Ind/ha), and *Lithocarpus pachyphyllus* (124.24 Ind/ha) **Table 3**. The lowest adult tree individual were recorded from *Acer campbellii* (6.06 Ind/ha), *Magnolia doltsopa, Prunus* sp. *Sorbus* sp (each having 9.09 Ind/ha) respectively. For the saplings highest presence was recorded from *Rhododendron arboreum* (42.4 Ind/ha) followed by *Rhododendron falconeri* (36.4 Ind/ha) whereas from the seedling the highest density was recorded from *Rhododendron arboreum* (45.5 Ind/ha) followed by *Lithocarpus pachyphyllus*, *Symplocos lucida, Rhododendron falconeri* (30.3 Ind/ha) respectively. Under mature tree the highest relative density for major tree species were *Rhododendron falconeri* (26.13) followed by *Rhododendron arboreum* (23.42) and *Lithocarpus pachyphyllus* (9.23), respectively.

4. IMPORTANCE VALUE INDEX

The highest important Value index (IVI) value was recorded for *Lithocarpus pachyphyllus* (58.70) followed by *Rhododendron arboreum* var. *arboreum* (50.17), *Rhododendron falconeri* (49.398) and *Tsuga dumosa* (28.691) were recorded correspondingly. The lowest IVI value was recorded for *Acer campbellii* (2.48) followed by *Magnolia doltsopa* (2.67) and *Prunus* sp (2.68) and the other remaining were shown in **Figure 3**.

5. SPECIES DIVERSITY & RICHNESS

In general, the species diversity (H') and richness of trees (adult, sapling & seedling) in the site were found as highest in concentration for the seedlings (H'=2.530) followed by trees H'=2.368 and the saplings (H'=1.888) in the area of 0.33 ha. The value of species richness was found to be highest from tree (adults) followed by seedlings and saplings **Figure 4.**

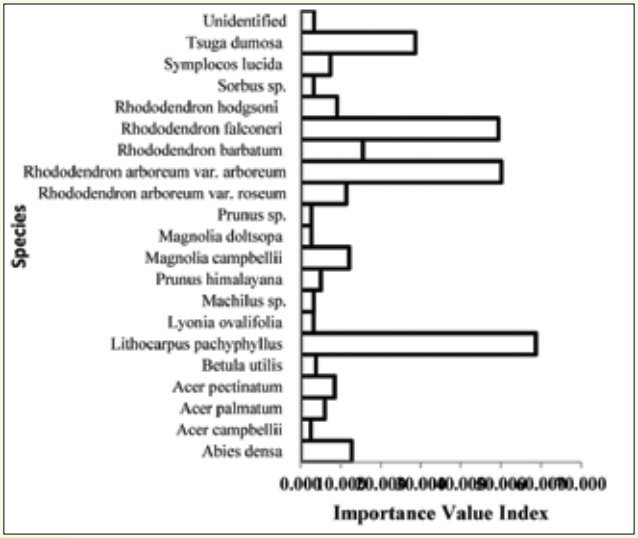


Figure 3: **Importance value index of mature tree species in sampling plots.**

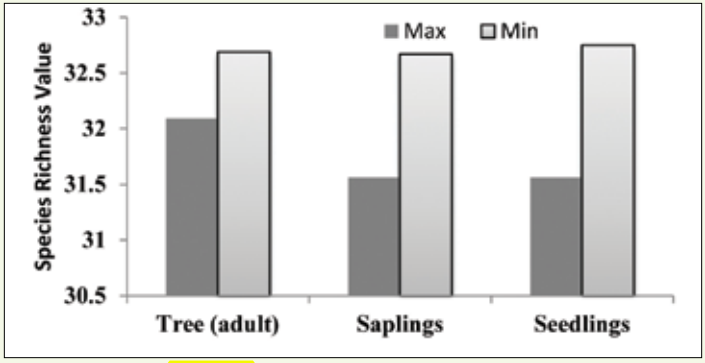


Figure 4: **Species richness of tree species**

A general structural data regarding density, species diversity, etc, of the canopy forming trees in the study site of the major species is depicted in Table 2. The relative density of major species was recorded higher from *Rhododendron falconeri* (26.13) and followed by *Rhododendron arboreum* (23.42) and *Lithocarpus pachyphyllus* (9.23) respectively shown in **Table** 3. The major species which has the highest frequency of occurrence was recorded for *Rhododendron arboreum* (15.69) followed by *Rhododendron falconeri* and *Lithocarpus pachyphyllus* (14.71 each having) [Table 3.]. The frequency occurrence of saplings was highest for Rhododendron *arboreum* var. *arboreum* (42.4) followed by *Rhododendron falconeri* (36.4) and *Lithocarpus pachyphyllus* & *Symplocos lucida* (21.2). However, in seedlings the frequency of occurrence was recorded highest for *Rhododendron arboreum* var. *cinnamomum* (45.5) followed by *Rhododendron falconeri*, *Lithocarpus pachyphyllus* and *Symplocos lucida* (30.3 each) the same value. The major species which has the highest frequency of occurrence was recorded for *Lithocarpus pachyphyllus* (Rel. Freq. 45.5%), followed by *Rhododendron falconeri* (Rel. Freq. 45.4%) and *Rhododendron arboreum* var. *arboreum* (39.4%), *Magnolia campbellii, Rhododendron arboreum*

var. roseum, *Rhododendron barbatum*, (each having 18.2 %). The lowest frequency of occurrence was recorded for *Acer campbellii, Acer palmatum, Betula utilis, Lyonia ovalifolia, Machilus* sp., *Magnolia doltsopa, Prunus* sp., *Sorbus* sp., (each having 6.061%) followed by *Prunus himalayana, Rhododendron hodgsonii, Acer pectinatum* (each having 9.091 %), etc.(**Table** 3).

Authors in the Barsey Rhododendron Sanctuary (Left) & *Rhododendron falconeri* along the path (Right)

Table 3: Structural data on the major species in Barsey Rhododendron Sanctuary, West Sikkim

Species	Plant density (Indiv/ha)	Rel. density	Rel. frequency	Pi =ni/N	lnPi	Pi*lnPi	H
Abies densa Griff	51.52	3.83	3.92	0.04	-3.26	-0.12	
Acer campbellii Hook.f. & Thomson ex Hiern	6.06	0.45	1.96	0.00	-5.40	-0.02	
Acer palmatum Thunb	30.30	2.25	1.96	0.02	-3.79	-0.09	
Acer pectinatum Wall. ex G.Nicholson	39.39	2.93	2.94	0.03	-3.53	-0.10	
Betula utilis D.Don	21.21	1.58	1.96	0.02	-4.15	-0.07	
Lithocarpus pachyphyllus (Kurz) Rehder	124.24	9.23	14.71	0.09	-2.38	-0.22	
Lyonia ovalifolia (Wall.) Drude	15.15	1.13	1.96	0.01	-4.49	-0.05	
Machilus sp.	12.12	0.90	1.96	0.01	-4.71	-0.04	
Prunus himalayana (Hook. f. & Thomson) J. Wen	24.24	1.80	2.94	0.02	-4.02	-0.07	
Magnolia campbellii Hook. f. & Thom.	33.33	2.48	5.88	0.02	-3.70	-0.09	
Magnolia doltsopa (Buch.-Ham. ex DC.) Figlar	9.09	0.68	1.96	0.01	-5.00	-0.03	-2.36
Prunus sp.	9.09	0.68	1.96	0.01	-5.00	-0.03	
Rhododendron arboreum var. *cinnamomeum* (Wall. ex G. Don) Lindl.	45.45	3.38	2.94	0.03	-3.39	-0.11	
Rhododendron arboreum Sm.	315.15	23.42	15.69	0.23	-1.45	-0.34	
Rhododendron barbatum Wall. ex G. Don	100.00	7.43	5.88	0.07	-2.60	-0.19	
Rhododendron falconeri Hook. F	351.52	26.13	14.71	0.26	-1.34	-0.35	
Rhododendron hodgsoni Hook. f.	66.67	4.95	2.94	0.05	-3.00	-0.15	
Sorbus sp.	9.09	0.68	1.96	0.01	-5.00	-0.03	
Symplocos lucida (Thunb.) Siebold & Zucc	33.33	2.48	4.90	0.02	-3.70	-0.09	
Tsuga dumosa (D.Don) Eichler	39.39	2.93	4.90	0.03	-3.53	-0.10	
Unidentified	9.09	0.68	1.96	0.01	-5.00	-0.03	

6. GIRTH CLASS

On the basis of girth class, the tree were measured under different girth class was done for precise determination of stand structure with the gradient of 10 cm rise starting from 30 cm at gbh. The intervals started from 30-41 cm and ended at 541-550 cm at gbh. Dominant species as well as a few major tree species of the study site was measured to understand the community structure. The girth size classes were as follows:

30-40 = 1; 41-50 = 2; 51-60 = 3; 61-70 = 4; 71-80 = 5; 81-90 = 6; 91-100 = 7; 101-110 = 8; 111-120 =9; 121-130 = 10; 131-140 = 11; 141-150 = 12; 151-160 = 13; 161-170 = 14; 171-180 = 15; 181-190 =16; 191-200 = 17; 201-210 = 18; 211-220 = 19; 221-230 = 20; 231-240 = 21; 241-250 = 22; 251-260 =23; 261-270 = 24; 271-280 = 25; 281-290 = 26; 291-300 = 27; 301-310 = 28; 311-320 = 29; 321-330 =30; 331-340 = 31; 341-350=32; 351-360 =33; 361-370 = 34; 371-380 = 35; 381-390 = 36; 391-400 = 37; 401-410 = 38; 411-420 = 39; 421-430 =40; 431-440 = 41; 441-450=42; 451-460 =43; 461-470 = 44; 471-480 = 45; 481-490 =46;491-500 = 47;501-510 = 48; 511-520 = 49; 521-530 =50; 531-540 = 51; 541-550=52.

The girth classes, in case of *Lithocarpus pachyphyllus*, the maximum no. of species were recorded in girth classes 3 (6 no. of species), girth classes 42 (4 no. of species), and girth classes 52 (2 no. of species). However, in *Rhododendron arboreum* var. *arboreum*, the maximum (15 no. of species) presence in girth classes 5 followed by (12 no. of species) were recorded in girth classes 3 and (10 no. of species) in girth classes 1 & 6, after along gap, the maximum girth size was recorded between girth classes 47 & 52 in entire sampling plots **(Figure 6.)** Similarly, in *Rhododendron arboreum* var. *roseum* the maximum (4 no. of species) were recorded in girth classes 3 and after a long gap only one individual is recorded in girth classes 34 **(Figure 6.)** *Abies densa* showed girth class 2-9 and there is no mature tree was recorded **(Figure 5.)**

Figure 5: Girth classes of *Abies densa*

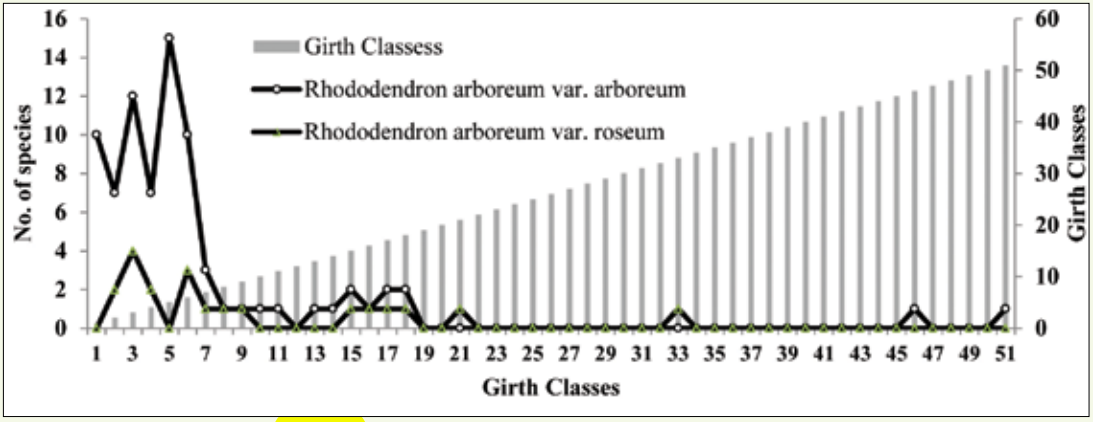


Figure 6: **Girth Classes of *Rhododendron arboreum***

7. DISTRIBUTION PATTERN

The abundance to frequency ratio revealed all the adult individuals of tree species showing contagious distribution and not exhibiting any random or regular distribution. The maximum abundance of the species of tree species were recorded for *Rhododendron arboreum* var. *arboreum* (16), followed by *Lithocarpus pachyphyllus* & *Rhododendron falconeri* (15 each species), *Rhododendron barbatum* and *Magnolia campbellii* (6 each), *Tsuga dumosa* (5), *Abies densa* & *Symplocos lucida* (4), *Acer pectinatum, Prunus himalayana, Rhododendron arboreum* var. *roseum* (3 each), *Sorbus* sp., *Prunus* sp., *Magnolia doltsopa, Machilus* sp., *Lyonia ovalifolia, Betula utilis, Acer plamatum, Acer campbellii* (2 each species) , etc were recorded along the sampling plots.

8. SHRUB COMPONENT

A total of 20 species of shrubs and scrubs belonging to 15 genera and 10 families were recorded **(Figure 7)**. The highest percent cover was recorded for *Viburnum erubescens* Wall. (22.03 %) followed by *Daphne cannabina* Lour. (12.65%), *Rosa sericea* Lindl. (11.25%), *Gaultheria nummularioides* D. Don (9.53%), etc. **(Figure 7).** The family-wise species composition the highest number of taxa was recorded for Ericaceae (6) followed by Rosaceae (4), Berberidaceae and Adoxaceae (2 each having). The other remaining families represented by single number of taxa in the entire sampling plots **(Figure 9)**. The highest percent cover of shrub was recorded for Ericaceae (6) followed by Rosaceae (4), Berberidaceae & Adoxaceae (2 each). The remaining families were represented by single species **(Figure 8.)**

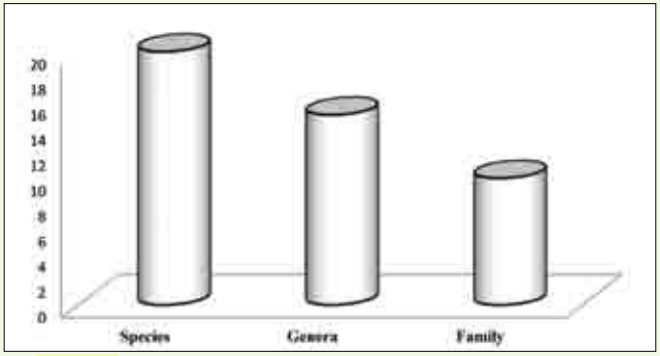


Figure 7: Spectrum of taxa for shrub and scrub species in BRS

Figure 8: Family-wise species composition of Shrub/scrub species in BRS

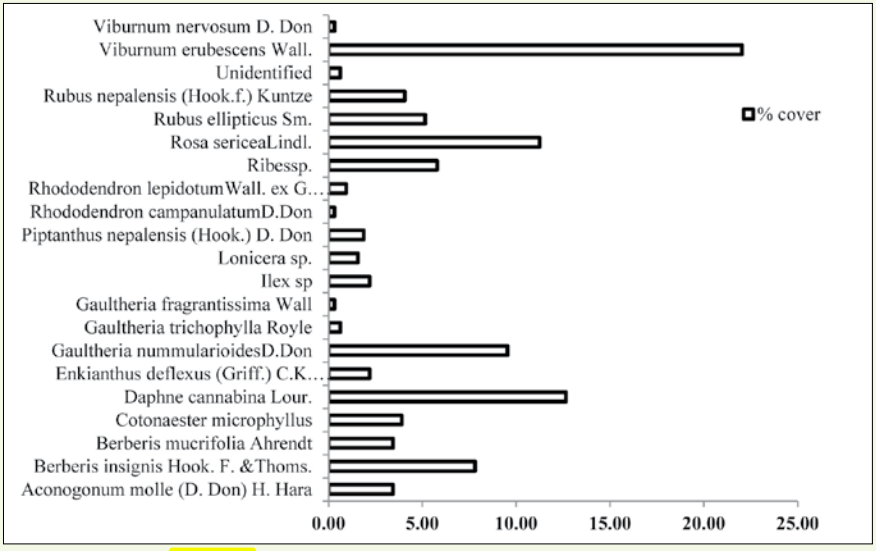


Figure 9: Percent cover of Shrub and scrub species in BRS

9. HERB COMPONENT

For the herb species, the highest percent cover was recorded for *Viola pilosa* Blume (9.55%) followed by *Persicaria capitata* (Buch.-Ham. ex D. Don) H.Gross (9.24%), *Fragaria nubicola* (Lindl. ex Hook.f.) Lacaita (9.09%) & *Ajuga lobata* D. Don (8.94%) **Figure 11.**The lowest percent cover was noted for *Ainsliaea aptera* DC (0.15%). Similarly, in family-wise species composition the maximum family of herbs species were recorded Apiaceae, Asteraceae, Gentianaceae, Rosaceae (3 no. of taxa each) and Araceae, Polygonaceae, Saxifragaceae, Violaceae (2 no. of taxa each). The other remaining species were represented in single family **Figure 10.**

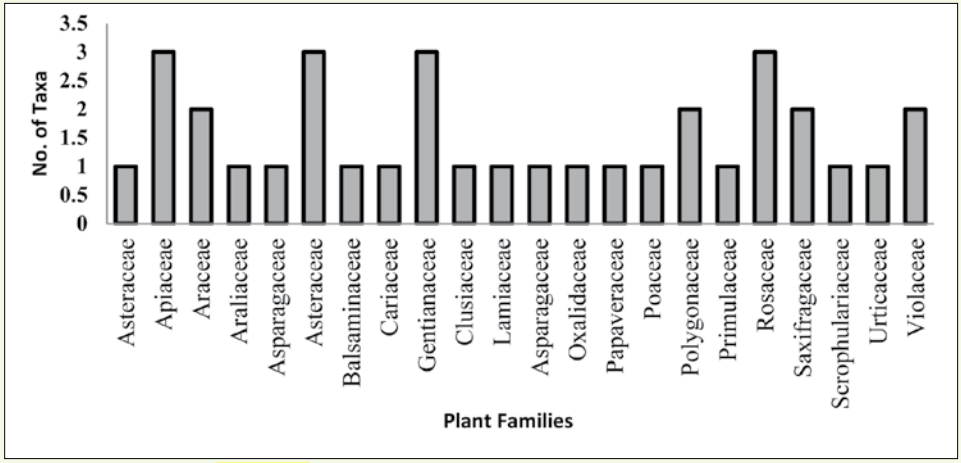


Figure 10: Family-wise species composition of herb species

DISCUSSION

The present study recorded 98 species from a 0.33-ha sampling plots of Barsey Rhododendron Sanctuary and can be compared with the findings of other trekking route, Yuksam-Dzongri trekking route which have 129 species in 1.8 ha (Subba et al. 2016) and 88 species from 0.064 ha is in Sang-Tinjure in FambongLho Wildlife Sanctuary by (Subba et al. 2017) is more than that. However, species richness was significantly positive correlation by humus depth. Positive species richness in the forest was probably related to humus depth indicates the good forest ecosystem. Positive species richness particularly in the area could be the result of the succession process that tends to increase species diversity in the plant community. The correlation between the elevation and total number of individuals showed the maximum of 27 of plant species being recorded at 2811 m elevation at plot 5 followed by 25 plant species at 2865-3069 m asl at plot 6 and 24. Similarly, in the Lachung Range-Yakchey Area (North Sikkim), the maximum no. of individuals was recorded in 2900 -3000 m asl by (Subba et al. 2015; Subba & Lachungpa 2016). It is also predicted that elevation ranges between (2900-3000 m asl) have rich plant diversity as compared to other elevation in the study area. It is also recommended that these elevation need to conserved for future

generation.

In general, the species diversity (H') and richness of trees (adult, sapling and seedling) in the site were found as highest in concentration for the seedlings (H'=2.530) followed by trees H'=2.368 and the saplings (H'=1.888) in the area of 0.33 ha. An evident character of the forest is the availability of a vast seedling emergence of many floral species of *Rhododendron arboreum*, *Lithocarpus pachyphyllus, Acer campbellii, Acer palmatum, Acer pectinatum, Magnolia campbellii, Rhododendron falconeri,* etc., indicating a positive regeneration potential. This sanctuary is a rich store house of flora and fauna species.

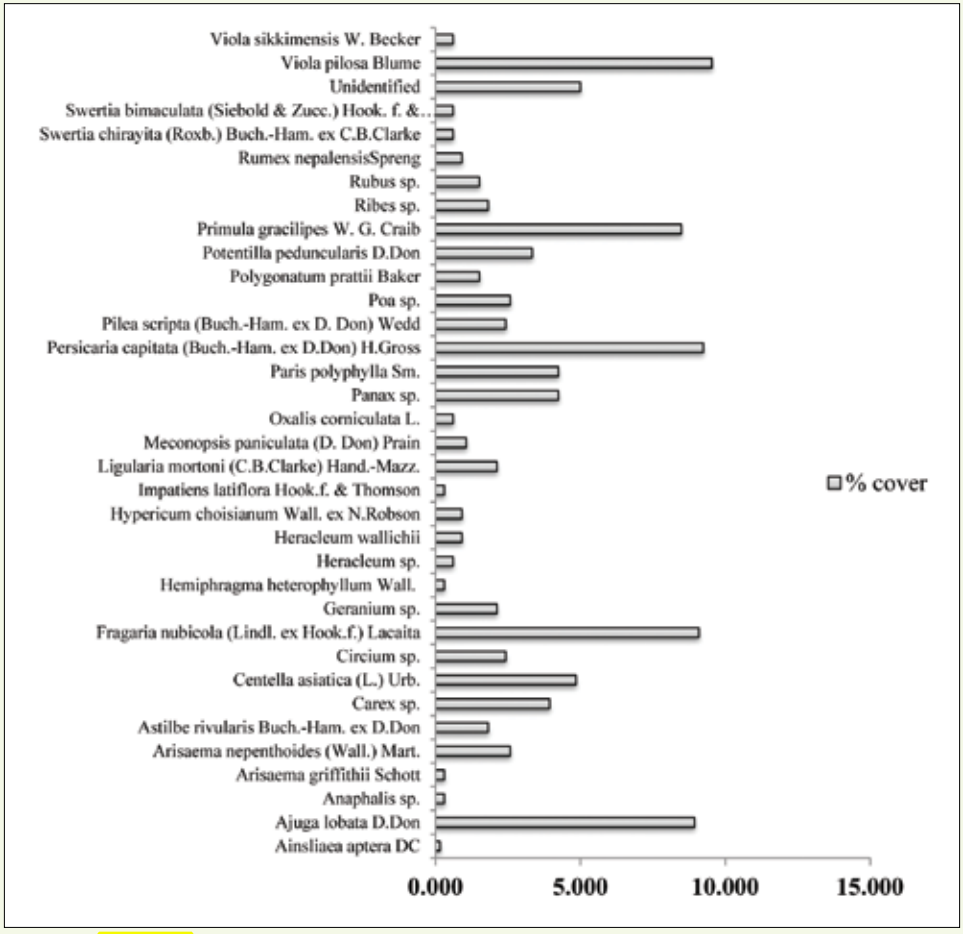


Figure 11: Percent Cover of herb species along the Barsey Rhododendron Sanctuary

The present study of forest was dominated by Ericaceae (21 species), and this was followed by Rosaceae (11 species), and Sapindaceae (9 species), Asteraceae (8 species), Papaveraceae (7), Apicaceae (4 species) in entire sampling plots. Ericaceae is major dominated family as compared to other family in the present study. The family included several species belonging to the genus *Rhododendron, Gaultheria, Enkianthus, Vaccinium,* etc. It is well known fact that *Rhododendron* is a very important keystone species and widely distributed in the temperate forest to alpine zone in Sikkim. Rhododendron species exhibit significant diversity in habit and broad range of distribution from the altitude of 800-6000 m by (Sekari & Srivastava 2010). In Sikkim Himalayan Region, many places were highly dominated by *Rhododendron* which has broad range of distribution. Present study observed that *R. arboreum* (both pinkish-rose and rosy-red forms) has a broad range of distribution and was observed up to 3400 m asl at Kalijhar top (Phoktay Dara) along the sampling plots.

Analysis of life forms gives unambiguous picture of the biological spectrum represented of the study area. The life-form exhibited by trees and shrubs comprised of Phanerophytes only but herbs belongs to four major life forms viz., Chamaephytes (h), Hemicryptophytes (H), Cryptophytes (Cr) and Therophytes (Th). Thus the present study showed that, (40.86%) is the highest percent among the life-forms of Hemicryptophytes which representing the ground vegetation of herbaceous plant species followed by Phanerophytes (34.41%) representing the canopy forming plant. The interactions between forest upperstory (tree) and understory (herbs) plants help in predicting the variations in richness and distribution of understory plants via processes of succession and in forestry by (McKenzie et al. 2000). Herb layer plants perform a significant function in the majority of plant biodiversity in most temperate forests (Von Oheimb & Hardtle 2009). Due to presence of *Rhododendron* sp., *Acer* sp., *Lithocarpus* sp., there is moderate tree canopy cover and the sunlight easily penetrated and rich diversity of underground vegetation is secured. Sometimes, the oak species have closed canopy cover but in the present study there are mixed forest types.

The density and frequency of major tree species contribute to the structure of forests. The tree density was recorded higher for *Rhododendron falconeri* followed by *Rhododendron arboreum* var. *arboreum* and *Lithocarpus pachyphyllus* whereas in the seedling category, the higher density were recorded for *Rhododendron arboreum, Lithocarpus pachyphyllus*, *Symplocos lucida* and *Rhododendron falconeri*. In saplings highest was recorded from *Rhododendron arboreum* & *Rhododendron falconeri,* etc. Some of the species had a low frequency suggesting that some of them would be expected in the typical distribution of species abundance.

Barsey Rhododendron Sanctuary has huge density of *Rhododendron arboreum* var. *arboreum* and *Rhododendron arboreum* var. *roseum* i.e., pink rose and red form covering the entire forest making it look like an ocean of *Rhododendron* flowers (Subba et al. 2017). *Rhododendron arboreum* is a wild plant species possesses high ecological importance and the flower of the species having unique medicinal and nutritional value by (Negi et al. 2013).Some of the species, viz., *Vaccinium* sp., orchids, fern and ferns-allies are epiphytic in nature and were found to favour the *Rhododendron arboreum* tree. It is a keystone species of the area. *Rhododendron arboreum* flowers are highly used for juice and wine preparation in this area and its flowers have medicinal properties. The flower is used to cure tonsillitis, cough and cold. Common local belief is that the flower petal is used when fish bones get stuck in throat. The juice of the flower is used in the treatment of menstrual disorders by (Subba et al. 2017). After fall to the ground and these are used to make wine and alcoholic beverages. It is in high demand in local market fetching Rs. 300 per bottle of wine and Rs. 200 per bottle of *Raksi* (local millet brew) which is considered beneficial for health too.

An overall picture of the ecological status of a species with respect to the community structure can only be obtained by synthesizing the values of the relative density, relative frequency and relative dominance. In

terms of IVI value in the different forest types, the dominant tree species were for *Lithocarpus pachyphyllus* (58.70) followed by *Rhododendron arboreum* var. arboreum (50.17), *Rhododendron falconeri* (49.39) and *Tsuga dumosa* (28.69), were the dominant species in entire sampling plots. In Sikkim Himalayas, the oak species (*Lithocarpus pachyphyllus*) is highly dominated in temperate forest, which has water holding capacity in the ground. The broad-leaved hill forest in temperate region comprises mostly oak forest (Subba et al. 2014) in Sikkim. This is evident in the present study area where *Lithocarpus pachyphyllus* has been found to be one of the dominant species. It is also indicator of faunal species presence especially; the fruits are eaten by Wild boar, Red Panda, directly relates to growth of predator species like Leopard (Subba et al.2014). Barsey Rhododendron Sanctuary is the habitat of Red Panda which is the State animal of Sikkim, due to the prominent presence of *Lithocarpus pachyphyllus* whose fruits are eaten by Red Panda (Subba et al. 2017).

According to (Odum 1971), contiguous distribution is the commonest pattern in nature, random distribution is found only in very uniform environment and the regular distribution occurs where severe competition between the individual exists. Under the regular (<0.025), random (0.025 to 0.05) and contiguous (>0.05) distribution the values indicate that all the adult individuals of tree species exhibits contagious distribution. No case of random and regular distribution was recorded in the sampled population.

Further analyzed with girth classes, the intervals started from 30-41 cm and ended at 541-550 cm at gbh. The dominant species as well as a few major tree species of the study site was measured to understand the community structure. The tree species *Lithocarpus pachyphyllus* followed almost a normal distribution curve with increasing the girth classes suggesting a fairly stable population. In case of *Rhododendron arboreum* var. *arboreum* and *Rhododendron arboreum* var. *roseum*, there is larger proportion of small girth classes to moderate girth classes than fairly big trees. This study suggested that the population of these trees is more stable and is capable of regenerating to mature trees under favourable conditions. *Abies densa* shows decreasing girth class 2-9 (i.e. gbh from 51 cm to 120 cm) and there is no mature tree was recorded.

The highest percent cover of shrub and scrub species were recorded in the diminishing order of *Viburnum erubescens*, *Daphne cannabina*, *Rosa sericea*, *Aconogonum molle*, *Berberis insignis*, *Berberis mucrifolia, Cotonaester microphyllus, Viburnum nervosum*, *Enkianthus deflexus*, *Gaultheria nummularioides*, *Gaultheria trichophylla*, *Gaultheria fragrantissima* , *Ilex* sp., *Lonicera* sp., *Piptanthus nepalensis* , *Rhododendron campanulatum*, *Rhododendron lepidotum*, *Rhododendron dalhousieae, Ribes* sp., *Rosa sericea*., *Rubus ellipticus*., *Rubus nepalensis*., *unidentified*., etc., in the entire sampling plots. *Rhododendron dalhousieae* is epiphytic in nature and was found to favour the common shrub *Vibrunum erubescens*. Similary, in FambongLho Wildlife Sanctuary, this species is distributed along 1900–2000 m epiphytic in nature with the oak species and also reported at Bulbuley Reserve forest, East Sikkim (Subba et al. 2014). The family-wise species composition the highest number of taxa was recorded for Ericaceae (6) followed by Rosaceae (4), Berberidaceae and Adoxaceae (2 each). These are the common shrubs and scrubs found in temperate to temperate coniferous forest in Sikkim.

A study of the population dynamics of herbaceous and the herb component was found as the most dominant habit group compared to other plant species. The highest herb percent cover was recorded as *Viola pilosa* (9.55%) followed by *Persicaria capitata* (9.24%), *Fragaria nubicola* (9.09%), *Ajuga lobata* (8.94%)., etc. Similarly, in family-wise species composition the maximum family of herbs species were recorded Apiaceae, Asteraceae, Gentianaceae, and Rosaceae (3 no. of taxa each) respectively **(Figure 10.)**. Highest family included several species belonging to the taxa of *Heracleum wallichii, Centella asiatica, Heracleum* sp. (Apiaceae) and the taxa belongings to *Ligularia mortoni*, *Anaphalis* sp., *Ainsliaea aptera*, etc, (Asteraceae) and *Geranium* sp., *Swertia bimaculata* , *Swertia chirayita*, (Gentianaceae) and *Fragaria*

nubicola, *Potentilla peduncularis*, *Rubus* sp., (Rosaceae) were recorded. Additionally, the reed-bamboo *Sinarundinaria macrophylla* (locally called "*Deonigale*") is widely distributed in Barsey trekking route in West Sikkim. The bamboo has a medicinal property where the smoke of leaves is used during headache and common cold. It is said that this study area was once a huge sacred lake which is now a marshy land making it a habitat for *Sinarundinaria macrophylla*.

Biodiversity is an essential tool for human survival and for economic and ecosystem functioning and stability. The present rapid biodiversity assessment found that the temperate rhododendron forest, temperate coniferous forest which have high plant diversity in Barsey Rhododendron Sanctuary, West Sikkim. There are two protected areas for the Rhododendrons in Sikkim where Barsey Rhododendron Sanctuary is one of them with a rich biodiversity and less anthropogenic footprint compared to the Shingba Rhododendron Sanctuary. It is concluded that the BRS forest community seems categorically rich in the number of trees, shrub, herbaceous plants compared to the Shingba Rhododendron Sanctuary (Subba et al. 2015). Seedling emergence is very high under the canopy and also all over the study area. This shows good regeneration potential for next generation providing a natural balance for the prevailing ecosystem. The species composition of forest depends on the regeneration of species in the forest. The present study of quantitative biodiversity data will be useful in forest management and conservation.

ACKNOWLEDGEMENTS

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Rapid Biodiversity Survey of Thangu – Lashar Valley, North Sikkim

Team: Sabita Dahal, Sanchi Subba, Meena Tamang

STUDY AREA

A field trip for conducting Rapid Biodiversity Survey to Thangu Valley and Adjacent areas covering a sampling path from Gay-Gaon – Nanghraylha - upto Yathang within Lachen Reserve Forest in North Sikkim, were carried out from 6th June to 15th June 2017 by the SBFP survey team. The trip was aimed for inventory and monitoring of the biodiversity of the area.

The present survey area along Gay-Gaon- Lashar – Yathang sampling path, the forest type of which is represented by Sub-Alpine Forest to Alpine scrub (**Plate 1**). The elevation range covered during the survey was from 3655m [Yathang (Below Thangu)] to 4850m [Nanghray-lha (Lashar valley)], which is represented by **Fig 1**. The slope angle of the area ranged between mild (10 degree) to stiff (85 degree) slope and was faced towards E, SE, N, NW, W, NE and SW aspect (**Table 1**.)

Plate 1. Forest types of Thangu valley and adjacent areas in Sikkim

Sub-alpine forest, dominated by *Abies densa*, *Betula utilis*, *Salix* sp. (3800m and below)

Alpine Scrub (4000m)

Alpine meadows, above 4500m

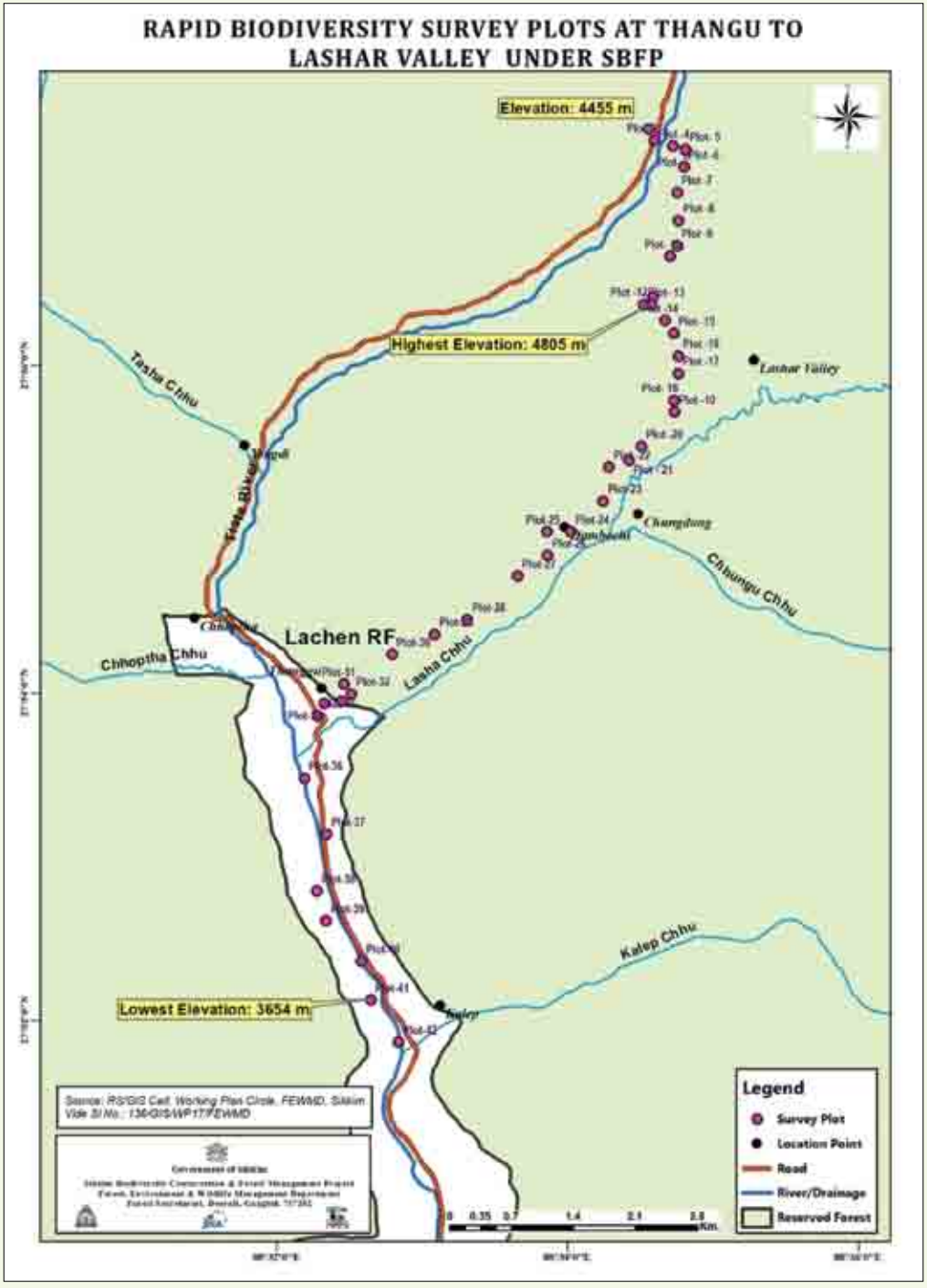


Figure 13: **Survey plots along Gay-Gaon – Nanghray-lha –Yathang sampling path, North Sikkim**

Table 1: Field characteristics of the survey area along Gay-Gaon- Lashar – Yathang sampling path, North Sikkim

Site Code	Forest type	Elevation (M)	GPS co-ordinates		Slope Angle (Degree)	Slope Aspect	Disturbances	Location name
			Lat	Long				
GLY1	Alpine	4455m	27°57' 24"	88°34'39"	30	E	NO	Gochuphalay
GLY2	Alpine	4450m	27°57' 20"	88°34'41"	45	E	No	Gochuphalay
GLY3	Alpine	4490m	27°57'16"	88°34'54"	70	E	NO	Gochuphalay
GLY4	Alpine	4545m	27°57'17"	88°34'48"	80	E	NO	Gochuphalay
GLY5	Alpine	4589m	27°57'16"	88°34'54"	70	N	NO	Gochung Pakha
GLY6	Alpine	4605m	27°57'10"	88°34'53"	85	N	NO	Gochung Pakha
GLY7	Alpine	4612m	27°57'00"	88°34'50"	80	SE	Boulders	Gochung Pakha
GLY8	Alpine	4650m	27°56'50"	88°34'50"	85	E	Boulders	Gochung Pakha
GLY9	Alpine	4696m	27°56'41"	88°34'50"	80	N	Boulders	Shenga
GLY10	Alpine	4742m	27°56'37"	88°34'47"	80	NE	NO	Shenga
GLY11	Alpine	4802m	27°56'22"	88°34'40"	5	N	NO	Nanghray-lha
GLY12	Alpine	4805m	27°56'19"	88°34'39"	5	N	NO	Nanghray-lha
GLY13	Alpine	4800m	27°56'19"	88°34'35"	40	NE	NO	Nanghray-lha
GLY14	Alpine	4762m	27°56'13"	88°34'44"	40	NE	NO	Sachung
GLY15	Alpine	4721m	27°56'09"	88°34'48"	40	NE	NO	Sachung
GLY16	Alpine	4673m	27°56'00"	88°34'50"	70	NE	NO	Sachung
GLY17	Alpine	4647m	27°55'54"	88°34'49"	70	NE	NO	Sachung
GLY18	Alpine	4627m	27°55'44"	88°34'48"	70	E	NO	Jha-chu
GLY19	Alpine	4600m	27°55'40"	88°34'48"	20	NE	NO	Dambachay
GLY20	Alpine	4556m	27°55'27"	88°34'34"	45	NW	NO	Latha

GLY21	Alpine	4533m	27°55'22"	88°34'29"	70	NW	NO	Latha
GLY22	Alpine	4515m	27°55'20"	88°34'20"	80	W	NO	Membarung
GLY23	Alpine	4478m	27°55'10"	88°34'16"	30	W	Grazing	Bamzay
GLY24	Alpine	4434m	27°54'56"	88°34'04"	30		Grazing	Bamzay
GLY25	Alpine	4388m	27°54'56"	88°33'54"	30	E	Grazing	Bamzay
GLY26	Alpine	4375m	27°54'48"	88°33'54"	70	E	Grazing	Bamzay
GLY27	Alpine	4362m	27°54'40"	88°33'42"	60	N	Grazing	Bamzay
GLY28	Alpine	4309m	27°54'24"	88°33'21"	60	NE	Grazing	Bamzay
GLY29	Alpine	4279m	27°54'19"	88°33'07"	45	S	Grazing	Bamzay
GLY30	Alpine	4234m	27°54'12"	88°32'50"	45	E	Grazing	Bamzay
GLY31	Alpine	4152m	27°54'01"	88°32'30"	45	N	Grazing	Bamzay
GLY32	Alpine	4123m	27°53'58"	88°32'33"	30	N	Road Construction	Thangu
GLY33	Alpine	4055m	27°53'55"	88°32'28"	30	NE	Road Construction	Thangu
GLY34	Alpine	4021m	27°53'54"	88°32'21"	45	NE	Road Construction	Thangu
GLY35	Alpine	3935m	27°53'50"	88°32'19"	45	NEE	Road Construction	Thangu
GLY36	Alpine	3859m	27°53'27"	88°32'13"	20	N	NO	Thangu
GLY37	Alpine	3820m	27°52'56"	88°32'14"	20	SW	NO	Rumchu
GLY38	Alpine	3810m	27°52'46"	88°32'17"	30	SW	Landslide	Rumchu
GLY39	Alpine	3801m	27°52'35"	88°32'21"	30	SW	NO	Rumchu
GLY40	Alpine	3756m	27°52'20"	88°32'36"	30	SW	NO	Kalep
GLY41	Alpine	3654m	27°52'05"	88°32'39"	30	SW	NO	Kalep
GLY42	Alpine	3655m	27°51'50"	88°32'50"	30	SW	NO	Yathang

RESULT AND DISCUSSION

FLORA

During the survey, a total of 42 plots were laid covering 0.42 ha area **(Table I; Figure 1)**, from which 2 tree, 3 small tree/ large shrubs, 15 shrubs / shrublets and 36 herb species were recorded and are marked with (*) in a general checklist prepared below. A general checklist of 104 species of the area (including the areas outside of the plots) were prepared of which, herbs represented the highest number of species (79 species) followed by small trees / shrubs / shrublets (18 species). Trees were very sparse; hence only 3 species were recorded from the area namely *Abies densa, Betula utilis and Acer pectinatum* **(Table 2)**.

Checklist of Floral Species Recorded in Thangu Valley and Surrounding Area, North Sikkim

Sl. No.	Name of Species	Family	Altitudinal range
TREES			
1	**Abies densa* Griff.	Pinaceae	2450-4000
2	*Acer pectinatum* wall. ex G.Nicholson	Aceraceae	2300-3800
3	**Betula utilis* D.Don	Betulaceae	2500-3800
SMALL TREE / LARGE SHRUBS			
1	**Juniperus indica* Bert.	Cupressaceae	2600-5100
2	**Lyonia ovalifolia* (Wallich) Drude	Ericaceae	300-3400
3	**Salix* sp.	Salicaceae	ca. 3900
SHRUBS / SHRUBLETS			
1	**Berberis* sp.	Berberidaceae	-
2	**Cassiope fastigiata* (Wall.) D.Don	Ericaceae	2800-4500
3	*Cassiope selaginoides* Hook. & Thoms.	Ericaceae	3000-5000
4	**Cotoneaster microphyllus* Wall. ex Lindl.	Rosaceae	2000-5400
5	*Gaultheria nummularioides* D.Don	Ericaceae	2700-4500
6	*Gaultheria trichophylla* Royle	Ericaceae	2700-4500
7	**Juniperus squamata* Buch.-Ham. ex D. Don	Cupressaceae	2000-4500
8	*Leptodermis* sp.	Rubiaceae	ca. 4400
9	**Lonicera* sp.	Caprifoliaceae	-
10	**Rhododendron anthopogon* D.Don	Ericaceae	3500-4500
11	**Rhododendron campanulatum* D.Don subsp *aeruginosum* Hook.f.	Ericaceae	3000-4400
12	**Rhododendron campanulatum* D.Don subsp sp. *campanulatum* D.Don	Ericaceae	Cupressaceae
13	**Rhododendron campylocarpum* Hook. f.	Ericaceae	3000-3900
14	**Rhododendron lepidotum* Wall. ex G.Don	Ericaceae	2500-5000
15	**Rhododendron nivale* Hook.f.	Ericaceae	4500-5500
16	**Rhododendron setosum* D.Don	Ericaceae	3500-5500
17	**Ribes himalense* Royle ex Decne.	Grossulariaceae	1500-4200
18	**Rosa sericea* Lindley	Rosaceae	2100-4500
19	**Salix sikkimensis* Andersson	Salicaceae	3700-4500

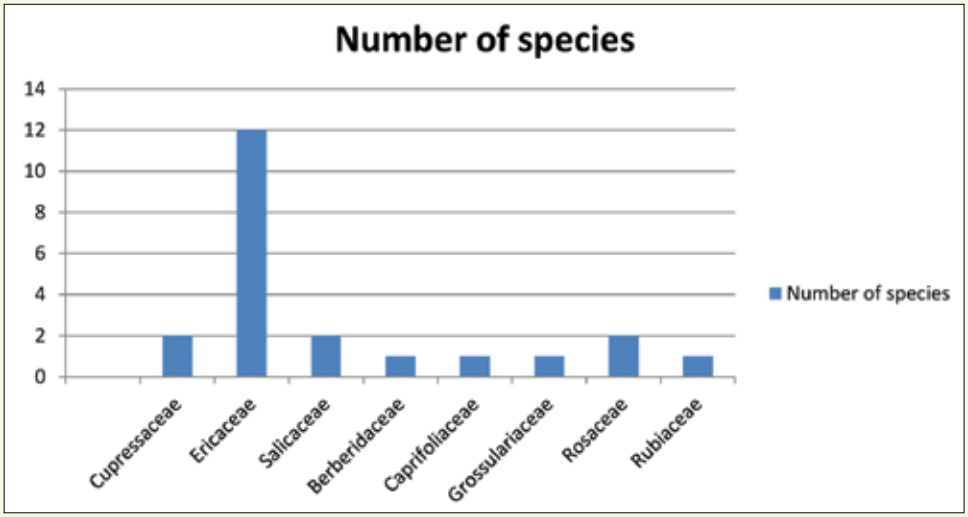
HERBS			
1	*Acanthocalyx nepalensis* (D. Don) M. J. Cannon	Morinaceae	2800-4500
2	**Acomastylis elata* var. *elata* Wall. ex G.Don	Rosaceae	3500-5400
3	**Aconitum spicatum* Stapf.	Ranunculaceae	ca. 4000
4	**Aletris pauciflora* (Klotzsch) Hand.-Mazz.	Liliaceae	3000-4300
5	**Anaphalis* sp.	Asteraceae	-
6	**Androsace selago* Hook. f. & Thomson ex Klatt	Primulaceae	3600-5000
7	**Aorchis spathulata* (Lindl.) Verm.	Orchidaceae	2300-4300
8	**Arenaria polytrichoides* Edgew	Caryophyllaceae	3500-5300
9	*Bistorta affinis* (D.Don) Greene	Polygonaceae	4000-4900
10	**Caltha scaposa* Hook.f. & Thomson	Ranunculaceae	2800-4300
11	*Cardamine macrophylla* Willd.	Brassicaceae	3000-4200
12	**Chesneya nubigena* (D.Don) Ali	Fabaceae	3600-5300
13	*Spongiocarpella nubigena (D.Don)Yakovlev	Fabaceae	3600-5200
14	*Clematis montana* Buch.-Ham. ex de Candolle.	Ranunculaceae	1000-4000
15	**Ephedra gerardiana* var. *sikkimensis* Stapf	Ephedraceae	ca. 4500
16	*Eriophyton wallichii* Benth.	Lamiaceae	2800-4800
17	**Ephedra gerardiana* Wall. ex Stapf.	Ephedraceae	2500-5000
18	*Euphorbia stracheyi* Boissier	Euphorbiaceae	3000-4900
19	*Eutrema* sp.	Brassicaceae	-
20	**Fragaria nubicola* (Lindl. ex Hook.f.) Lacaita	Rosaceae	1800-3800
21	**Fritillaria cirrhosa* D.Don	Liliaceae	3200-4600
22	*Juncus inflexus* L.	Juncaceae	1800-3200
23	*Juncus alpinoarticulatus* Chaix	Juncaceae	ca.3200
24	*Juncus himalensis* Klotzsch	Juncaceae	2400-4300
25	**Juncus thomsonii* Buchenau	Juncaceae	2800-5000
26	**Lloydia flavonutans* H.Hara	Liliaceae	3600-4500
27	*Meconopsis horridula* J. D. Hooker & Thomson	Papaveraceae	3600-5400
28	**Meconopsis simplicifolia* (D. Don) Walp.	Papaveraceae	3300-5300
29	*Microula sikkimensis* (C. B. Clarke)	Boraginaceae	3000-4500
30	*Mosses	-	-
31	*Myricaria rosea* W.W.Smith	Tamaricaceae	2600-4800
32	*Nannoglottis hookeri* (C. B. Clarke ex J. D. Hooker)	Asteraceae	3400-4100
33	*Oxyria digyna* (L.) Hill	Polygonaceae	2400-5000
34	*Parnassia nubicola* Wall.ex Royle	Parnassiaceae	3000-4500
35	*Pedicularis longiflora* Rudolph	Scrophulariaceae	2100-5300
36	*Pedicularis megalantha* D.Don	Scrophulariaceaee	2300-4300
37	**Pedicularis oederi* Vahl	Scrophulariaceae	2600-5400
38	**Persicaria wallichii* Greuter & Burdet	Polygonaceae	2500-3800
39	**Phlomis rotata* Benth. ex Hook.f.	Lamiaceae	3800-6100
40	*Pleurospermum hookeri* C.B.Clarke	Apiaceae	2700-5400
41	**Poa* sp.	Poaceae	-

42	*Podophyllum hexandrum* Royle	Berberidaceae	2400-4500
43	**Polygonatum cirrhifolium* (Wallich) Royle	Asparagaceae	2000-4000
44	**Potentilla peduncularis* D.Don	Rosaceae	3000-4500
45	*Potentila arbuscula* D.Don	Rosaceae	2500-5500
46	**Potentilla reptans* L.	Rosaceae	ca.3800
47	**Primula calderiana* Balf. f. & R.E. Cooper	Primulaceae	3800-4700
48	**Primula capitata* Hook.	Primulaceae	2800-4300
49	**Primula concinna* Watt.	Primulaceae	4000-5000
50	**Primula concinna* Watt. (White form)	Primulaceae	4000-5000
51	*Primula denticulata* Sm.	Primulaceae	1500-4500
52	**Primula dickieana* watt	Primulaceae	4000-5000
53	**Primula sikkimensis* Hook.	Primulaceae	3200-4500
54	**Ranunculus hirtellus* Royle	Ranunculaceae	2800-5500
55	**Ranunculus* sp. (Purple flower)	Ranunculaceae	
56	*Rheum nobile* Hook.f. & Thoms.	Polygonaceae	3600-4500
57	*Rhodiola* sp.	Crassulaceae	ca. 4600
58	*Rhodiola. himalensis* (D. Don) S. H. Fu	Crassulaceae	3300-4800
59	**Rumax* sp.	Polygonaceae	ca. 4000
60	*Saxifraga brachypoda* D.Don	Saxifragaceae	3600-4800
61	*Saxifraga engleriana* Harry Smith	Saxifragaceae	4100-4700
62	*Saxifraga stenophylla* Royle	Saxifragaceae	3600-5000
63	**Senecio raphanifolius* Wall. ex DC.	Asteraceae	2700-4400
64	*Taraxacum* sp.	Asteraceae	ca. 4200
65	**Thermopsis barbata* Benth.	Fabaceae	2700-4500
66	*Triosetum himalayanum* Wall.	Caprifoliaceae	1800-4100
67	*Urtica hyperborea* Jacquem. ex Wedd.	Urticaceae	3000-5200
68	*Viola biflora* Linn.	Violaceae	2500-4300
FERN AND FERN ALLIES			
1	*Araiostigiella hookeri* (T. Moore ex Bedd.) Fraser-Jenk	Davalliaceae	2700 – 3800
2	*Athyrium davidii* Christ.	Woodsiaceae	Above 3200
3	*Deparia subsimilis* (Christ.) Fraser-Jenk.	Woodsiaceae	3000 – 3600
4	*Dryopteris barbigera* (T. Moore ex Hook.) Kunze	Dryopteridaceae	Above 3500
5	*Dryopteris* sp.	Dryopteridaceae	ca.4000
6	*Dryopteris xanthomelas* (Christ) C. Chr.	Dryopteridaceae	3600 – 4300
7	*Lycopodium veithii* Christ Nagbeli	Lycopodiaceae	2600 – 4000
8	*Osmunda claytoniana* L	Osmundaceae	3000 – 4000
9	*Pichisermollodes erythrocarpa* Mett. ex Kuhn (Fraser-Jenk)	Polypodiaceae	2600 – 3400
10	*Pichisermollodes fraser – jenkinsonii*	Polypodiaceae	2600 – 3400
11	*Polystichum* sp.	Dryopteridaceae	ca. 3800
Note: (*) represents the species recorded inside the sample plots.			

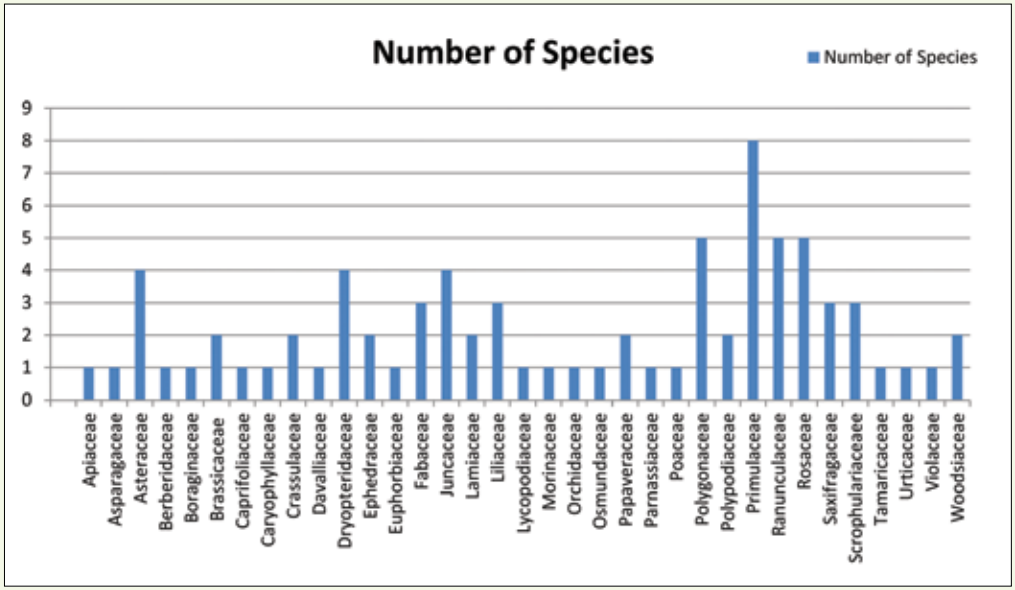
Table 2: Diversity of Floral species in Thangu Valley and surrounding area, North Sikkim.			
Habit	**Species**	**Genus**	**Family**
Trees	3	3	3
Small trees / large shrubs	3	3	3
Shrubs/ shrublets	19	11	8
Herbs	79	57	35
Total	**104**	**74**	**49**

Family wise analysis revealed that belonging to the shrubs category Ericaceae was the dominant family, with 12 species under the genus Rhododendron (7 species), Cassiope (2 species), Gaultheria (2 species) and Lyonia (1 species); followed by Rosaceae, Salicaceae and Cupressaceae **(Graph I).** In case of herbs, Primulaceae family appeared as dominant with 8 species followed by Polygonaceae, Ranunculaceae and Rosaceae, each with 5 species **(Graph II)**

The number of species per plot for tree, small tree / large shrub, shrub / scrub and herb species ranged between 0 and 3, 0 and 3, 0 and 6 and 2 and 7 respectively; nonetheless, species were completely absent from 95.24% (Tree), 78.57% (small tree / large shrub), 9.52% (shrub / shrublets) and 0.00% (herb) of the total plots **(Table 3)**.



Graph I: Family-wise distribution of shrub species



Graph II: **Family wise distribution of herb species**

Table 3: **Species availability in the different sampling site**

Number of species	Tree	Small Tree / Large Shrub	Shrub / Scrub	Herb
0	95.24	78.57	9.52	0.00
1	0.00	16.67	23.81	0.00
2	4.76	2.38	28.57	9.52
3	0.00	2.38	11.90	28.57
4	0.00	0.00	16.67	26.19
5	0.00	0.00	4.76	16.67
6	0.00	0.00	4.76	9.52
7	0.00	0.00	0.00	9.52

Table 4: Availability and distribution of Tree species along Gay-Gaon – Nanghray-lha –Yathang sampling path, North Sikkim

Species	Adult			
	Density (Ind/ha) ± SE	TBC (m2/ha)	A/F ratio	IVI
Abies densa	9.52 ±34.24	8.93	0.42	153.45
Betula utilis	9.52 ±30.48	7.78	0.42	146.55

Table 5: Tree species diversity and distribution along Gay-Gaon – Nanghray-lha –Yathang sampling path, North Sikkim

Parameters	Trees
Diversity Index (H)	0.690
Concentration of Dominance (D)	0.009
Species richness index (I)	1.510
Species evenness index (E)	-1.000

Out of three species of trees recorded from the area, from the sub-alpine part below Thangu, only *Abies densa* and *Betula utilis* were recorded from the sample plots. *Abies densa* and *Betula utilis* was thinly scattered in the area, hence, only 4 individual of each were recorded from the entire sampling site, from the lower three plots. The cumulative adult stem density of trees found very low, which was only confined to the sub-alpine part of the survey area. Adult stem density of *Abies densa* were 9.52 ±34.24 ind/ha; Rel. Den.: 50.00%; IVI: 153.45 and of of *Betula utilis* were 9.52 ±30.48 ind/ha; Rel.Den.: 50%; IVI: 146.55 **[Table 4]**. **The Total Basal Cover (TBC)** and **Relative Dominance** of *Abies densa* were 8.93m^2/ha and 53.44% respectively and that of *Betula utilis* were 7.78 m^2/ha and 46.55%. In the remaining 39 plots in the alpine area above Thangu (4000m), the trees were completely absent.

In case of trees, the sampled area was not much rich in terms of tree species richness (I = 1.51) and recorded low species diversity (H = 0.69) **[Table 5)**. The abundance to frequency ratio revealed that, the adult individuals of both *Abies densa* and Betula utilis (A/F ratio: 0.42) shows contagious distribution. Saplings and seedlings of the trees were not recorded from the sample plots.

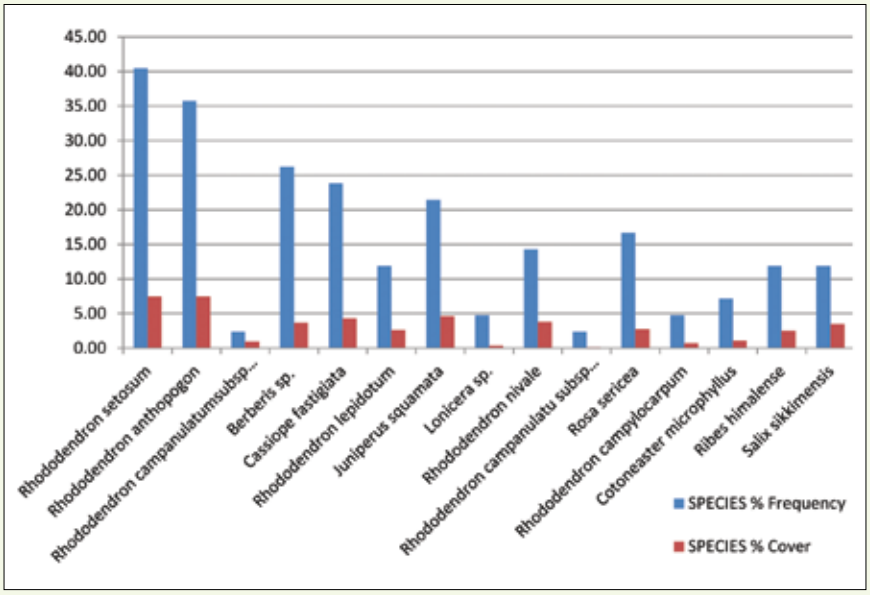
The small tree/large shrub recorded from the sample plots are *Lyonia ovalifolia, Juniperus indica* and *Salix* sp. Of the 3 small tree / large shrub species present, *Salix* sp had the highest frequency of occurrence (9.52%) and *Lyonia ovalifolia* and *Juniperus indica* had the lowest frequency of occurrences (4.76% and 2.38% respectively) **[Table 6).** In respect to percent cover, *Salix sp. was found dominant* (average percent cover: 3.81 %) followed by *Juniperus indica* and *Lyonia ovalifolia*.

Table 6: Availability and distribution of Small Trees / large shrubs along Gay-Gaon – Nanghray-lha –Yathang sampling path, North Sikkim.

Species	Average % Cover	Frequency %
Salix sp.	3.81	9.52
Juniperus indica	0.24	2.38
Lyonia ovalifolia	0.48	4.76

Table 7: Availability and distribution of shrubs and shrublets along Gay-Gaon – Nanghray-lha –Yathang sampling path, North Sikkim

Sl. No.	Species	Average % Cover	Frequency %
1	*Rhododendron setosum* D.Don	7.50	40.48
2	*Rhododendron anthopogon* D.Don	7.50	35.71
3	*Rhododendron campanulatum* D.Don subsp *aeruginosum* Hook.f.	0.95	2.38
4	*Berberis* sp.	3.69	26.19
5	*Cassiope fastigiata* (Wall.) D.Don	4.29	23.81
6	*Rhododendron lepidotum* Wall. ex G.Don	2.62	11.90
7	*Juniperus squamata* Buchanan-Hamilton ex D. Don	4.64	21.43
8	*Lonicera* sp.	0.36	4.76
9	*Rhododendron nivale* Hook.f.	3.81	14.29
10	*Rhododendron campanulatum* D.Don subsp sp. *campanulatum* D.Don	0.12	2.38
11	*Rosa sericea* Lindley	2.74	16.67
12	*Rhododendron campylocarpum* Hook. f.	0.71	4.76
13	*Cotoneaster microphyllus* Wall. ex Lindl.	1.07	7.14
14	*Ribes himalense* Royle ex Decne.	2.50	11.90
15	*Salix sikkimensis* Andersson	3.45	11.90



Graph III: Status of shrubs or shrublets in the sample plots

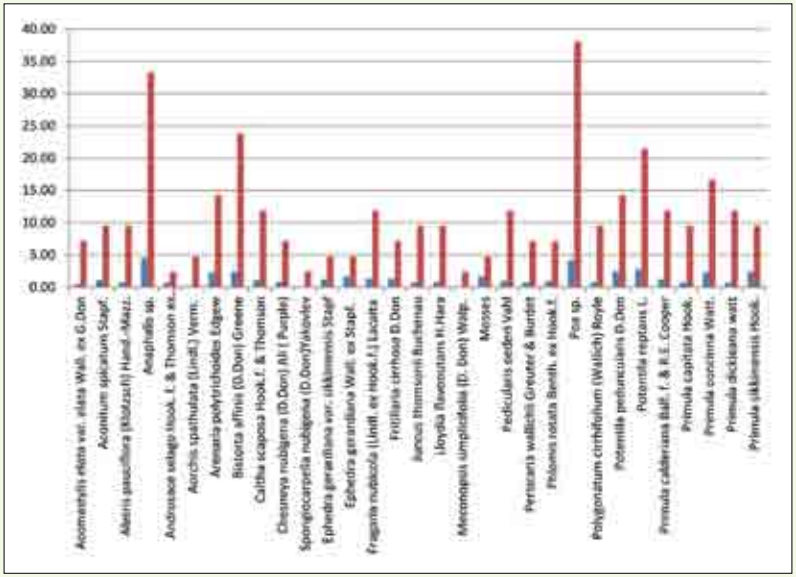
Of the 15 shrubs or shrublets recorded from the sample plots, *Rhododendron setosum*, *Rhododendron anthopogon, Berberis* sp., and *Cassiope fastigiata* had wide availability in the area, the frequency of occurrence was 40.48%, 35.71%, 26.19% and 23.81% respectively. The species such as *Cotoneaster microphyllus*, *Rhododendron campanulatum* subsp *campanulatum*, *Rhododendron nivale, Lonicera* sp., *Rosa sericea, Rhododendron campylocarpum, Ribes himalense, Salix sikkimensis* recorded occurring less frequently in the area. The density in terms of percent cover for the recorded shrubs or shrublets were comparatively low, which is shown in **Table 7** and **Graph III.**

In the case of herbaceous species, a total of 36 species were recorded from 42 plots, of which, different species of *Poa* and *Anaphalis* had the highest frequency of occurrences (38.10% and 33.33% respectively) followed by *Bistorta affinis* and *Ranunculus hirtellus* (23.81% each). Other species such as *Androsace selago* (2.38%), *Aorchis spathulata* (4.76%), *Meconopsis simplicifolia* (2.38%), *Spongiocarpella nubigena* (2.38%), *Ephedra gerardiana* var. *sikkimensis* Stapf (4.76%) etc. had low frequency of occurrences. Other species such as A*conitum spicatum, Aletris pauciflora, Arenaria polytrichoides, Caltha scaposa*, *Chesneya nubigena*, *Fragaria nubicola*, *Juncus thomsonii*, *Lloydia flavonutans, Pedicularis oederi, Polygonatum cirrhifolium* had an average availability in an area in terms of frequency of occurrences. Similarly, with regard to average density in terms of percent cover, the species such as *Ranunculus hirtellus*, *Senecio raphanifolius*, *Primula concinna, Primula sikkimensis*, *Potentila reptans, Potentila peduncularis*, *Poa* sp., *Fragaria nubicola*, *Arenaria polytrichoides, Bistorta affinis*, *Anaphalis* sp. etc was dominant over other herbs species. The species such as *Acomastylis elata* var. *elata*, *Aconitum spicatum*, *Aletris pauciflora*, *Androsace selago*, *Aorchis spathulata*, *Caltha scaposa*, *Spongiocarpella nubigena*, *Ephedra gerardiana* var. *sikkimensis*, *Lloydia flavonutans*, *Meconopsis simplicifolia*, *Persicaria wallichii*, *Polygonatum cirrhifolium*, *Primula dickieana*, *Thermopsis barbata* etc. have appeared rarely with very less number of populations in the study area **(Table 8, Graph IV).**

Table 8: Availability and distribution of herbs species along Gay-Gaon – Nanghray-lha –Yathang sampling path, North Sikkim

Sl. No.	Species	Average % Cover	Frequency %
1	*Acomastylis elata* var. *elata* Wall. ex G.Don	0.43	7.14
2	*Aconitum spicatum* Stapf.	1.07	9.52
3	*Aletris pauciflora* (Klotzsch) Hand.-Mazz.	0.71	9.52
4	*Anaphalis* sp.	4.52	33.33
5	*Androsace selago* Hook. f. & Thomson ex Klatt	0.71	2.38
6	*Aorchis spathulata* (Lindl.) Verm.	0.19	4.76
7	*Arenaria polytrichoides* Edgew	2.26	14.29
8	*Bistorta affinis* (D.Don) Greene	2.38	23.81
9	*Caltha scaposa* Hook.f. & Thomson	1.07	11.90
10	*Chesneya nubigena* (D.Don) Ali (Purple)	0.83	7.14
11	*Spongiocarpella nubigena* (D.Don)Yakovlev	0.12	2.38
12	*Ephedra gerardiana* var. *sikkimensis* Stapf	1.19	4.76
13	*Ephedra gerardiana* Wall. ex Stapf.	1.67	4.76
14	*Fragaria nubicola* (Lindl. ex Hook.f.) Lacaita	1.31	11.90
15	*Fritillaria cirrhosa* D.Don	1.31	7.14
16	*Juncus thomsonii* Buchenau	0.71	9.52
17	*Lloydia flavonutans* H.Hara	0.83	9.52
18	*Meconopsis simplicifolia* (D. Don) Walp.	0.12	2.38
19	Mosses	1.67	4.76
20	*Pedicularis oederi* Vahl	0.95	11.90
21	*Persicaria wallichii* Greuter & Burdet	0.71	7.14
22	*Phlomis rotata* Benth. ex Hook.f.	0.95	7.14

23	*Poa* sp.	4.17	38.10
24	*Polygonatum cirrhifolium* (Wallich) Royle	0.73	9.52
25	*Potentila peduncularis* D.Don	2.38	14.29
26	*Potentila reptans* L.	2.74	21.43
27	*Primula calderiana* Balf. f. & R.E. Cooper	1.19	11.90
28	*Primula capitata* Hook.	0.71	9.52
29	*Primula concinna* Watt.	2.26	16.67
30	*Primula dickieana* watt	0.71	11.90
31	*Primula sikkimensis* Hook.	2.38	9.52
32	*Ranunculus hirtellus* Royle	2.62	23.81
33	*Ranunculus* sp (Purple flower)	0.71	7.14
34	*Rumax* sp.	1.19	4.76
35	*Senecio raphanifolius* Wall. ex DC.	2.38	14.29
36	*Thermopsis barbata* Benth.	0.43	9.52



Graph IV: Status of herbs species in the sampling path

FAUNA

During the survey, the existence of a total of 23 bird species belonging to 3 order and 13 families were recorded. Similarly existence of a total of 10 mammalian species was recorded through direct and indirect evidence.

Checklist of Avi-fauna of Thangu Valley and surrounding area in North Sikkim

Sl. No	Common Name	Scientific Name	Family	Order	Evidence
1	Blood pheasant	*Ithaginis cruentus*	Phasianidae	Galliformes	PC, DS
2	Satyr tragopan	*Tragopan satyra*	Phasianidae	Galliformes	PC,
3	Black-faced Laughingthrush	*Garrulax affinis*	Turdidae	Passerriformes	PC, DS
4	Red-headed Bullfinch	*Pyrrhula erythrocephala*	Fringillidae	Passerriformes	PC
5	Dark breasted Rosefinch	*Carpodacus nipalensis*	Fringillidae	Passerriformes	PC
6	Plain Mountain Finch	*Leucosticte nemoricola*	Fringillidae	Passerriformes	PC
7	White-capped Redstart	*Phoenicurus leucocephalus*	Muscicapidae	Passerriformes	PC
8	Fire-tailed Sunbird	*Aethopyga ignicauda*	Nectariniidae	Passerriformes	PC
9	House Crow	*Corvus splendens*	Corvidae	Passerriformes	PC, DS
10	House Sparrow	*Passer domesticus*	Passeridae	Passerriformes	PC, DS
11	Green-backed tit	*Parus monticolus*	Paridae	Passerriformes	PC
12	Blue Whistling Thrush	*Myophonus caeruleus*	Muscicapidae	Passerriformes	PC, DS
13	Common Myna	*Acridotheres tristis*	Sturnidae	Passerriformes	PC, DS
14	Rock Dove	*Columba livia*	Columbidae	Columbiformes	PC, DS
15	Oriental turtle dove	*Streptopelia orientalis*	Columbidae	Columbiformes	PC, DS
16	Green Pigeon	*Treron*	Columbidae	Columbiformes	PC, DS
17	Kalij Pheasant	*Lophura leucomelanos*	Phasianidae	Galliformes	PC
18	Ashy Throated Warbler	*Phylloscopus maculipennis*	Sylviidae	Passerriformes	PC
19	Red Billed Chough	*Pyrrhocorax pyrrhocorax*	Corvidae	Passerriformes	PC
20	Snow Pigeon	*Columba leuconota*	Columbidae	Columbiformes	PC
21	Long tailed thrush	*Zoothera dixonii*	Turdidae	Passerriformes	DS
22	Golden Naped Finch	*Pyrrhoplectes epaulette*	Fringillidae	Passerriformes	DS
23	Whiskered Yuhina	*Yuhina flavicollis*	Zosteropidae	Passerriformes	DS

PC: Photo Capture, **DS:** Direct Sighting

Checklist of mamalian species of Thangu Valley and surrounding areas in North Sikkim				
Sl. No.	Common Name	Scientific Name	Family	Evidence[1]
1	Musk Deer (Kasturi mriga)	*Moschus chrysogaster*	Moschidae	SI
2	Red fox	*Vulpes vulpes*	Canidae	S
3	Kiang	*Equus kiang*	Equidae	SI
4	Tibetan Sand Fox	*Vulpes ferrilata*	Canidae	DS
5	Himalayan Marmot	*Marmota Himalayana*	Sciuridae	SI
6	Himalayan Black Bear	*Ursus thibetanus*		FS
7	Yellow-throated Marten (Malsapra)	*Martes flavigula*	Mustelidae	SI, S
8	Pika	*Ochotona sp.*	Ochotonidae	DS
9	Serow (Thar)	*Capricornis thar*	Bovidae	HM, P
10	Wild dog	*Cuon alpinus*	Canidae	SI

[1]**SI**: Secondary Information, **DS**: Direct Sighting, FS: Foraging sign, **HM:** Hoof mark, **P:** Pellet, **S**: Scat [2] **EN:** Endangered, **LC:** Least concern, **VU:** Vulnerable, **NT:** Near threatened

CONCLUSION AND RECOMMENDATIONS

Till date, the area remain unexplored which, during the present study, found to be rich in terms of the diversity of the species. Forest being sub alpine to alpine type, herbs are the most predominant taxa in the area, followed by shrubs and shrublets. The area constitutes a diverse habitat for both flora and fauna and the wide range of habitat diversity the area harbour, in the form of several globally threatened species as well as high value medicinal plants such as *Aconitum spicatum*, *Ephedra gerardiana* var *sikkimensis*, *Rheum nobile, fritillaria cirrhosa, Podophyllum hexandrum, Meconopsis simplicifolia etc.* The lower elevation of the study area, below Thangu valley is occupied mainly with scattered *Abies densa*, *Salix* sp. and the species of *Rhododendrons*. In addition, the area also provide diverse habitat for faunal species such as Serow, Musk Deer, Blood Pheasant, Leopard, Lesser Cats and Himalayan Marmot, Satyr Tragopan, Common Langur, Tibetan Fox, Martens Weasel and Impeyan Pheasant. A wide variety of avifauna, which includes Blood Pheasant, Monal Pheasant, Tragopan, Rose finches, Red-billed Chough, Forktails and Laughing Thrushes also resides in the area. Direct sightings of House Crow, House Sparrow, Blue Whistling Thrush, Common Myna, Rock Dove, Oriental turtle dove, Kalij Pheasant, Ashy Throated Warbler, Snow Pigeon, and Red Billed Chough were achieved during the present Rapid Biodiversity Survey.

The area is highly impacted by the natural as well as anthropogenic disturbance which needs immediate attention. Massive threat to the biodiversity due to grazing pressure by yak, cow and horse observed very high in the Lashar valley; for which immediate action should be taken. Increase in feral dog population is emerging as a serious threat to the wildlife; hence the problem of feral dog needs to be resolved at the earliest. Other existing threats to the biodiversity of the area observed during present study are construction of roadways, army personnel garrisoned and tourist influx. The deforestation and unsustainable extraction of plants specially *Abies densa* and *Rhododendron anthopogon*, *Juniperus* sp. for firewood and incense respectively by the local inhabitants are the general disturbances resulted in the building up considerable pressure on the survival of the species. Other major threats are obviously, the effect of drastic changes in climate. The sudden changes in the environmental parameters including strange weather such as

unusual rainfall, hailstorm etc. effects the vegetation greatly. In our observation, the blooming patterns of *Rhododendrons* of sub alpine and alpine areas have been changed and has observe the late initiation of flowering in case of some of the species like *R.niveum*, *R.campanulatum subsp aeroginosum, R.nivale, R.lanatum* etc.

Major threats to the Biodiversity of Thangu Valley and adjacent areas at Lachen Reserved Forest, North Sikkim

Natural disturbances: Boulders, Landslides

Anthropogenic: Herds and Grazing

Anthropogenic: Road construction

Field activities of SBFP survey team at Thangu – Lashar, North Sikkim

Laying of plots and collecting data

Taking GPS co-ordinate at the habitat of *Ephedra gerardiana* **var** *sikkimensis*

Collection of unidentified species, tagging with field number, for further identification

Recording informations and taking photographs

Ephedra gerardiana var *sikkimensis*

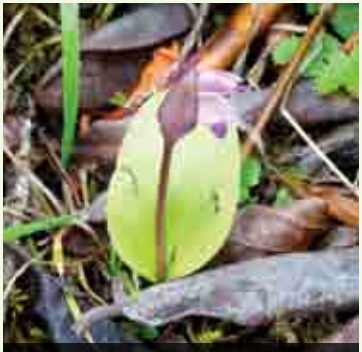
Fritillaria cirrhosa

Ephedra gerardiana

Lilum nanum

Microula sikkimensis

Nannoglotis hookeri



Aorchis spathulata

Arenaria polytrichoides

Rhododendron nivale

Blue-Fronted Redstart

Large Billed Crow

Bull Finch

White Collared Black Bird

Plain Mountain Finch

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Analysis of Vegetation in a Representative Temperate Plant Community in Lachung Range of the Sikkim Himalaya

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ABSTRACT

Quantitative assessment recorded a total of 75 species under 68 genera falling in 49 plant families, and 6 of fern and fern-allies, a moss and lichen. *Picea spinulosa* showed highest density (214.81 ind/ha), relative density (38.16 %), and IVI (75.76) followed *Tsuga dumosa* (81.48 ind/ha). Highest relative frequency of occurrence was recorded for *Picea spinulosa* and *Tsuga dumosa* (Rel. Freq. 21.40 %) followed by *Rhododendron arboreum* (11.52 %). For saplings and seedlings the highest score was observed in *Rhododendron arboreum* (37.0 % & 22.2 %) followed by *Prunus nepalensis* (33.3 % at 22.2 %); sapling lowest from *Populus jacquemontiana* (3.7 %) and seedlings from *Sorbus* sp and *Magnolia globosa* (3.7 % each). The species diversity (adult, sapling and seedlings) in the site were found to be highest in concentration for the trees (H'= 2.2914) followed by seedlings (H'= 2.2124) and the saplings (H'=2.1474). The highest IVI value recorded for *Tsuga dumosa* effectively makes it the dominant species. Abundance-to-frequency ratio revealed that random distribution was evinced in *Tsuga dumosa* and the rest showed contiguous distribution.

KEYWORDS:
Lachung, Plant community, Sikkim Himalaya, Temperate Forest

Introduction

Plant communities have specific plant species composition and physiognomy, which largely defines the habitat type selected not only by the plants but by animals too and other life forms. Plant communities are recognized as elements of biodiversity which need to be identified and monitored. In this case, monitoring ecosystem health and changes in biodiversity can be achieved to a significant degree by monitoring changes in plant communities. To an extent, vegetation is also relatively easy to measure, inventory and monitor both spatially and temporally, at various scales. Presently, international standardized classification of ecological communities using vegetation has been recognized as an essential tool for identification, monitoring, and conservation of ecosystems (Grossman *et al*. 1998, NatureServe 2003, Jennings *et al*., 2003).

Sikkim Himalaya shows tremendous biological diversity, covering just 0.2 % of the geographical area of the country. The plant diversity of Sikkim is fascinating blend of flora because of species richness and diverse community structure. The flowering plants are represented by about 4400 species in the region, belonging to 1371 genera of 197 families. The forest cover in the state is 47.34 % and this figure is one of the largest in the country.

Different vegetation types are identified for Sikkim Himalaya which is mainly the product of diverse climatic, physiographic and pedologic conditions that are found at different elevations. The present work was undertaken in the Mixed Coniferous Temperate Forest (2700-3000 m) with the dominant tree species as *Abies densa, Acer campbellii, Betula utilis, Rhododendron arboreum, Taxus baccata, Tsuga dumosa, Larix griffithiana*, etc., found mainly at Lachen, Lachung, Yakthang and Zemu in North Sikkim. The objective of the present study was to find out the vegetation characteristics of a representative temperate plant community in Lachung forest range of Sikkim Himalaya.

Study site

The study site is a representative vegetation of the temperate forest at Lachung Range in Sikkim Himalaya lying between 88°44'57" E and 27°42'45" N. The elevation ranged between 2800-3200 m asl showing aspects of E, N and NE with the slope angle falling between 5 and 40 degree inclination. A total of 27 plots were taken in an area of 7 km^2 approx. The study area is close to the Shingba Rhododendron Sanctuary which is the home of *Rhododendron niveum*, an endangered plant and an endemic for the region. The climate is characterized by a long moist season followed by a dry spell during the winters. Snow is common and heavy at the site as also hailstorms and high winds. Small landslips are frequent in the area with occasional case of avalanches.

Methodology

Random sampling was done using quadrat of 10 m^2 laid out at 27 points covering an area of 0.027 ha. Within these the tree sampling quadrat of 10 m^2 and 5 m^2 was taken for shrub, sapling, and scrub and at the centre 1 m^2 for herb species were laid out. The 1 m^2 quadrats were also laid for seedling sampling. Plant samples were identified through standard flora and floral references (Hooker 1888-90, Hooker 1849, Pradhan & Lachungpa 1990, Kholia 2010). All the sampling plots were geotagged for reference under long-term monitoring and altitude was recorded.

Figure 1. Biodiversity Survey sites in Lachung Range, North Sikkim.

The vegetation data were quantitatively analyzed for density and frequency following Curtis and McIntosh (1950) and species diversity index (H') was derived using the Shannon-Wiener Index (Shannon & Wiener, 1963). Importance Value Index was calculated by summing up relative frequency, relative density and relative dominance values. The ratio of abundance to frequency for different species was determined through the distribution patterns of the species. The ratio indicates regular (<0.025), random (0.025 to 0.05) and contagious (>0.05) distributions (Cottam & Curtis, 1956). The adult individuals (diameter >10 cm) were grouped into different classes on the basis of diameter as A;10-20, B;20-30, C;30-40, D;40-50, E;50-60, F;60-70, G;70-80, H;80-90, I;90-100, J; >100 cm.

Results

The study revealed a total of 75 species under 68 genera falling in 49 plant families, and 6 of fern and fern-allies were recorded. Herbs represented the highest number of species (36 species, 31 genera, 22 families and 1 unidentified) followed by small shrub/scrub (14 species, 13 genera, 8 families) and large tree (11 species, 10 genera, 8 families) and other remaining floral species (Table 1).

Diversity of vegetation was found most in case of the ground flora in comparison to the shrubs and trees. Small shrub/scrub recorded the highest diversity on a species-to-family ratio (1.75). Overall species-to-family ratio was found to be 1.39 for the study site.

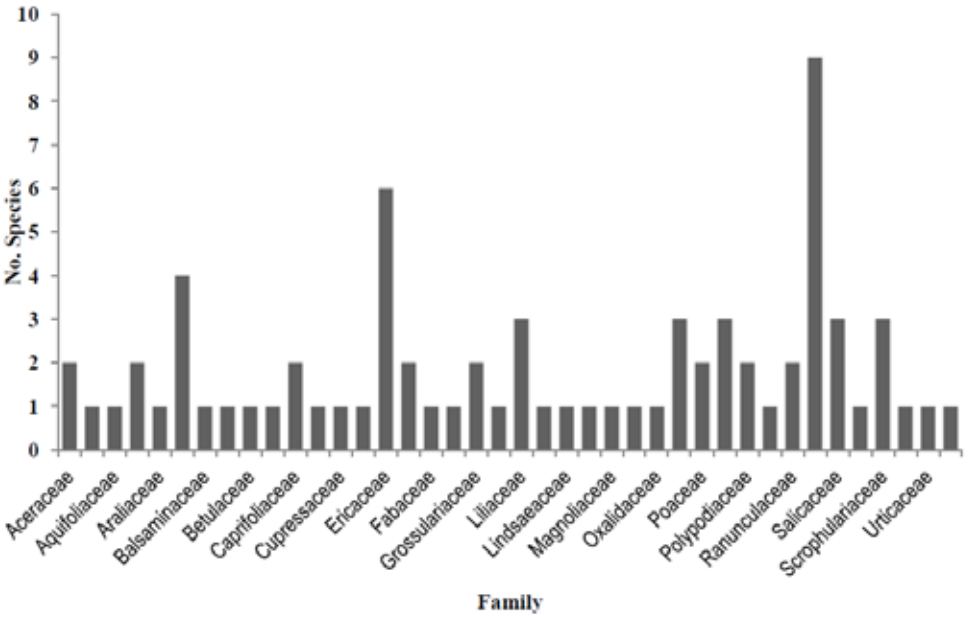

Figure 2. Family-wise species composition

Table 1. Distribution of Floral species recorded in Lachung Range, North Sikkim

Habit	Species	Genus	Family	Unidentified
Large Tree	11	10	8	0
Small tree & Large Shrub	8	8	6	0
Small shrub/scrub	14	13	8	0
Herb	36	31	22	1
Fern & fern-allies	6	6	5	0
Total	**75**	**68**	**49**	**1**

A total of 40 plant families containing 75 number of plant species represented the floral face of the study site. For the phanerogamic flora maximum species recorded for any family was that of Rosaceae (9 species), and this was followed by Ericaceae (6 species), and Asteraceae (4 species) (Fig. 2). The families of Liliaceae, Pinaceae, Polygonaceae, Salicaceae and Scrophulariaceae were represented by 3 species each. Remaining was showed in (Fig. 2).

The tree species were recorded cumulatively, viz., adult, sapling and seedling and the highest adult individuals were recorded for *Picea spinulosa* (214.81 ind/ha) followed by *Tsuga dumosa* (81.48 ind/ha) and *Rhododendron arboreum* (62.96 ind/ha) (Table 2). The minimum adult density was recorded from *Larix griffithiana* and *Populus jacquemontiana* where both showed 11.11 ind/ha and relative density of 1.97 each (Table 2).

The highest adult IVI value was recorded for *Tsuga dumosa* (105.11) followed by *Picea spinulosa* (75.76) and *Rhododendron arboreum* (23.35), *Acer campbellii* (20.77), *Cupressus torulosa* (19.07) and *Prunus nepalensis* (17.52) [Table 2]. For sapling density the highest was recorded for *Rhododendron arboreum* (129.63 ind/ha) followed by *Prunus nepalensis (*100.00 ind/ha), *Betula utilis* and *Acer campbellii* (each 33.33 ind/ha), *Tsuga dumosa* and *Picea spinulosa* (each 18.52 ind/ha). The lowest sapling density was recorded from *Cupressus torulosa, Acer caudatum, Sorbus* sp. (each 7.41 ind/ha) [Table 2], whereas the highest seedling density was recorded from *Rhododendron arboreum* (59.26 ind/ha) followed by *Acer caudatum* (55.56 ind/ha) and *Prunus nepalensis* (51.85 ind/ha); the lowest seedling density was recorded from *Magnolia globosa* (3.70 ind/ha) (Table 2). The abundance to frequency ratio revealed all the adult individuals of large tree species to be contagiously distributed except *Tsuga dumosa* which showed the random distribution but none of the species showed regular distribution (Table 2).

A general structural data regarding density, species diversity, etc, of the canopy-forming species in the study site of major species is depicted in Table 3. The relative density of major species was recorded higher from *Picea spinulosa (*38.16) (Table 3). The major species which has the highest frequency of occurrence was recorded for *Picea spinulosa* and *Tsuga dumosa* (Rel. Freq. 21.40 %) followed by *Rhododendron arboreum* (11.52 %) (Table 3). The frequency occurrence in the saplings and seedlings were found highest for *Rhododendron arboreum* (37.0 % & 22.2 %) followed by *Prunus nepalensis* (33.3 % 22.2 %); sapling lowest from *Populus jacquemontiana* (3.7%) and seedlings from *Sorbus* sp. and *Magnolia globosa* (3.7 % each). In general, the species diversity (H') and richness of trees (adult, sapling and seedling) in the site were found as highest in concentration for the trees (H'= 2.2914) followed by seedlings (H'= 2.2124) and the saplings at H'=2.1474.

The value of species richness was found in the range of 25.56-26.67 for the entire site. The highest species richness was observed in Plot 2 at 2931 m followed by Plot 10 at 3000 m asl. The correlation between the humus depth and total number of species varied much all through the sampling plots; however, maximum number of species was recorded at humus depth of 1 cm (Fig. 2).

Highest number of individual species was recorded along 2900 – 3000 m asl elevation range followed by 2800 – 2900 m asl (Fig. 3). Species richness was recorded higher in Plot 2 at (2931 m asl) followed by Plot 10 at 3000 m, both of the plots falling under 2900-3000 m asl distributional range as shown in Figure 3. Out of the 27 sampling plots 6 were found open canopy cover and the rest showed poor to insignificant canopy cover never crossing beyond 10 %.

Table 2. Availability and distribution of tree species in Lachung Range sampling path, North Sikkim

Species	Adult			Sapling	Seedling
	Density Ind/ha	A/F ratio	IVI	Density Ind/ha	Density Ind/ha
Acer campbellii	59.26	0.120	20.77	33.33	29.63
Acer caudatum	18.52	0.338	8.03	7.41	55.56
Betula utilis	29.63	0.086	14.05	33.33	25.93
Cupressus torulosa	14.81	0.068	19.07	7.41	0.00
Larix griffithiana	11.11	0.203	5.43	0.00	0.00
Magnolia globosa	14.81	0.270	6.03	0.00	3.70
Picea spinulosa	214.81	0.093	75.76	18.52	37.04
Populus jacquemontiana	11.11	0.203	5.45	11.11	18.52
Prunus nepalensis	44.44	0.130	17.52	100.00	51.85
Rhododendron arboreum	62.96	0.094	23.35	129.63	59.26
Sorbus sp	0.00	0.00	0.00	7.41	11.11
Tsuga dumosa	81.48	0.035	105.11	18.52	0.00

Table 3. Structural data on the major species in the Lachung Forest Range, North Sikkim

Species	Rel. Den.	Rel. Freq.	Pi =ni/N	lnPi	Pi*lnPi	H'
Populus jacquemontiana	1.97	3.29	0.019737	-3.93	-0.0775	
Rhododendron arboreum	11.18	11.52	0.111842	-2.19	-0.2450	
Picea spinulosa	38.16	21.40	0.381579	-0.96	-0.3676	
Prunus nepalensis	7.89	8.23	0.078947	-2.54	-0.2004	
Betula utilis	5.26	8.23	0.052632	-2.94	-0.1550	
Tsuga dumosa	14.47	21.40	0.144737	-1.93	-0.2798	
Cupressus torulosa	2.63	6.58	0.026316	-3.64	-0.0957	
Acer campbellii	10.53	9.88	0.105263	-2.25	-0.2370	1.94
Acer caudatum	3.29	3.29	0.032895	-3.41	-0.1123	
Magnolia globosa	2.63	3.29	0.026316	-3.64	-0.0957	
Larix griffithiana	1.97	3.29	0.019737	-3.93	-0.0775	
Daphniphyllum himalayense	23.08	13.66	0.230769	-1.47	-0.3384	
Lyonia ovalifolia	6.99	6.07	0.06993	-2.66	-0.1860	
Rhododendron hodgsonii	7.69	7.59	0.076923	-2.56	-0.1973	
Sorbus ursina	3.50	4.55	0.034965	-3.35	-0.1173	
Salix sp.	3.50	3.04	0.034965	-3.35	-0.1173	

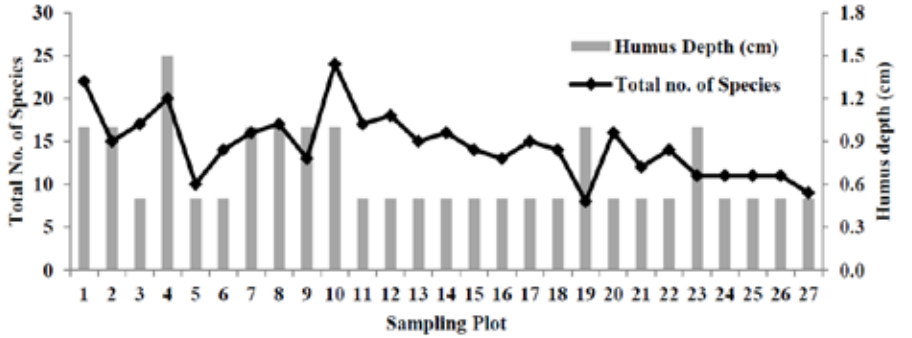

Figure 2. Correlation between humus depth and total number of species.

On the basis of diameter class, the C diameter class had the highest density (207.4 ind/ha) followed by J diameter class (88.9 ind/ha) and E diameter class (66.7 ind/ha) (Fig. 4), whereas, A & B diameter class were completely absent in study sites. Other remaining was showed in Figure 4. In respect to percent cover of shrub species, the highest percent cover was recorded at 20 % for *Rosa sericea* followed by *Salix* sp. at 19 % and *Cotoneaster microphyllus* coming at 10 %. The lowest cover presence of 1 % was found in *Ilex sikkimensis*, *Lonicera* sp. and *Prinsepia utilis* (Fig. 5).

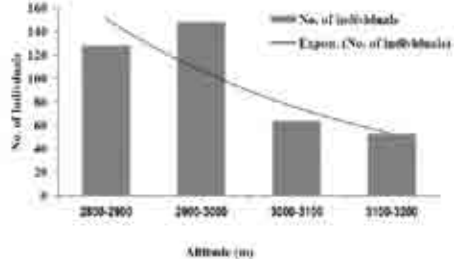

Figure 3. Relation between altitude and the number of species

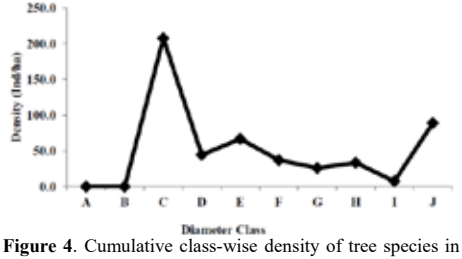

Figure 4. Cumulative class-wise density of tree species in sampling site.

For the herbs the highest percent cover was recorded for *Arisaema griffithii* at 10.74 %, followed by *Fragaria nubicola* (8.26 %), *Paris polyphylla* (6.15 %), *Euphorbia sikkimensis* (5.56%), *Rumex nepalensis* (4.44 %) and *Polygonatum multiflorum* (3.89 %), respectively (Fig. 6). The lowest percent cover were noted for *Mazus dentatus* and *Pedicularis rhinanthoides* (both at 0.19 %) followed by *Potentilla peduncularis*, *Hypericum elodeoides*, *Pilea umbrosa* and *Oxalis corniculata* (all at 0.37 %) and *Hemiphragma heterophyllum* (0.56 %) (Fig. 6).

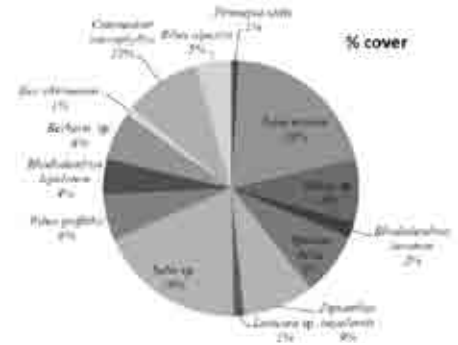

Figure 5. Percent cover of shrub & scrub species

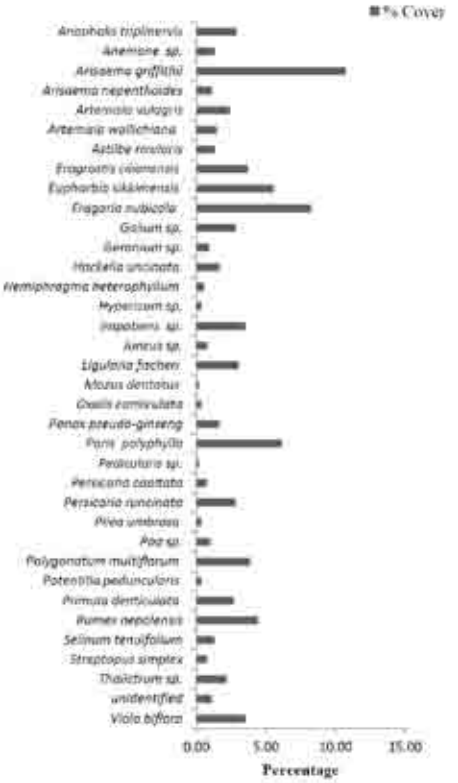

Figure 6. Herb percent cover

Discussion

The number of species present in a forest community has been variously expressed for different locations and normally falls between 85 species (Chowdhury *et al.* 2000) and 148 species (Makail *et al*. 1997). The present study reveals a floral assemblage of 75 numbers of plants species in an estimated 3 ha of study. On a localized level this figure can be considered a fair representation of biological diversity if we compare it with the total floral constituents of Sikkim (ca. 4500 species within 7096 km^2 land area). For a cool or upper temperate floristic composition this figure is appreciably close to what is found in other similar regions. The dominance of families Ericaceae and Rosaceae is typical of cool temperate communities that are found in Sikkim, and this is particularly evident in high shrub cover in the study site constituting *Cotoneaster microphyllus, Prinsepia utilis, Rosa sericea*, *Rubus* sp., *Spirea bella* (all Rosaceae plants) and *Rhododendron lanatum, Rhododendron arboreum* and *Rhododendron lepidotum* (Ericaceae). On the other hand the representation of Asteraceae is rather poor and is unexpected for such a location. This could be partly due to the site falling at the lower edge of subalpine zone. The floristic elements start changing markedly in reaching the next zone, the subalpine, and the most remarkable change is in the form of Himalayan Silver Fir (*Abies densa*) community. This key subalpine element though quite visible from the study site did never fall into any of the sampling plots.

The highest IVI value recorded for *Tsuga dumosa* makes it the dominant species in the site with the figure (105.11) far above the other contenders, viz., *Picea spinulosa* (75.76), *Rhododendron arboreum* (23.35), *Acer campbellii* (20.77), *Cupressus torulosa* (19.07) and *Prunus nepalensis* (17.52). The visible presence of *Tsuga dumosa* in the form of large trees everywhere in the site speaks more than what the IVI figure denotes. However, a point of note is that most of the conifers are naturally gregarious and often form large tracts of forest cover, as in western Sikkim, which incidentally is not the case found in the present study. Many small isolated patches of *T. dumosa* therefore are difficult to explain unless it was created as a plantation long years back. This fact is additionally reinforced from the A/F ratio taken to analyze species distribution. The abundance-to-frequency ratio revealed all the adult individuals of large tree species to be contagiously distributed except *Tsuga dumosa* which showed the random distribution.

The value of diversity index in the present study was found to be falling between 2.1474 – 2.2914. The diversity index is a highly fluctuating figure and is variously assigned to 2-3 for temperate forests (Risser & Rice 1971) or between 1.16 and 3.4 for temperate forests (Braun 1950, Monk 1967, Pande *et al*. 1996, Saxena and Singh 1982, Singhal *et al*. 1986). It is assigned to as high as 5.06 and 5.40 for young and old stand, respectively, by Knight (1975), and for the forests in India it is taken between 0.83 and 4.1 (Parthasarathy *et al*. 1992, Singh *et al*. 1984, Visalakshi 1995). Taking in the Index which is provided by Risser & Rice, (op. cit.), the diversity index scored in the present work falls within the estimated boundaries. Community studies are usually carried out taking in the adult mature trees along with the saplings and seedlings with the aim to find out the population structure. In this work the species

diversity of trees (adult, sapling and seedlings) in the site were found to be highest in concentration for the trees (H'= 2.2914) followed by seedlings (H'= 2.2124) and the saplings (H'=2.1474). The figures, however, stand out as top heavy as opposed to a natural stand which is normally found to be triangular in disposition with the greatest number of seedlings at the bottom. This is much easily observed in any undisturbed stands, for example, undisturbed and isolated natural forests in the Andaman Islands (Tripathi *et al*. 2004), and especially in sacred groves and sacred forests (Supriya Devi & Yadava 2006) where number of individuals always progressively increase from adult mature trees towards seedlings.

In regard to the species richness value for the site it was found to be in the range of 25.56-26.67 which is high in view of its temperate life zone. On a gradient of sampling plots the species richness was recorded highest in Plot 2 at 2931 m asl followed by Plot 10 at 3000 m asl. As is evident both of these plots are located within a very narrow zone of less than 100 m and as such shows a critical niche character. Nevertheless, more work is needed to understand such situations on how species accommodate themselves within a small area.

In Table 2 there are some odd cases of missing sapling and seedlings in the four tree species, viz., *Cupressus torulosa*, *Larix griffithiana*, *Magnolia globosa* and *Tsuga dumosa*. In the case of *Sorbus* sp. mature trees are absent whereas saplings and seedlings are reasonably represented in which case it may be construed that a natural progression is in force. However, in regard to the four species cited earlier the mature trees are present but saplings or seedlings or in one case both the saplings and seedlings absent. The seedlings of these four species neither come under grazing nor have these been found to be of any direct use to human. It may be that the trees might have a broad distributional range and the present survey only took up a small part of it. There might also be other reasons which may be connected to human infringement during the process of community development. However, the fact remains a little disturbing and ecological restoration may help the community to grow and survive as naturally as possible.

Conclusion

The floristic composition of the study site depicts temperate floral diversity in the Sikkim context despite habitat disturbances coming in at different levels or unless the forest communities are severely encroached or selectively modified. Total plant diversity of 75 number of plant species within a small area of 0.027 ha is a figure which can be termed as rich even when the sampling done was at best not near to 1 percent sampling intensity. There are several indications that were brought forward by the present study in regard to conservation which almost every time has to be tackled along for sustainability of nature and natural resources. On a general note the community studied did not show any marked sign of environmental stress worth concern.

The present study shows presence of comparatively few epiphytes even when moisture regime is high suggesting that the location experiences physiological draught during the winter months when water turns into snow rendering it unusable to the plants.

According to Odum (1971), clumped (contiguous) distribution is the commonest pattern in nature, random distribution is found only in very uniform environment and the regular distribution occurs where severe competition between the individual exists. Under the regular (<0.025), random (0.025 to 0.05) and contiguous (>0.05) distribution the values indicate that random distribution was evinced in *Tsuga dumosa* and the rest showed contiguous distribution. No case of regular distribution was recorded in the sampled population. It may be concluded that the community studied exhibited high diversity of plant forms, better ranking on IVI and other associated parameters and a little uneven stand structure in regard to the tree elements.

Aknowledgements

Authors are thankful to Japan International Cooperation Agency (JICA) Assisted Sikkim Biodiversity Conservation and Forest Management Project (SBFP), of Department of Forest, Environment and Wildlife Management, Govt. of Sikkim, for providing the necessary facilities and encouragement.

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A VERSATILE MEDICINAL PLANT SPECIES *PARIS POLYPHYLLA*- AT LACHUNG FOREST, SIKKIM-CONSERVATION INITIATIVES

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INTRODUCTION

Medicinal plants play a significant role in all around the world. Himalayas has diverse medicinal plant available and has been recorded in ancient Indian scripts 1000 BC. Indian Himalayan Region (IHR) there are over 1748 plant species, (1685-angiosperms, 12-gymnosperms and 51 pteriophytes, including 1020 herbs, 335 shrubs and 330 trees of medicinal value (Samant *et al.,* 1998). Medicinal plants mostly found in herbs category which are being used for the treatment of various diseases/ailments of both human being and animal too. The herbal medicines have global market value of about US$ 43 billion a year (Christie, 2001).

Sikkim Himalayan region is home to several versatile medicinal plant species such as *Podophyllum hexandrum, Aconitum ferox, Aconitum heterophyllum, Angelica glauca, Hedychium spicatum, Gloriosa superba, Paris polyphylla, Nardostachys jatamansi, Rheum australe, Rhododendron anthopogon, Picrorhiza kuriooa, Saussurea costus, Swertia chirayita, Taxus baccata etc.,* Among them *Paris polyphylla* Sm. which have versatile medicinal properties and have been listed under vulnerable category (V) by IUCN.

The present articles revealed the *Paris polyphylla* plant species was discovered, abundantly distributed in partial shade, humus rich soil and moisture places under the canopy of *Tsuga dumosa*, *Picea smithiana* with *Rhododendron arboreum* and under most common shrub *viz., Viburnum erubescens*, *Piptanthus nepalensis, Ribes* sp, and small tree *Rhododendron niveum* and herb which was inventorised viz., *Arisaema griffithii, Euphorbia sikkimensis, Polygonatum* sp. *Persicaria* sp. including many ferns species at Lachung temperate coniferous forest near Yakchey (North Sikkim) at elevation between 2900 - 3000 m asl. But scarcely distributed in FambongLho Wildlife Sanctuary (East Sikkim) at elevation 2500 m asl and Maenam Wildlife Sanctuary (South Sikkim) at 2500 m asl of Oak broadleaved forest mixed with *Schima wallichii* plant species during Rapid Biodiversity Survey undertaken under the JICA funded Sikkim Biodiversity Conservation and Forest Management Project.

Globally, *Paris polyphylla* is distributed in the Himalayas of E. Asia to China including Bhutan, India, Laos, Myanmar, Nepal, Sikkim, Sri Lanka, Thailand and Vietnam at elevation of 2000 - 3500 m asl. In India, this species is distributed in Himachal Pradesh, Jammu and Kashmir, Manipur, Sikkim and Uttar Pradesh ((Polunin & Stainton, 1984) Manipur, Uttarakhand, and Himachal Pradesh (Shah *et al.,* 2012).

The species in recent time, has been heavily exploited unscientific harvesting leading to rapid decline in its population and illegal export to neighbouring country. The seed germination is found to be very low in the wild. The young shoots and fruits are eaten by foraging livestock. Once grazed it takes considerable time to regenerate. *Paris polyphylla* has anti-tumor active constituents from the rhizome parts of *Paris polyphylla* var. yunanensis in China by Zhongguo. 2007. Yan *et al*. (2009) mentioned that *Paris polyphylla* is used to treat anticancer activity of steroid saponins isolated from the rhizomatic parts of the plant.

STUDY AREA

The present study area between 2800-3200 m asl, 88'44"57.3N Longitude and 27'42"45.0E Latitude lies within Lachung Forest of North Sikkim, covering approx. 7 km^2. The slope angle of the sampled sites range between mild up to 40 degree and facing E, N and NE aspect. The area is prone to natural calamities, e.g., avalanche and landslides.

Photo 1: A Part of Lachung Forest, North Sikkim

MATERIAL& METHODS

For data collection, field survey was carried out during rapid biodiversity survey in May 2014. A technique of random systematic design was applied. The random sampling sites were selected and each quadrat site of $1m^2$ were laid down under 27 plots for herbs. In each small quadrat total number of herbs including *Paris polyphylla* and its percent coverage were

inventorised. Additionally, GPS were calibrated in study area recording altitude, latitude and longitude.

MORPHOLOGY

Paris polyphylla Sm. (*Paris* = equal and *polyphylla* = many-leaved. The plant is grows about 10-100 cm tall. It is a perennial herbaceous plant which is much sought after for its beautiful spidery flowers. Leaves 4-9 numbers arise from whorl. The flower has a ring of 4-6 green leaf-like perianth segments, which are 5-10cm long and occurs single at the end of the branches. There is an inner ring of long-purple or yellow perianth segment which look like spider legs. Ten short stamens are arranged again in a ring. Flowers turn into globular fruit with scarlet seeds. Flowering occurs from April to May and fruiting occurs between September to October.

ECOLOGY

Paris polyphylla in natural habitat it blooms well at places which are moist with humus rich soil and high nutrient content under partial shade. It is grows in forest, bamboo forests, thickets, grassy or rocky slopes and bank of streams. This plant species is propagated through seed and underground rhizomes. The aerial part of the plant dries out but the underground rhizomes remain dormant during the winter. At the onset of spring the rhizome gives a new plant.

MEDICINAL VALUES

The rhizome part is used for various medicinal purposes viz., for treatment of anti – tumor, cancer, liver, stomach, nose, lung, throat and breast cancer in traditional Chinese medicine. Paste is applied as an antidote to snake bites and poisonous insects bite. A piece of underground parts is chewed to treat internal wounds. The rhizome part is in high demand in international markets and fetches Rs. 40,000 - 50,000 per kilo/gram leading unscrupulous harvesting and illicit trading. In Nepal, the plants are harvested on Tuesday of mid April (i.e., last Tuesday of Chaitra month) when it is believed to be more effective as medicine than those harvested at any other season (Madhu *et al.,* 2010).

Photo 2: Underground part of *Paris polyphylla*

Photo 3: Flowering and Fruiting of *Paris polyphylla*

Results & Discussion

Total 27 plots, the maximum plant species were recorded from herb category (Subba *et al.* 2015) including the *Paris polyphylla* high medicinal plant species. 7 plots were found *P. polyphylla* out of 27 plots and maximum number of population was recorded at 2900 - 3000 m asl. Between these altitudes it is most suitable for the growth in Sikkim Himalayan Region. The maximum herbs percent cover was recorded *viz.,* in association with *Arisaema griffithii* and *Fragaria nubicola.* It is also good indicator the growth of *P. polyphylla* with *Arisaema* species. Madhu *et al.* (2010) have mentioned that the *Paris polyphylla* found growing with shrub associated species *Vibrunum erubescens* and *Arisaema* sp and fern. A similar case was recorded in this study. This species is found growing in natural habitat

mostly in temperate coniferous forest, ecological conditions and physiological factors are most suitable for the growth of the plant.

CONSERVATION INITIATIVES

The conservation initiatives have to be started for the preservation of wild natural forest by encouraging local people and the dissemination of biodiversity information for promoting public awareness on the value of medicinal plants.

Medicinal plant as natural resources has tremendous scope and also generates revenue in the state. Medicinal plants are one of the major wild biological natural resource that offer entrepreneurial opportunities to young people in the Sikkim Himalayan Region by promoting herbal medicinal nursery garden though in-situ and ex-situ conservation.

Sikkim Biodiversity Conservation and Forest management Project aims to enhance the socio-economic value of biodiversity, which can be achieved through establishment of nursery and maintenance of biodiversity in the State.

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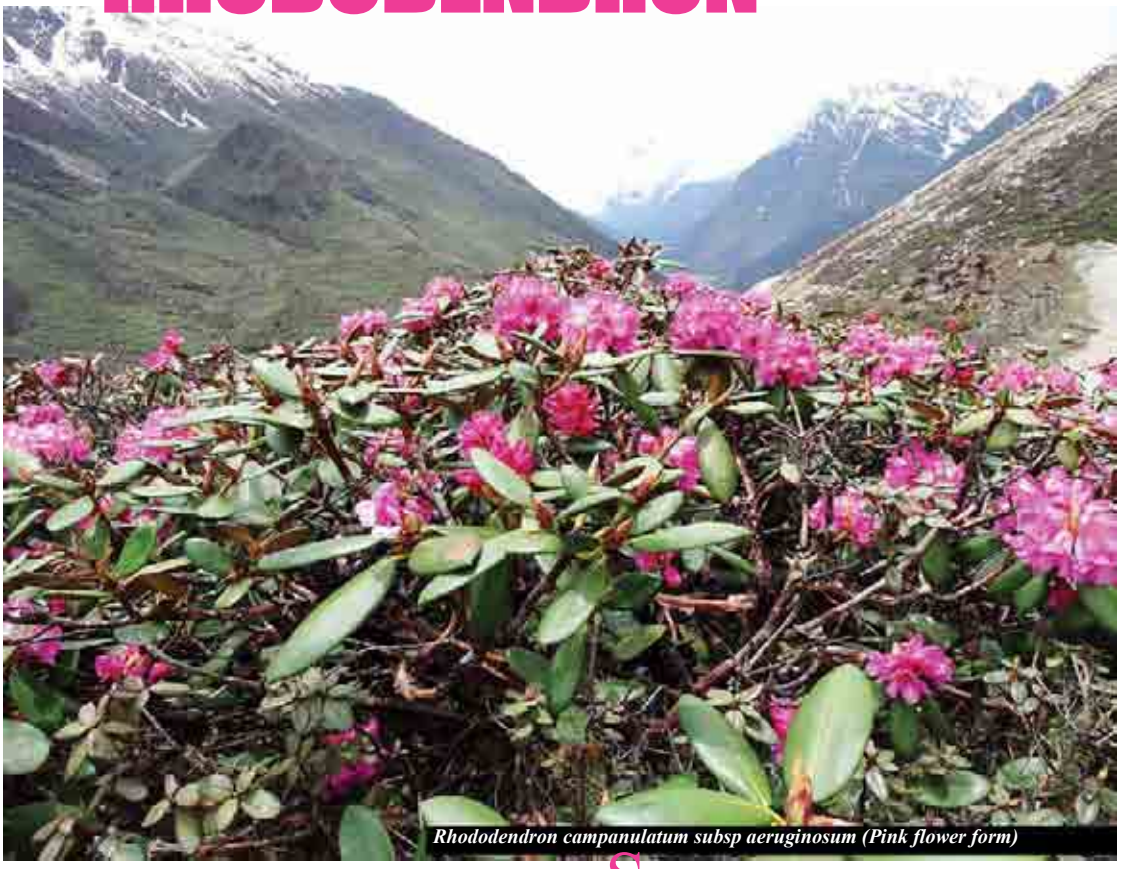
SIKKIM HIMALAYAN RHODODENDRON



Rhododendron campanulatum subsp aeruginosum (Pink flower form)

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Forest, Environment & Wildlife Management Department
Government of Sikkim

Sikkim, a tiny state of India located in its North Eastern part forming the part of meeting ground of Indo-Malayan and Indo-Chinese bio-geographical realms as well as Himalayan and Peninsular Indian elements, falls under Himalayan (2) Bio-geographic zone and Central Himalaya (2c) biotic province. Within an area of 7096 square kilometer in between 27°5' - 28° 10' N latitudes and 88°4'-88°55' E longitudes, it holds an altitudinal gradient from 225m

in south to 6100m in north and north-east and 8598m in north-west. Broadly, the vegetation of Sikkim is classified into the tropical zone (244-750m), subtropical zone (750-1500m), temperate zone (1500-3000m), sub alpine region (3000-4000m), alpine region (4000m and above) and is endowed with rich diversity of habitat in which large range of plants including several high value medicinal plants, other endemic plants and animals and many more rare and threatened taxa are found.

Rhododendron mecongense at Shingba Rhododendron Sanctuary, North Sikkim

Rhododendron is the largest genus in the family Ericaceae with greatest number of species and was first described by Carl Linnaeus in 1837 in Genera Plantarium. Worldwide it has broad range of distribution and occurs highly in the area extending along the southern Himalayas east into south-western China. This region includes parts of Nepal, Bhutan, North-eastern India, north-eastern Burma, South east Tibet, Western Szechuan and north western Yunnan. Many species also occur in the mountain ranges of Thailand, Vietnam and Malaya. In the Sikkim state of India, the species of *Rhododendrons,* which can be seen in the temperate region upto 3000m altitude are *R.arboreum*, *R.thomsonii, R.maddenii, R.dalhausiae, R.falconeri, and R.grande.*

In the sub-alpine region i.e., 3000m to 4000m, some of the shrubby species are found forming large populations called "Rhododendron thickets" which comprises of the species such as *R.ciliatum, R.fulgens, R.lepidotum, R.triflorum, R.campanulatum, R.cinnabarinum, R.campylocarpum, R.cinnabarinum, R.vaccinoides, R.baileyi, R.barbatum, R.sikkimense, R.niveum, R.hodgsonii, R.glaucophyllum, R.decipiens, R.pendulum and R.wightii* in association with other high altitude species such as *Primula sikkimensis, Larix griffithii, Pedicularis elwesii, Abies densa, Viburnum nervosum, Juniperus recurva* etc. In alpine region above 4000m, the vegetation are highly dominated by very small prostrate shrub-lets of *Rhododendron* species such as *R.nivale, R.anthopogon, R.lepidotum, R.fulgens, R.campanulatum subsp aeruginosum and R.setosum* in association with other species such as *Primula* sp., *Potentila sp*. S*axifraga* sp., *Aerigeron* sp., *Sedum* sp. etc.

The genus comprises of almost 1200 species worldwide. In India 92 species; a total of 109 taxa including, 8 sub species and 9 varieties of Rhododendrons have been reported, of which maximum species diversity reported from Arunachal Pradesh with 75 species (Sastry and Hajra 2010). Sikkim also has the rich diversity of Rhododendrons having 38 species; 41 taxa including sub species and varieties (**Annexure 1**) and excluding *R.dalhausiae* subsp *dalhausiae* (Darjeeling population) and including *R. argipeplum* and *R. keysii* (www.eFloras.org; Mao 2010; Sastry and Hajra 2010) and the recent report of *R.mecongense* (Pradhan BK, Dahal S, Nilson J and Lachungpa D. 2015).

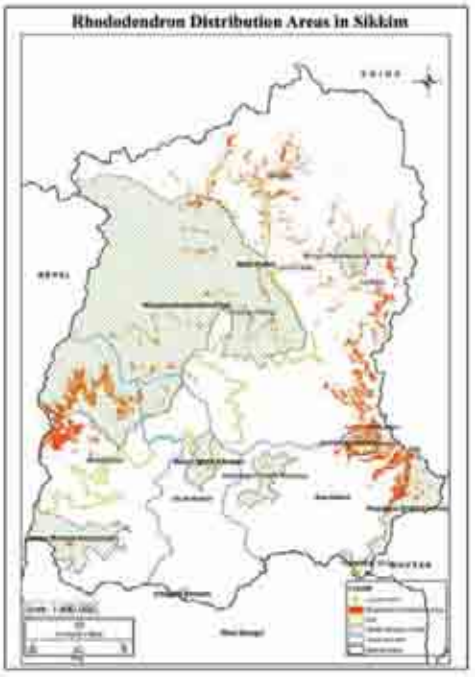

Fig Ia. Temperate forest dominated by R.falconeri at Pangolakha Wildlife Sanctuary, East Sikkim

Fig Ib Sub alpine forest at Shingba Rhododendron Sanctuary, North Sikkim

Rhododendron distribution areas in Sikkim

The species of Rhododendrons exhibit significant diversity in habit from dwarf tussocks to robust trees and occupies variety of habitats such as ridges and cliffs, marshy areas, forest floors, mountain tops, alpine meadows and on trees and rocks. In Sikkim, these are widely distributed along sub-tropical, temperate, sub-alpine and alpine region along 700-5500m elevation **(Map 1, Annexure 1)** however, the maximum number of Rhododendrons occurs in the altitudes of 3000-4500m i.e., sub-alpine to alpine zone **(Fig Ia, Ib, Ic, Id).** These altitudes are considered as the best suitable sites for Rhododendrons for conservation and multiplication. Amongst the Rhododendron species available in Sikkim, *R.maddenii* has the lowest elevation range along sub-tropical to temperate belt i.e., 700m-2000m and *R.nivale* occupying the highest elevation range, 4500-5500m. In the North district of Sikkim, Shingba Rhododendron Sanctuary up to Yumthang- Yume Samdong area, Thangu valley and Tholung Kissong are the highly potential area for various species of Rhododendrons, where *R.thomsonii, R.arboreum, R.lepidotum, R.hodgsonii, R.wightii, R.triflorum, R.ciliatum, R.anthopogon, R.setosum, R.cinnabarum, R.campylocarpum, R.baileyi* are commonly available. *R.maddenii* has their gregarious population along Chungthang - Tsho Pembo and Upper Dzongu (Badola and Pradhan 2010b, BKP *et al* 2014).

Fig Ic Rhododendron potential site at Tamzey, East Sikkim (4000m)

Fig Id Rhododendron scrub at Thangu valley, North Sikkim (4000m)

Rhododendron nivale at Yumesamdong (4500m), North Sikkim

Highest altitudinal ranged species namely *R.nivale* was observed in Yume-Samdong area, above Yumthang, the species has also been reported from Lhonak valley in a Herbarium at Botanical Survey of India (BSI), Sikkim circle.

(Left) *Rhododendron arboreum* subsp *arboreum* (corolla red); (Right) *Rhododendron arboreum* subsp. *cinnamomeum* var *Roseum* (corolla pink)

The red and pink flower forms of *Rhododendron arboreum* are commonly available in all the four districts of Sikkim.

Rhododendron sikkimense, which is considered to be a natural hybrid between *R.thomsonii* and *R.arboreum*, which along with both the parent species were found at Shingba Rhododendron Sanctuary. *Rhododendron niveum,* a state tree of Sikkim has been reported and witnessed from Yakchey – Shingba Rhododendron Sanctuary, Temrong and Thijom (Upper Dzongu) in between 3000-3600m and recently another population has been observed in Kyongnosla Alpine Sanctuary at ca. 3800m, which is the new elevation record for this species.

(Left) *Rhododendron campanulatum* subsp *aeruginosum* , purple flower form; (Right) *Rhododendron campanulatum* subsp. *campanulatum*

Rhododendron sikkimense at Shingba Rhododendron Sanctuary, North Sikkim

Two sub species of *Rhododendron campanulatum* was encountered viz. *Rhododendron campanulatum* subsp *aeruginosum***,** a pink to purple flowered form, which found widely distributed in the Yumthang- Yume Samdong and Lachen valley while *Rhododendron campanulatum* subsp. *campanulatum* with a white flower form was rarely occur with very few individuals in Shingba Rhododendron Sanctuary. In the east, Kyongnosla Alpine Sanctuary above 3000m up to Tamzey, Gnathang, Kupup, along the way to Tsomgo upto Baba Mandir has been observed highly potential area for Rhododendrons where the species such as *R.thomsonii, R.fulgens, R.campanulatum, R.arboreum* are richly occurred; followed by Pangolakha Wildlife Sanctuary, where the low altitude preferring species such as *R.falconeri, R.grandii, R.hodgsonii, R.cameliflorum* were highly available.

Few species, namely *R.dalhausiae* var *tashii*, *R.arboreum* was observed in Fambong-Lho Wildlife Sanctuary and Bulbulay Reserved Forest in east, and in

Rhododendron baileyi at Yakshay, North Sikkim

Rhododendron setosum at Yumesamdong, North Sikkim

Rhododendron thomsonii at Shingba Rhododendron Sanctuary, North Sikkim

Rhododendron wightii at Shingba Rhododendron Sanctuary, North Sikkim

and around Mangan, Chungthang to Lachung in north Sikkim. In the west, Barsey Rhododendron Sanctuary, Bakhim-Tshoka-Dzongri, Thangsing – Samiti Lake and in the south, Maenam Wildlife Sanctuary, Tendong Reserve Forest, Ravangla, Damthang, Ralong, where species such as *R.lanatum*, *R.arboreum*, *R.dalhausiae* subsp *tashii*, *R.falconeri, R.hodgsonii*, *R.griffithianum*, *R.barbatum* and other several species of Rhododendrons are widely distributed.

SIGNIFICANCE

In the Himalayan region, Rhododendrons are the only group of plants that has continuum in maintaining eco tone and biological sustenance and can be considered as an ecosystem engineer, as these have direct impact on soil and moisture regime, affects the environment by soil formation, soil binding, prevent soil erosion and allows regeneration of vegetation (Leach, 1961) and also affects climate by affecting the hydrological balance. In the Himalayan ecosystem Rhododendrons are one of the pioneer groups of plants; the dominating habitat of which plays a unique and crucial role for specific faunal communities by providing them a unique habitat. Rhododendrons provide food source for wide range of animals; with the immense flowers, it sustains a community of insects, birds, butterflies, which are the frequent pollinators. Hence, Rhododendrons can be considered as the keystone element in context of upper temperate and the alpine region of Sikkim Himalayas; same has been mentioned in Singh et al. 2009.

Rhododendrons are incredible taxa forming an important component of the temperate and the alpine ecosystem that can be seen from early succession stage to the late succession stage with tremendous diversity and high variation. It forms the potential component for the nature based tourism. Tourists are becoming more sensitive to environmentally degraded conditions, and the sustainable tourism is the demand of present day world.

Nature based tourism is one of the rapidly growing sector of income which is directly dependent on the natural resources including scenery, topography, vegetation and wildlife etc. and has proved to be a powerful incentive for conservation of nature and culture in many parts of the world. The economy and

the livelihood of people of Sikkim is highly dependent on tourism, and the state government is now actively promoting tourism to areas that are the best examples i.e. protected areas where there is richness of biological and cultural elements and is highly focusing on nature based tourism or eco-friendly tourism through Forest Environment and Wildlife Management Department, and has formed an ecotourism policy for Sikkim to make Sikkim as an ultimate and unique ecotourism destination and to promote conservation of nature and the resources. Several eco-treks have been declared by the Government of Sikkim in all four districts of Sikkim, for example, Tholung – Kishong trek, Yumthang-Yume Samdong trek, Lachen-Yabuk-Green Lake trek (North); Golitar-Chuli-Luing trek, Saang-Tinjurey trek, Rate Chu trek (East); Yambong trek, Khecheopalri trek, Uttarey-Singelila trek, Okherey/ Barsey to Uttarey trek, Hee Bermiok (Panda Gate-Uttarey trek (West); Kitam trek, Melli trek, Lingee-Sokpay Bhaley Dunga trek (South) which familiarize with the

Rhododendron niveum is the state tree of Sikkim and *Rhododendron arboreum* is the national flower of Nepal. Rhododendrons are used by the local people in the Himalayas in several ways. *Rhododendron arboreum's* nectar is brewed to make wine and is effective in diarrhoea and dysentery. Its corolla is administered in case if fishbone is stuck in the gullet. Snuff made from the bark of the tree is excellent cold reliever. Young leaves can be processed into paste and applied on the forehead to reduce headaches. It has been reported that the plant is of anti-inflammatory and hepato-protective functions against related diseases, which is probably due to its anti-oxidant efficacy due to presence of flavonoids, saponins and phenolic compounds. In Sikkim and Arunachal Pradesh the aromatic twigs and leaves of *R.anthopogon, R.setosum, R.lepidotum* are used as incense. In Nepal, *Rhdodendron campanulatum* is used as snuff and is effective in case of cold and hermicrania. Also the species is used in curing chronic rheumatism, syphilis. The dried twigs and wood are used by Nepalese against phthisis and chronic fever. *Rhododendron setosum* is used in making aromatic oil, perfumery and cosmetics, *R.cinnabarinum* is used in making flavouring agents, jam etc. and in Sikkim, and dried corolla of the species is liked by local inhabitants which taste delicacy. In north Sikkim, the extract from *R.thomsonii* is used as natural insecticides, while it is reported toxic to human beings (rajeshkoirala. wordpress.com).

Rhododendron niveum, a state tree of Sikkim
at Shingba Rhododendron Sanctuary, North Sikkim

DISTURBANCE AND THREAT ANALYSIS

According to Botanic Gardens Conservation International (BGCI) 2011, a quarter of the world's Rhododendrons are threatened with extinction in the wild. The Rhododendrons Red List, published jointly by Botanic Gardens Conservation International (BGCI), Fauna & Flora International (FFI) and Royal Botanic Garden Edinburgh, in June 2011 identifies 317 Rhododendrons as being in danger of extinction (Endangered or Critically Endangered), and hence urgent attention is required; habitat protection and restoration should be reviewed and mechanism put in place for local people to be involved in.

Sikkim is practicing several bio-diversity conservation efforts. It has an enormous traditional knowledge on bio-resources and their conservation practices**.** The state harbor 30.77% of its geographical area under Protected Area Network (one national park and seven wildlife sanctuaries) which includes two Rhododendron sanctuaries viz. Barsey Rhododendron Sanctuary in west district and Shingba Rhododendron Sanctuary in the north district for the in situ conservation of Sikkim's Rhododendrons. Rhododendrons are the important component of biodiversity which, if disturbed, can degrade the habitats that threatened other associated biodiversity in maintaining eco-tone and biological sustenance in the particular zone. It has a characteristic slow growth rate, due to which their survival in the wild is threatened. One major reason for the global decline of rhododendron population is habitat loss and fragmentation. Other existing threats are due to natural as well as an anthropogenic pressure. Increase in human population with demand on land for farming, construction of roadways, army personnel garrisoned, the tourist influx at alpine locations, avalanche, landslides, flash flood etc. are highly observed during present study. The deforestation and unsustainable extraction for firewood and incense by the local inhabitants are the general disturbances resulted in the building up considerable pressure on the survival of Rhododendron species in the nature. Other major threats for the sub alpine and alpine Rhododendrons globally are the effect of drastic changes in climate. The sudden changes in the environmental parameters including strange weather such as unusual rainfall, hailstorm etc. effects the vegetation greatly. In our observation, the blooming patterns of Rhododendrons of sub alpine and alpine areas have been changed and has observe the late initiation of flowering in case of some of the species like *R.niveum*, *R.campanulatum, R.nivale* etc.

CONCLUSION AND RECOMMENDATIONS

Through the entire survey in all the four districts of Sikkim it has been found that Rhododendrons have fragmented distribution throughout the state, highly concentrated in the temperate and lower alpine belt, which are highly prone to natural disturbance than anthropogenic pressure. Some of the species such as *Rhododendron sikkimense, R.niveum, R.mecongense, R.cammeliflorum, R. decipiens* and *R. edgeworthii* have observed very few or hardly in one or two sites and are seen growing in highly disturbed habitat. The occurrence of *R.keysii, R.argipeplum, R.leptocarpum* in Sikkim has been mentioned in Flora of China (www.eflora.org) and Sastry & Hajra, 2010 but are not witnessed during our survey. Hence, more research and immediate conservation measures are suggested with the following recommendations.

1. More field exploration in unexplored areas to check the availability of species and their population in Sikkim.
2. Repeated observations and monitoring in the Rhododendron potential sites**.**
3. Research on the entire phonological progression including effects of climate change, nutrient dynamics, reproductive mechanism etc.
4. As high altitude areas are the places of major tourist destinations and their effects on Rhododendrons and other vegetation is high, which should be checked somehow.

5. The growth rate of Rhododendrons is very slow; hence grazing should be checked as grazing may suppress the seeds germination and growth of seedlings and saplings.
6. More nursery management and restoration of the species of rare, vulnerable and endangered Rhododendrons in the natural areas by checking their habitat suitability.
7. In case of high altitude species of Rhododendrons, the success rate of nursery is very low, for them, the nursery management can be practiced in their natural habitation zone.

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Pleione of Sikkim Himalayas
Conservation Concern

Sanjyoti Subba*

INTRODUCTION

Orchidaceae is the largest family of flowering plants is distributed globally in China, Eastern Himalayas, Nepal, Bhutan, India, Laos, Myanmar, Vietnam, E. Tibet and Thailand. In the Indian sub-continent, Orchidaceae the species which is estimated to be around 1220 of which the maximum 620 species are recorded from Arunachal Pradesh followed by Sikkim Himalayan Region having 523 species (Sudhizong Lucksom 2011). Sikkim is beautiful state of the Indian Union; an area of 7096 sq.km and vast variation in height over very short distances ranging from about tropical to alpine meadows.

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The epiphytic orchids were by and large represented by large genera such as *Bulbophyllum, Coelogynae, Dendrobium, Eria* and *Oberonia* mentioned by (Mehra & Vij, 1974; Hajra, 1996). The genus *Pleione* species was established by David Don in the year 1825, under the genus *Coelogyne*. It is primarily epiphytic in habit, although it grows often found as lithophytes.

Four species of *Pleiones* are found in Sikkim Himalayas, viz., *Pleione maculata* (Lindl.) & Paxton, Rollisson, *Pleione praecox*, (Sm.) D. Don, *Pleione hookeriana* (Lindl.) and *Pleione humilis* (Sm.) D. Don.

Worldwide *Pleione maculata* (Lindl.) is distributed in China, Assam India, Eastern Himalaya, Nepal, Laos, Myanmar, Thailand and Vietnam spread over 130-400 m above sea level and is found in tropical forest mentioned by Naresh Swami.

(indiabiodiversity.org/biodiv/content/documents/document.../880.pdf)

Pleione humilis distributed in the Himalayas of Nepal, Sikkim, and Burma & eastern Tibet (www.eflora.org) grows on mosses or the smooth trunks of rhododendron trees along 1800-2600 m asl.

Pleione praecox (Sm.) D. Don is distributed in China, India, Eastern Himalayas, Nepal, Laos, Myanmar, Vietnam and Thailand between 1400-2200m above sea level on mossy tree trunks and branches, often on rocky slopes.

Globally, *Pleione hookeriana* is distributed in Bhutan, NE India, Myanmar and Nepal growing in mossy rocks and cliffs mostly at the margin of woodlands up to 3500 m asl. During Rapid Biodiversity Survey in May 2014, SBFP Survey Team discovered that *Pleione hookeriana* is abundantly found in temperate coniferous forest in Lachung at Yakchey Area (88₀45'05 "E, 27₀43'19" N) is distributed between 2900-3000 m asl. It was found growing in coniferous tree (*Tsuga dumosa*) on the tree trunks and also over mossy rocks and cliffs situated at the margin of thickets.

Interestingly, *Pleione hookeriana,* (Lindl) B.S. Williams., holds for the highest growing epiphytic species of Sikkim Himalayan Region also found in Zema III, Lachen, Ravangla and Maenam Wildlife Sanctuary, mentioned by Naresh Swami.

Photo: Habitat on the tree trunk and on the rocky slopes

MORPHOLOGY

Pleione hookeriana (Lindley) is epiphytic / lithophytes to 10 cm growing in height. The pseudobulb is greenish purple, ovate to conical base is sometimes linked to a slender rhizome and 1-leaved. The leaves are elliptical-lanceolate or suboblong shape and are in papery structure. These develop after the flowering is over. Inflorescence is erect, peduncle with several membranous sheaths below middle; floral bract suboblong, apex obtuse. Flower is solitary, small, sepals and petals are pale purplish-red to nearly white, lip is white with a yellow center and purple or yellowish brown spot. The dorsal sepal is nearly suboblong or oblanceolate. Flowering periods occurs between May-July

CONSERVATION INITIATIVES

Biodiversity conservation is an important issue in the world. Conservation initiatives of the orchid started for the preservation of the natural forest in wild. The conservation of epiphytic plants plays an important role for the forest ecology and preserving the diversity of epiphytes makes evergreen forest and healthy ecosystem. If the management and conservation initiatives are not taken in time, it ought to be extinction of the natural habitat. Hence, the species should be conserved in time for future generations.

The state has been remarkable step in protecting the network's Sanctuary and National Park which has the rich biodiversity hotspot. In Sikkim the areas already declared as conservation zone for orchids, the Orchid Conservation Centre (for slipper orchids) Tinkitam, South Sikkim. This article suggested that the *Pleione hookeriana* is abundantly distributed in Lachung; Yakchey area should be preserved and conserved which hold the highest growing epiphytic species in Sikkim Himalayas Region. The Lachung forest is near to Shingba Rhododendron Sanctuary which has several rare species of flora including *Rhododendron niveum, Primula* sp. many wild orchids like *Pleione hookeriana* and other rhododendrons species too, many wild animals, many varieties of birds and butterflies and the area is rich biodiversity hotspot.

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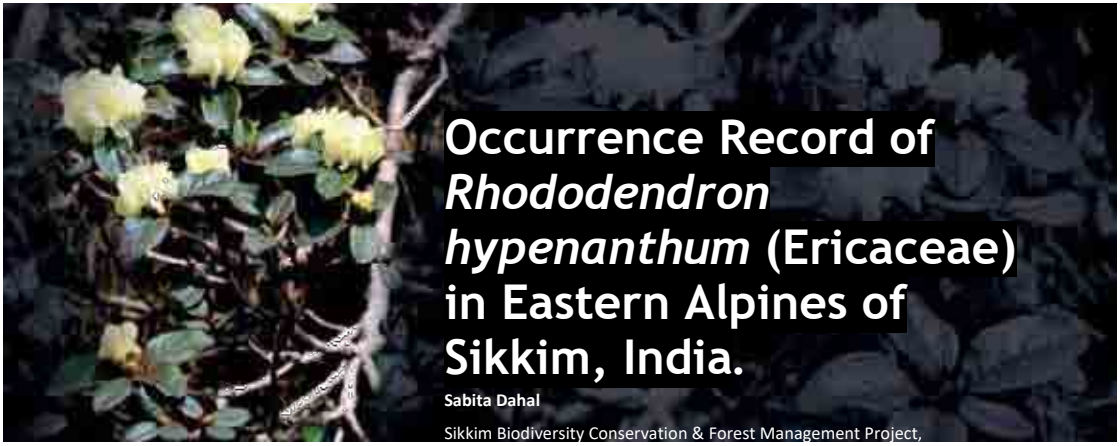

Occurrence Record of *Rhododendron hypenanthum* (Ericaceae) in Eastern Alpines of Sikkim, India.

Sabita Dahal

Sikkim Biodiversity Conservation & Forest Management Project,

Rhododendron hypenanthum photographed in Tamze valley ca. 4000m

Rhododendron is the largest genus in the family Ericaceae with greatest number of species. In Sikkim, the species of Rhododendrons are distributed from temperate region (1800m) up to the Trans- Himalaya (5500m). The genus comprises of almost 1200 species worldwide. In India 92 species; a total of 109 taxa including, 8 sub species and 9 varieties of Rhododendrons have been reported, of which maximum species diversity reported from Arunachal Pradesh with 75 species (Sastry and Hajra 2010). Sikkim also has its rich diversity with 38 species; 41 taxa including sub species and varieties (Dahal, S. 2016) including recent report of *Rhododendron mecongense* (Pradhan BK, Dahal S, Nilson J and Lachungpa D. 2015). Present article is an occurrence report of *Rhododendron hypenanthum* from Kyongnosla Alpine Sanctuary, Tamze valley and surrounding areas of the Eastern Himalaya of Sikkim, resulting in addition of one species to the existing list of 38 species of Sikkim Himalayan Rhododendrons.

Rhododendron hypenanthum is commonly known as Yellow Dwarf Rhododendron. The taxon was treated as a subspecies or variety of *Rhododendron anthopogon* (Synonym: *Rhododendron anthopogon* D.Don subsp *hypenanthum* or *Rhododendron anthopogon* var. *hypenanthum* (I.B.Balfour) H.Hara. It is closely related to pinkish or white flowered *Rhododendron anthopogon* D.Don (Dwarf Rhododendron). It is an evergreen, aromatic shrub, up to 40 cm tall. The branches are rough and scaly; branch-lets are generally short. Leaves are elliptic-oblong, 1-3 cm long, dorsal surface rough, wrinkled, ventral densely covered with dark reddish brown scales. Leaf petioles are 3-7 mm long. Leaf blades are elliptic or oblong-elliptic or obovate elliptic, base rounded or broadly cuneate, apex obtuse or rounded. Flowers are borne in terminal clusters of 5-10. Bracts are ovate, margin ciliate. Flowers are yellow, tube cylindrical, lobes orbicular, spreading outside. Capsule is ovoid, 4-6 mm long.

The species is commonly occurring in the Rhododendron thickets, scrub, and open alpine slopes from 3500-4500m in Bhutan, Northern India, Nepal and Sikkim. In Sikkim, the species are flourishing well in Kyongnosla Alpine Sanctuary, Tamze valley and surrounding areas in the eastern part from sub-alpine to alpine areas with good number of populations. As a medicinal plant, its stems, leaves and flowers are used in Tibetan Herbalism. They are antitussive, febrifuge, tonic, diaphoretic and digestive and are used in treatment of inflammations, lung disorder, and general weakening of the body, also treat lack of appetite, cough and various skin diseases (Source: Karna, N. & Carthy, G.Mc. 2008.).

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For Further Readings:

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Analysis of vegetation of temperate forest at Sang-Tinjure area of FambongLho Wildlife Sanctuary in Sikkim, India

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Abstract

A total of 88 plants species were recorded of which 33 tree species, 30 herbs and 12 shrubs-scrub, 10 climbers and 1 epiphyte were recorded in a total of 16 sampling plots. Raunkiaer's life form assessments revealed the Phanerophytes (44.7) representing the highest, which is canopy forming plant species followed by Hemicryptophytes (16.0) representing the ground vegetation of herbs species. The tree species of which the highest adult individual were recorded from *Castanopsis tribuloides* (Sm.) A.DC. (387.50 Ind/ha) followed by *Leucosceptrum canum* Sm. (212.50 Ind/ha). IVI of adult (tree) was recorded highest for *Castanopsis tribuloides* (Sm.) A.DC. (62.7) followed by *Quercus lamellosa* Sm. (22.6), *Symplocos lucida* (Thunb.) Siebold & Zucc. (20.9) and *Symplocos glomerata* King ex C.B.Clarke (13.2), respectively. The abundance to frequency ratio revealed all the adult individuals of tree to be contagious distributed except *Acer caudatum* Wall.,and *Cinnamomum impressinervium* Meisn. which showed the random distribution but none of the species showed regular distribution. The species diversity (H) and richness of trees (adult, sapling and seedlings) in the site were found as highest in concentration for the tree (H = 3.17) followed by seedling (H=2.68) and sapling (H = 2.60) in the area of 0.064 ha. Several girth classes were measured.

***Key words*:** Plant life form, Species diversity, Species richness, temperate forest, vegetation analysis

INTRODUCTION

The vegetation throughout the world is normally formed by one or more plant communities, exhibiting a homogenous stand or more often a heterogeneous assemblage. In nature, it is found that each plant community is a unique system having its own characteristics in terms of structural, functional and spatial features. Normally any type of vegetation should constitute some specific plant species composition and physiognomy, which largely defines the habitat type which again select the plants of definite life-forms by (Smith 1913). Raunkiaer's systems of life-form classification there are five major classes viz., Phanerophytes, Chamaephytes, Hemicryptophytes, Cryptophytes and Therophytes by Raunkiaer's 1934). Plants can be grouped in life-form classes based on their similarities in structure and function of forest (Mueller-Dombois & Ellenberg 1974) and also study of vegetation description (Cain 1950).

Understanding the life-forms is a primary objective and basic requirement for most of the plant ecological works to understand the community dynamics, its functional aspects, succession, vegetation continuum and many more. Usually vegetation is relatively easy to

measure and monitor both in space and time, and also at various magnitudes. Different vegetation tracts are the actual pool of biodiversity which differs from place to place and each one showcasing its unique identity. In fact, biodiversity itself in its true form is the face of the vegetation. As vegetation also represents an ecosystem, or a part of the ecosystem, it helps to know about it, before trying to understand any specific ecosystem. Monitoring ecosystem health and changes in biodiversity can be achieved to a significant degree by monitoring changes in vegetation. In recent years the baseline value of vegetation is becoming so important that standardized classification of ecological communities using vegetation has been recognized as an essential tool for identification, monitoring, and conservation of ecosystems (Grossman *et al*.1988; NatureServe 2003). This very important thought is entrenched in the present work and many similar works currently in progress by Subba *et al*. (2015, Subba *et al*. 2016) in the region with underlying idea of long-term monitoring of vegetation changes in Sikkim forests.

Sikkim Himalaya which constitutes a part of the Eastern Himalayan ensemble (others being Arunachal Himalaya, Bhutan Himalaya and Darjeeling Himalaya) follows altogether similar characteristics in biotic richness with the other three regions for which it is recognized under world biodiversity hotspots. The Eastern Himalaya is also referred as the Cradle for Flowering Plants (Takhtajan 1969) and the region houses largest number of endemic and schedule I species than anywhere else in the country (MacKinnon & MacKinnon 1986). The Sikkim state is endowed with rich floral and faunal species diversity in (http://www.sikkimforest.gov.in). In this sense the plant diversity of Sikkim is considered as a rich biodiversity because of the species richness and diverse plant community. Present study, therefore, is a small step towards understanding a plant community on ecological footing of a protected area in Sikkim.

The objective of the present paper is to describe the vegetation structure, plant species composition and diversity from 16 plots in the Sang-Tinjure area in FambongLho Wildlife Sanctuary in Sikkim.

STUDY AREA

The survey was conducted in the Sang-Tinjure area of FambongLho Wildlife Sanctuary (FWS) in East Sikkim. FWS is covering an area of 51.76 sq km and the altitude ranges between 1200 and 2624 m asl. The highest point of this sanctuary, Tinjure, can be reached from more than one point. This sanctuary is described as very rich in biodiversity by (Pradhan & Lachungpa 2015), which is natural, virgin and to a large part still remains undisturbed. However, at certain patches the forest department has made plantations of fast growing *Cryptomeria japonica* for timber purpose. The elevation of the study site ranges between 1600 m and 2300 m asl lying between 27°16'20.7 – 27°17'50.62 N latitudes and 88° 30'04.4' – 88°31'31.4 E longitudes on the northeastern part of the sanctuary. Over 50 mammalian species and 280 bird species have been reported from the sanctuary and its surrounding areas (Pradhan & Lachungpa 2015).

METHODOLOGY

In April 2013, random samplings of the study site were done through the laying of 16 nested quadrate plots. The largest quadrate of 20 X 20 m was laid at every 50 – 90 meter distances depending upon the site feasibility, covering total area of 0.064 ha. Within these the-tree sampling quadrat of 20 X 20 m and four 5 X 5 m quadrates were laid for shrub, tree-saplings and scrub and at the centre, and five 1 X 1 m for herb and seedlings were laid out (Das & Lahiri 1997). Plant samples were identified using standard floras (Hooker 1888-97; Hooker

1849; Pradhan & Lachungpa 1990; Kholia 2010). The shrubs/scrub was calculated by percent cover of species. The unidentified plants were photographed and later identified by consulting plant taxonomists and web references (www.efloras.org; www.flowersofindia.net & www.floraofchina) were made and also consulting with the local communities of the nearby villages. For the updated nomenclature of plants http://www.theplantlist.org was consulted. All the sampling plots were geotagged for references for long-term monitoring and altitude of each plot was recorded (Table 1).

Quantitative Analysis

The quantitative analysis such as frequency, density, and abundance of the recorded species were determined as per (Curtis & McIntosh 1950).

1. $\text{Frequency (\%) (F)} = \frac{\text{Total no. of quadrates in which the species occurred}}{\text{Total no. of quadrates studied}} \times 100$

2. $\text{Relative Frequency (RF)} = \frac{\text{Frequency of a species}}{\text{Frequency of all species}} \times 100$

3. $\text{Density (D)} = \frac{\text{Total no. of individual in all the quadrates}}{\text{Total no. of quadrates studied}} \times 100$

4. $\text{Relative Density (RD)} = \frac{\text{Number of individual of a species}}{\text{Total number of individuals of all species}} \times 100$

5. $\text{Abundance (A)} = \frac{\text{Total number of individuals of a species}}{\text{Total number of quadrates in which the species occurred}} \times 100$

6. $\text{Relative Dominance (RDo)} = \frac{\text{Total basal cover of individual species}}{\text{Total basal cover of all species}} \times 100$

7. Basal cover = $Pi * r^2$

8. Importance Value Index (IVI) = RD + RF + RDo

9. Species Diversity Index:

The Shannon-Weiner diversity index (Shannon & Weiner 1963) is calculated using the species diversity in a community

$$H' = -\sum_{i=1}^{S} (ni/N) \log_2 ni/N)$$

Where, 'ni' represents total number of individuals of particular species, and 'N' represents the total number of individuals of all species.

10. Species Richness

It is simply the number of species per unit area. (Margalef's index of species richness 1958) was calculated by using formula.

$$D = \underline{(S-1)/\ln(N)}$$

Where, 'S' = the number of species in the sample and 'N'= the total number of individual in the sample.

RESULTS

Vegetation Life-form Spectrum

From the study site, a total of 88 plant species were recorded from the selected 16 sampling plots. Out of these 33 are trees, 30 herbs, 12 shrubs, 10 climbers and 1epiphytes. Raunkiaer's life-form assessments revealed in the 5 spectra were represented by Phanerophytes, Chamaephytes, Hemicrytophytes, Geophytes and Epiphytes. The missing life-forms in the site were Aerophytes, Helophytes, Hydrophytes and Therophytes. Highest percent among the life-forms was of the Phanerophytes (44.7%) representing the canopy forming plant species followed by Hemicryptophytes (16.0 %) representing the ground vegetation of herbaceous species. Between the ground flora and canopy-forming species other life-forms like Chamaeophytes (13.8 %), Epiphytes (11.7 %) and Geophytes (2.1 %) were recorded (Figure 1).

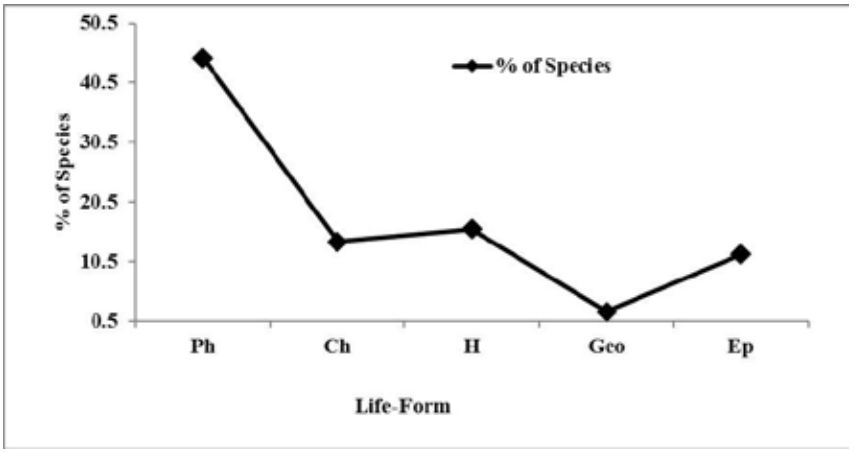

Fig. 1: Plant Life-form spectrum of temperate forest at Sang-Tinjure in East Sikkim.

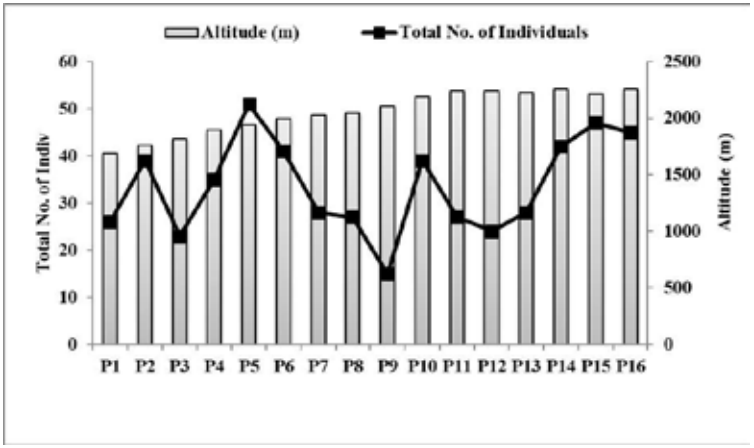

Fig. 2: Correlation between the altitude and total number of individuals

The correlation between the altitude and total number of individuals showed the maximum of 51 of plant species being recorded in plot no. 5 at 1939 m altitude followed by plot no. 15 with 47 plant species at 2213 m and plot no. 16 with 45 plant species at 2258 m altitude (Figure 2).

Site characteristics including the geographic location of sampling plots, species richness, humus depth, slope angle, etc. in the study area has been presented in Table 1.

Table 1: Site Characteristics & Species richness of the sampling plots in the Sang-Tinjure in FambongLho Wildlife Sanctuary, East Sikkim (between latitude 27°16'20.7"- 17'50.62"& longitude 88°30'04.4" - 31'31.4")

Site code	Altitude (m)	Slope angle (°)	Slope Aspect	Humus depth (cm)	Species Richness	Disturbance
P1	1686	30	E	1	15.65	Fodder, fuel wood collection
P2	1762	20	E	1	15.71	Fuel wood collection
P3	1816	15	E	1	15.66	Cut stumps
P4	1895	35	E	1	15.70	Cut stumps
P5	1939	20	E	2	15.74	Fuel wood collection
P6	1995	35	E	1	15.71	Fodder collection
P7	2028	40	SE	1	15.69	Fodder collection
P8	2051	25	SE	0.5	15.67	Fuel wood collection
P9	2105	15	N	1	15.60	Grazing
P10	2194	15	W	1	15.71	Cut stumps
P11	2245	20	W	1	15.65	Cut stumps
P12	2242	20	E	0.5	15.65	Cut stumps
P13	2228	35	NW	0.5	15.67	Cut stumps
P14	2253	30	NW	1	15.71	Cut stumps
P15	2213	35	SW	2	15.72	Fodder, fuel wood collection
P16	2258	40	N	1	15.71	Nil

Tree Density and Frequency

The tree species were recorded cumulatively viz., adult, sapling and seedling from 16 plots, the highest adult individuals were recorded is *Castanopsis tribuloides* (387.50 Ind/ha) followed by *Leucosceptrum canum* (212.50 Ind/ha), *Symplocos lucida* (187.50 Ind/ha) and *Rhododendron arboreum* (143.75 Ind/ha) The lowest adult tree individual were recorded from *Glochidion acuminatum* (18.8 Ind/ha) and *Rhododendron grande* (18.75 Ind/ha) respectively. For the saplings highest presence was recorded from *Symplocos lucida* (637.50 Ind/ha) followed by *Cryptomeria japonica* (281.25 Ind/ha) and *Castanopsis hystrix* (206.25 Ind/ha) whereas from seedling the highest individual was recorded from *Castanopsis tribuloides* (325.00 Ind/ha) followed by *Symplocos lucida* (306.25 Ind/ha) and *Symplocos glomerata* 231.25 Ind/ha) were recorded as shown in Table 2. Under mature trees the highest relative density for major tree species were recorded from *Castanopsis tribuloides* (14.9) followed by *Leucosceptrum canum* (8.2), *Symplocos lucida* (7.2), whereas highest relative frequency of occurrence was recorded for *Castanopsis tribuloides* (10.5) followed by *Symplocos lucida* (7.5) as shown in Table 2. The frequency of occurrence in the saplings and seedlings were found highest for *Castanopsis hystrix* (RF 10.00 % & 15.91 %) followed by *Symplocos lucida* (RF 9.0 % & 10.2 %) and *Symplocos glomerata* (RF 8.0 %) etc.

Table 2: Structural data on the major tree species of Sang-Tinjure sampling path in FambongLho Wildlife Sanctuary, East Sikkim

Scientific name [family]; voucher specimen	Density (plant/ha)	Relative density	Relative frequency	Pi =ni/N	lnPi	Pi*lnPi
Acer caudatum Wall. [Sapindaceae]; ST-1	68.8	2.657	5.697	0.027	-3.628	-0.096
Acer oblongum Wall. ex DC. [Sapindaceae]; ST-2	125	4.831	4.069	0.048	-3.03	-0.146
Betula alnoides Buch.-Ham. ex D.Don [Betulaceae]; ST-3	37.5	1.449	2.441	0.014	-4.234	-0.061
Castanopsis hystrix Hook.f. & Thomson ex A.DC. [Fagaceae]; ST-4	56.3	2.174	3.255	0.022	-3.829	-0.083
Castanopsis tribuloides (Sm.) A.DC. [Fagaceae]; ST-5	387.5	14.976	10.579	0.15	-1.899	-0.284
Choerospondias axillaris (Roxb.) B.L.Burtt & A.W.Hill [Anacardiaceae]; ST-30	31.3	1.208	1.628	0.012	-4.416	-0.053
Cinnamomum impressinervium Meisn. [Lauraceae]; ST-7	37.5	1.449	4.069	0.014	-4.234	-0.061
Cryptomeria japonica (Thunb. ex L.f.) D.Don [Cupressaceae]; ST-8	112.5	4.348	1.628	0.043	-3.135	-0.136
Elaeocarpus lanceifolius Roxb. [Elaeocarpaceae]; ST-9	37.5	1.449	1.628	0.014	-4.234	-0.061
Engelhardtia spicata Lechen ex Blume [Juglandaceae]; ST-10	50	1.932	3.255	0.019	-3.946	-0.076
Eurya acuminata DC. [Pentaphylacaceae]; ST-11	87.5	3.382	5.697	0.034	-3.387	-0.115
Exbucklandia populnea (R.Br. ex Griff.) R.W.Br. [Hamamelidaceae]; ST-12	50	1.932	1.628	0.019	-3.946	-0.076
Glochidion acuminatum Mull.-Arg. [Phyllanthaceae]; ST-13	18.8	0.725	1.628	0.007	-4.927	-0.036
Leucosceptrum canum Sm. [Lamiaceae]; ST-14	212.5	8.213	1.628	0.082	-2.5	-0.205
Lithocarpus fenestratus (Roxb.) Rehder [Fagaceae]; ST-15	50	1.932	3.255	0.019	-3.946	-0.076
Lyonia ovalifolia (Wall.) Drude [Ericaceae]; ST-22	112.5	4.348	1.628	0.043	-3.135	-0.136
Macaranga denticulata (Blume) Mull.-Arg. [Euphorbiaceae]; ST-16	68.8	2.657	1.628	0.027	-3.628	-0.096
Machilus sp. [Lauraceae]; ST-17	43.8	1.691	3.255	0.017	-4.08	-0.069
Magnolia campbellii Hook.f. & Thomson [Magnoliaceae]; ST-18	43.8	1.691	1.628	0.017	-4.08	-0.069
Magnolia doltsopa (Buch.-Ham. ex DC.) Figlar [Magnoliaceae]; ST-19	37.5	1.449	1.628	0.014	-4.234	-0.061
Magnolia velutina (DC.) Figlar [Magnoliaceae]; ST-20	56.3	2.174	1.628	0.022	-3.829	-0.083
Nyssa javanica (Blume) Wangerin [Cornaceae]; ST-21	62.5	2.415	3.255	0.024	-3.723	-0.09
Prunus napaulensis (Ser.) Steud. [Rosaceae]; ST-23	50	1.932	4.069	0.019	-3.946	-0.076
Quercus lamellosa Sm. [Fagaceae]; ST-24	137.5	5.314	5.697	0.053	-2.935	-0.156
Rhododendron arboreum Sm. [Ericaceae]; ST-25	143.8	5.556	2.441	0.056	-2.89	-0.161
Rhododendron grande Wight [Ericaceae]; ST-26	18.8	0.725	1.628	0.007	-4.927	-0.036
Rhododendron griffithianum Wight [Ericaceae]; ST-27	31.3	1.208	1.628	0.012	-4.416	-0.053
Rhus chinensis Mill. [Anacardiaceae]; ST-28	37.5	1.449	1.628	0.014	-4.234	-0.061
Schima wallichii Choisy [Theaceae]; ST-29	37.5	1.449	1.628	0.014	-4.234	-0.061
Symplocos glomerata King ex C.B.Clarke [Symplocaceae]; ST-31	112.5	4.348	5.697	0.043	-3.135	-0.136
Symplocos lucida (Thunb.) Siebold & Zucc. [Symplocaceae]; ST-32	187.5	7.246	7.324	0.072	-2.625	-0.19
Toona sureni (Blume) Merr. [Meliaceae]; ST-6	43.8	1.691	1.628	0.017	-4.08	-0.069

Importance Value Index

Importance Value Index (IVI) of adult trees was recorded highest for *Castanopsis tribuloides* (62.7) and is followed by *Quercus lamellosa* (22.6), *Symplocos lucida* (20.9) and *Symplocos glomerata* (13.2). The lowest adult IVI was recorded for *Rhododendron grande* (2.9) followed by *Rhus chinensis* (3.6), respectively as shown in Figure 3.

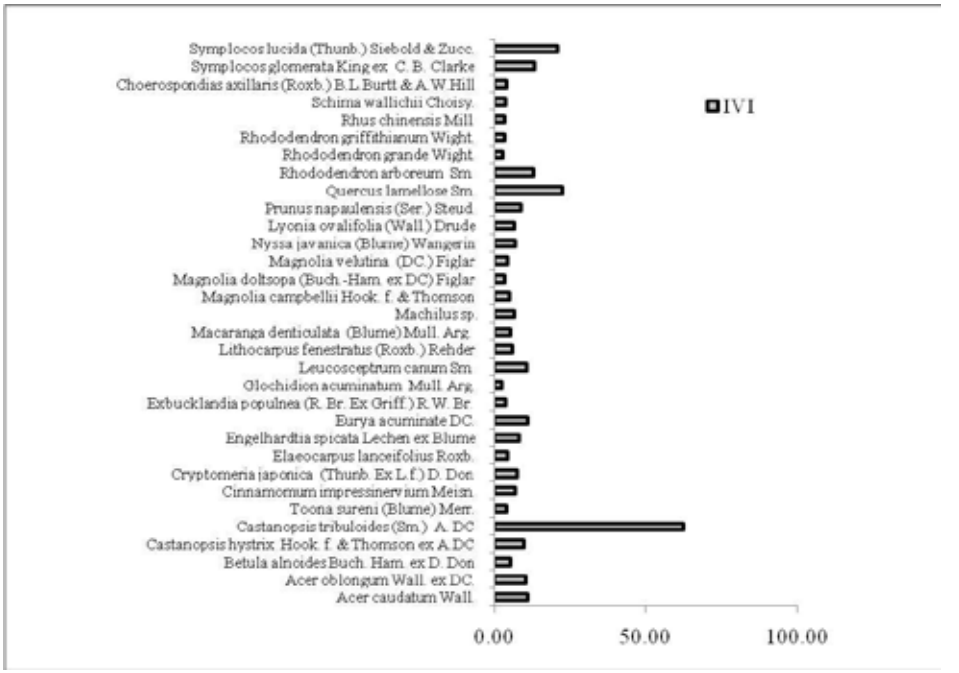

Fig. 3: Importance Value Index of the major tree species along Sang-Tinjure sampling plots

Distribution Pattern

The abundance to frequency ratio revealed all the adult individuals of tree species to be contagious distributed except *Acer caudatum* and *Cinnamomum impressinervium* which showed the random distribution but none of the species showed regular distribution. The maximum abundance of the species of tree species were recorded for the *Castanopsis tribuloides* (13) followed by *Symplocos lucida* (9), *Acer caudatum, Quercus lamellosa, Symplocos glomerata, Eurya acuminata* (7 for each species) were recorded showed in Table 3.

Species Diversity

The species diversity (H) and richness of trees (adult, sapling and seedlings) in the site were found as highest in concentration for the tree (H = 3.17) followed by seedling (H = 2.68) and sapling (H = 2.60) in the area of 0.064 ha. The value of species richness was found in the range of trees (15.6 – 15.7) and sapling (15.3 – 15.8) and seedling (15.1 – 15.7) for the entire sampling plots.

Table 3: Composition and Distribution of tree species in 16 sampling plots

Botanical Name	Presence in Quadrat																Total presence
Acer caudatum Wall.	-	-	-	-	-	+	-	-	-	+	+	-	+	+	+	+	**7**
Acer oblongum Wall. ex DC.	+	-	-	+	+	+	-	+	-	-	-	-	-	-	-	-	**5**
Betula alnoides Buch.-Ham. ex D.Don	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+	**3**
Castanopsis hystrix Hook.f. & Thomson ex A.DC.	+	+	+	-	-	-	-	-	-	+	-	-	-	-	-	-	**4**
Castanopsis tribuloides (Sm.) A.DC.	+	+	-	+	-	+	-	+	+	+	+	+	+	+	+	+	**13**
Toona sureni (Blume) Merr.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	**2**
Cinnamomum impressinervium Meisn.	-	-	-	-	-	-	-	-	+	+	+	-	-	-	+	+	**5**
Cryptomeria japonica (Thunb. ex L.f.) D.Don	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	**2**
Elaeocarpus lanceifolius Roxb.	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	**2**
Engelhardtia spicata Lechen ex Blume	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	**4**
Eurya acuminata DC.	-	-	-	-	-	+	-	+	-	-	+	+	-	+	+	+	**7**
Exbucklandia populnea (R.Br. Ex Griff.) R.W.Br.	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	**2**
Glochidion acuminatum Mull.-Arg.	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	**2**
Leucosceptrum canum Sm.	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	**2**
Lithocarpus fenestratus (Roxb.) Rehder	-	-	-	-	-	-	+	-	-	+	-	-	-	+	+	-	**4**
Lyonia ovalifolia (Wall.) Drude	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	**2**
Macaranga denticulata (Blume) Mull.-Arg.	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	**2**
Machilus sp.	-	-	-	-	-	-	-	-	-	+	-	+	-	+	+	-	**4**
Magnolia campbellii Hook.f. & Thomson	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	**2**
Magnolia doltsopa (Buch.-Ham. ex DC.) Figlar	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	**2**
Magnolia velutina (DC.) Figlar	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	**2**
Nyssa javanica (Blume) Wangerin	+	+	-	+	-	+	-	-	-	-	-	-	-	-	-	-	**4**
Prunus napaulensis (Ser.) Steud.	-	-	-	-	-	-	-	-	-	+	+	+	+		+	-	**5**
Quercus lamellosa Sm.	-	-	-	-	-	-	-	-	+	-	+	+	+	+	+	+	**7**
Rhododendron arboreum Sm.	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	**3**
Rhododendron grande Wight	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+		**2**
Rhododendron griffithianum Wight	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	**2**
Rhus chinensis Mill.	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	**2**
Schima wallichii Choisy	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**2**
Choerospondias axillaris (Roxb.) B.L.Burtt & A.W.Hill	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**2**
Symplocos glomerata King ex C.B.Clarke	-	-	-	-	-	+	-	+	-	-	+	+	+	+	-	+	**7**
Symplocos lucida (Thunb.) Siebold & Zucc.	-	-	-	-	-	+	-	+	-	+	+	+	+	+	+	+	**9**
TOTAL	8	8	4	8	4	11	4	6	3	9	9	7	8	10	12	12	**123**

Girth Class

On the basis of girth class, other than the above additional sampling under different girth class was done for precise determination of stand structure with the gradient of 10 cm rise starting from 30 cm at gbh. The intervals started from 30 – 40 cm and ended at 331 – 340 cm at gbh. Dominant species as well as a few major tree species of the study site was measured to understand the community structure. The girth size classes were as follows:

30-40 = 1; 41-50 = 2; 51-60 = 3; 61-70 = 4; 71-80 = 5; 81-90 = 6; 91-100 = 7; 101-110 = 8; 111-120 = 9; 121-130 = 10; 131-140 = 11; 141-150 = 12; 151-160 = 13; 161-170 = 14; 171-180 = 15; 181-190 = 16; 191-200 = 17; 201-210 = 18; 211-220 = 19; 221-230 = 20; 231-240 = 21; 241-250 = 22; 251-260 = 23; 261-270 = 24; 271-280 = 25; 281-290 = 26; 291-300 = 27; 301-310 = 28; 311-320 = 29; 321-330 = 30; 331-340 = 31.

Several girth classes were found missing in between and sometimes large gaps emerged between two girth-classes. It was noteworthy that some of the species started with size class 30 – 40 cm at gbh but after that different size-classes kept on missing. In case of *Magnolia campbellii* a girth class of 41 - 50 and 61 – 70 cm gbh were recorded after that there is gap between them and 91 – 100 and 101 – 110 cm gbh were recorded but after that only 241 – 250 cm gbh was found. In case of *Choerospondias axillaris* the lower girth-classes were entirely missing and only 3 entities were found which were recorded for very mature trees (girth-classes over 100 cm). Similarly, in case of *Leucosceptrum canum* 22 individuals were recorded and all were falling within the 30 – 40 cm girth-class in all the sampling plots. The lowest 3 individual girth-classes were recorded for *Glochidion acuminatum* which fell within 51 – 60 and 61 – 70 cm girth-classes. In the entire girth-classes, the 44 maximum individuals were found falling within 30 – 40 cm gbh followed by 35 individual in 81 – 90 cm gbh, 32 individuals in 51 – 60, 61 – 70, and 111 – 120 cm girth-classes. The minimum, i.e., only 1 individual was found falling within 271 – 280 and 370 – 381 cm at gbh.

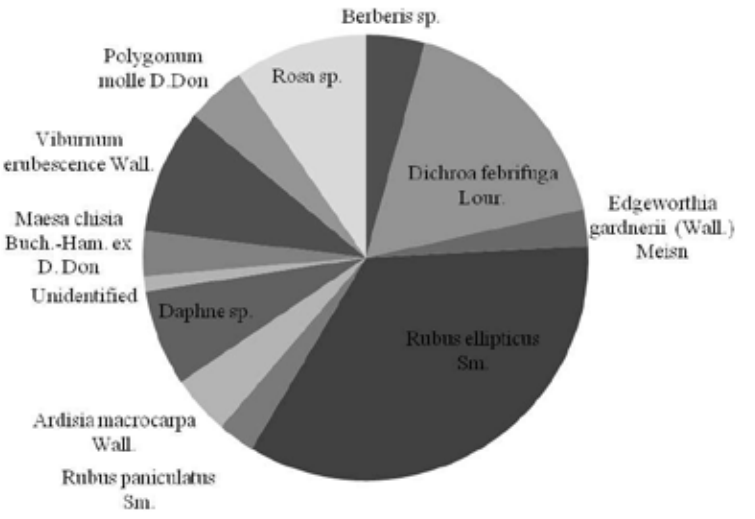

Fig. 4: Percent cover for shrub and scrub species.

Shrub Component

The highest percent cover of shrub was recorded for *Rubus ellipticus* (34.8 %) followed by *Dichroa febrifuga* (17.4 %), *Rosa* sp. (9.8 %), *Viburnum erubescence* (9.2 %), *Polygonum molle* (8%), *Daphne* sp. (7.1 %) respectively. The lowest percent cover was recorded for unidentified (1 %) followed by *Rubus paniculatus* and *Edgeworthia gardneri* (each having 2.7 %) as shown in Figure 4.

Herb Component

A total of 30 species of herbs belonging to 26 genera and 17 families were recorded including fern and fern-allies viz., *Polygonum molle* D.Don, *Arisaema intermedium* Blume, *Asplenium laciniatum* D.Don, *Boehmeria* sp., *Carex* sp., *Digitaria sanguinalis* (L.) Scop., *Diplazium dilatatum* Blume., *Allantodia stoliczkae*(Bedd.) Ching., *Elatostema platyphyllum* Wedd., *Eragrostis cilianensis* (All.) Janch., *Ageratina adenophorum* Spreng., *Girardinia diversifolia* (Link) Friis., *Gleichenia longissima* Blume., *Impatiens stenantha* Hook.f., *Lycopodium japonicum*Thunb., *Monachosoram henryi* Christ., *Nephrolepis cordifolia* (L.) C.Presl., *Pilea stricta* (Buch.-Ham. ex D.Don) Wedd., *Pilea umbrosa* Blume., *Plagiogyria pycnophylla* (Kunze) Mett., *Pouzolzia sanguine* (Blume) Merr., *Rumex nepalensis* Spreng., *Selaginella biformis* A.Braun. ex Kuhn., *Selaginella chrysocaulos* (Hook. & Grev.) Spring., *Selaginella monospora* Spring., *Smilax aspera* L., *Urtica dioica* L., *Urtica parviflora* Roxb., *Oreocnide frutescens* (Thunb.) Miq., and *Viola sikkimensis* W.Becker etc., in entire sampling plots shown in (Figure 5). The family wise species composition the highest number of taxa was recorded for Urticaceae family (9) followed by Selaginellaceae (3), other remaining was showed in (Figure 6)**.**

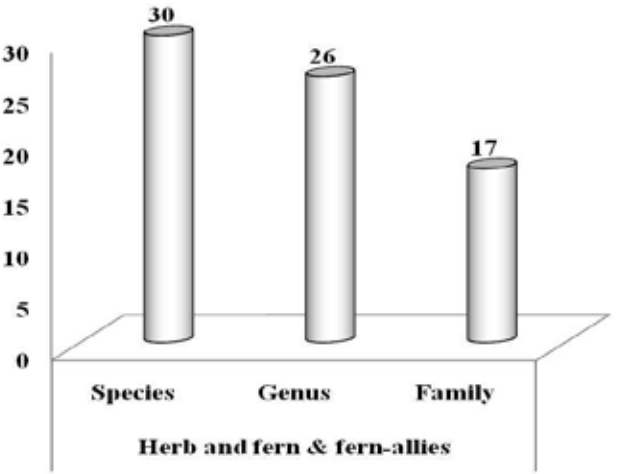

Fig. 5: Spectrum of taxa for herbs (ground cover plants)

DISCUSSION

This study reveals a floral assemblage of 88 species of plants in an estimated 0.064 ha of study area, which is slightly more as compared to 75 species in 0.027 ha by Subba *et al*. (2015) at a higher temperate location. On a small area level this figure can be considered as a fair representation of biodiversity if it is compared with the total floral constituents of

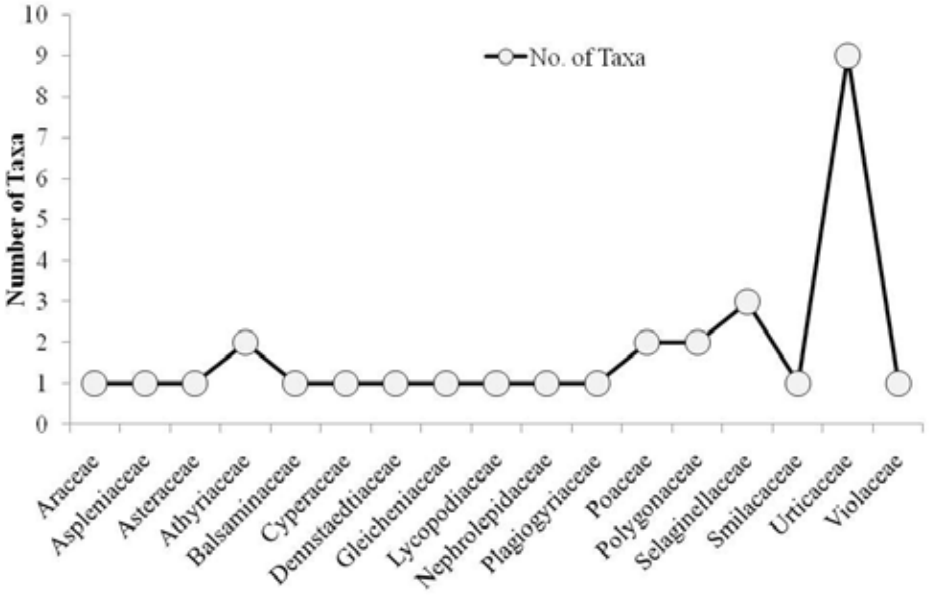

Fig. 6: Family-wise species composition of herbs including ferns & fern-allies.

Sikkim (ca. 4500 species within 7096 km^2) by Subba *et al*. (2015). The life-form study under Raunkiaer's system (1934) was made for classifying plant entities within a community and understanding its adaptive manifestation to certain ecological condition (Mera *et al*. 1999). In true sense, the Raunkiaer's life-form shows the structural diversity of the plants in any place and is therefore important from the ecological point of view, whereby most of the time it reveals the change in the forest continuum.

Almost all of the Raunkiaer's life-forms was found in the study site barring the Aerophytes, Heliophytes, Hydrophytes and Therophytes. The absence of these life-forms could be attributed to the absence of permanent water bodies for helophyte and hydrophytes, and absence of harsh environment for the therophytes. Probably this is due to close canopy**.** Incidentally, the absence of fewer epiphytes in the location is rather intriguing even when the moisture regime is found sufficient to support these life-forms. In regard to the epiphytes it may be viewed as lack of suitable host trees and prevalent low temperature. Highest percent among the life-forms was of the Phanerophytes (44.7) representing the canopy forming plants followed by Hemicryptophytes (16.0) representing the ground vegetation of herbs; similar was reported at Lachung Range (Subba *et al*. 2015; Subba & Lachungpa 2016) where the herb component was found as the most dominant habit-group compared to other plant species. The highest percent cover of shrub was recorded for *Rubus ellipticus* (34.8 %) followed by *Dichroa febrifuga* (17.4 %), *Rosa* sp. (9.8 %), *Viburnum erubescence* (9.2 %), *Polygonum molle* (8 %), *Daphne* sp. (7.1 %) respectively. Similarly, *Daphne* sp. was reported wide distribution range of habitat along the Barsey Rhododendron Sanctuary by (Subba *et al.* 2017). The lowest percent cover was recorded for unidentified (1.1 %) followed by *Rubus paniculatus* and *Edgeworthia gardnerii* (each having 2.7 %). In case of herbaceous species, maximum family-wise species composition is represented by Urticaceae (9 spp.), followed by Selaginellaceae (3 spp.) which indicates that fern and fern-allies are highly dominant in the study site.

Of Orchidaceae, the *Coelogyne flaccida* is primarily an epiphyte, is often found growing here as lithophytes. The presence of epiphytic plants, especially orchids, play important roles for the forest ecology and preserving the diversity of epiphytes makes evergreen forests healthy and floristically rich (Subba 2016). The highest IVI value (62.7) recorded for *Castanopsis tribuloides* effectively makes it the dominant species in the site which is far above the other contenders, viz., *Quercus lamellosa* (22.6), *Symplocos lucida* (20.9) and *Symplocos glomerata* (13.2), etc. The visible presence of *Castanopsis tribuloides* in the form of large trees throughout the site speaks more than what Figure IVI portrays (62.65). However, it should be noted that most oaks are found in temperate forests forming large areas of forest cover in Sikkim. The *Castanopsis tribuloides* as the second highest IVI was reported in Kangchendzonga Biosphere Reserve (Yuksom-Dzongri sampling Path) by (Subba *et al*. 2016). The abundance-to-frequency ratio revealed all the adult individuals of large tree species to be contiguously distributed except *Acer caudatum* and *Cinnamomum impressinervium* which showed the random distribution but none of the species showed regular distribution (Table 3).

Community studies are usually done taking in the tree diversity of the community and the different state of its growth which are primarily found as seedlings, saplings and mature trees. This work the species diversity of trees (adult, sapling and seedlings) in the site were found to be highest in concentration for the trees (H'= 3.17) followed by seedlings (H'= 2.68) and the saplings (H'=2.60). In regard to the species richness value for the site it was found to be in the range of 15.1 – 15.8 which is high in view of its temperate life zone. On a gradient of sampling plots the species richness was recorded highest in Plot 5 at 1939 m amsl followed by Plot 15 at 2213 m amsl. As is evident both of these plots have the maximum humus depth as compared to other plots. However, humus depth has no influence on the species richness in the study plots (Table 1). It may point towards the correlation of humus depth with species richness**.**

This situation was further analyzed with precise girth-class gradient taken up from 30 – 40 cm and leading up to 331 – 340 cm of gbh which revealed some interesting results. All of these major tree species from the site do not show curves which are gentle showing natural continuum of girth-class, but on the contrary severe gaps suggest that it is not normal or natural possibly due to anthropogenic infringement in the area For *Magnolia campbellii* girth classes of 41 – 50 and 61 – 70 cm gbh were recorded after that there is gap between them and 91 – 100 and 101 – 110 cm gbh were recorded but after that only 241 – 250 cm gbh was found. In case of *Choerospondias axillaris* the lower girth-class were entirely missing and only 3 entities were found which were recorded for very mature trees (girth-class over 100 cm). Similarly for *Leucosceptrum canum* a sum of 22 individuals were recorded and all were falling within 30-40 cm girth-class in all the sampling plots. The lowest 3 individual number of girth-class were recorded in *Glochidion acuminatum* which is falling within 51 – 60 and 61 – 70 cm girth-classes. In the entire girth-classes, the 44 maximum individual numbers were found falling within 30 – 40 cm gbh followed by 35 individuals falling in 81 – 90 cm gbh, 32 individual falling in 51 – 60, 61 – 70, 111 – 120 cm girth-classes. The minimum i.e., only 1 individual were found falling within 271 – 280 and 370 – 381 cm gbh classes. It may be suggested that the trees may have a wide distribution range which is generally supported by the site characteristics. However, in every plot there are traces of human interferences, and mostly the trees of size class 271 – 280 and above which are preferred for logging purpose are taken away and only a few remains in the study site which made the size class 271 – 280 and 370 – 381 few in number.

The apparent absence of therophytes shows that the community is under some kind of environmental stress. The therophytes which thrive on harsh climatic conditions and prosper

largely in the hottest and driest region (at 36.36 % presence, Chaudhry *et al*. 2006) or in desert environment (at 48 % presence, Wariss *et al.* 2013) were absent in the site due to obvious absence of these extreme situations. It may be the case of coldness, continuous canopy blocking the entry of sunlight to the forest floor and thick litter fall under dhupi forest that contributes to the unsuitable condition for the therophytes. The therophytes in such situations naturally outnumber Phanerophytes, Hemicryptophytes and Cryptophytes. It can be concluded that the studied community has a high diversity of plant forms, a better ranking on IVI and other related parameters and a somewhat uneven stand structure with respect to the tree elements.

Acknowledgements

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QUANTITATIVE ANALYSIS OF VEGETATION PATTERNS AND PLANT SPECIES DIVERSITY IN DIFFERENT FOREST TYPES AT YUKSAM – DZONGRI – GOCHELA SAMPLING PATH IN KHANGCHENDZONGA BIOSPHERE RESERVE, WEST SIKKIM, INDIA

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Abstract

Quantitative assessment of plant species recorded a total of 129 species belonging to 81 genera and 61 families in three forest types along Yuksam-Dzongri-Goechela sampling path. Herbaceous flora were maximum (48 species, 28 genera, 22 family) followed by trees (45 species, 29 genera, 21 family), shrub-scrub (26 species, 14 genera, 9 family), 6 epiphytes and 2 species each of bamboo, one each from mosses and lichens respectively. The highest frequency of occurrence was recorded from Plot 1; (29 species). High frequency of occurrence was recorded for tree of *Abies densa* (42.2) followed by *Rhododendron hodgsonii* (31.1) and Betula utilis, *Acer campbellii, Prunus nepalensis, Castanopsis tribuloides, Magnolia campbellii*, *Rhododendron falconeri* (15.6 each) respectively. The seedling frequency for *Rhododendron hodgsonii* (10.6) was highest followed by *Abies densa* (9.86), *Castanopsis tribuloides* & *Rhododendron barbatum* (5.31 each.). The saplings frequency was highest for *Abies densa* (9.10) followed by *Rhododendron hodgsonii* (8.34) and *Acer campbellii* (6.83). The highest density was recorded for *Rhododendron hodgsonii* (915.6) followed by *Rhododendron barbatum* (540.0), *Abies densa* (535.6) and *Rhododendron falconeri* (424.4), respectively. The maximum seedling density was encountered for *Rhododendron hodgsonii* (404.4) followed by sapling of *Rhododendron falconeri* (373.3) and adult of *Rhododendron hodgsonii* (295.6) were recorded. The highest Importance Value Index (IVI) of *Abies densa* effectively makes it the dominant species. Abundance –to-frequency ratio revealed woody life form had contagious distribution along the Yuksam-Dzongri-Goechela sampling path.

Keywords: Yuksam-Dzongri-Goechela, Sikkim Himalaya, Quantitative analysis, forest types, plant diversity

Introduction

PHOTO 1: *Rhododendron hodgsonii* along trekking route

The forest is a fundamental ecological resource preserving biodiversity and maintaining the ecological diversity in the region. The Khangchendzonga Biosphere Reserve (KBR) in Sikkim is an important conservation area with high ecological, biological diversity, and also contributes to natural and cultural significance in the Indian Himalayan region. The distribution of plant species in the beautiful landscape ranges from the tropical to alpine meadows. Based on topography and elevation, the habitat of KBR can be broadly categorized into wet temperate broad leaved forests, temperate conifer forest, sub-alpine forest, alpine scrubs and alpine meadows. These extreme topographic variations of the landscape provide diversity in the microclimatic conditions and habitat types, enriching the landscape as a biodiversity repository in the Himalayas (Chettri *et al*., 2008).The inventory of tree species that provides information on plant species diversity will represent an important tool to enhance our ability to maintain the biodiversity conservation and forest management purposes. Many workers have been studied in tree species diversity in northeast India by Nath *et al*., (2005), Das & Das, (2005); Kumar *et al*., (2006) and Devi and Das, (2012). In

Sikkim, several workers have been studied in tree species by Rai & Rai, 1993, Singh & Chauhan 1998, Cowan & Cowan 1929). Quantitative evaluation and analysis of the community structure are important for accurate assessment of biodiversity. The enumeration and quantification of individual species have been determined. Trees are the most important structural and functional basis of forest ecosystems and can serve as robust indicators of change and stress at the landscape scale. Tree diversity varies greatly from place to place, mainly due to variations in geography, habitat and disturbance in different forests. Human disturbance patterns also affect the structure and composition of forest ecosystem. Therefore, long-term study of tree population dynamics is crucial for our understanding of the vulnerability of the forest ecosystem.

The present work was conducted in wet temperate broad-leaved forest, temperate conifer forest, sub-alpine forest, alpine scrubs and alpine meadows. The altitude of these habitat ranges between 1800-4200 m asl. The dominant woody species along Yuksam-Dzongri-Goechela trekking route consists of *Acer campbellii, Beilschmiedia* sp*, Exbucklandia populnea, Castanopsis tribuloides, Cinnamonum impressinervium, Elaeocarpus lanceaefolius, Engelhardtia spicata, Garuga floribunda, Juglans regia*, *Machilus edulis, Michelia cathcartii, Michelia doltsopa, Michelia velutina, Nyssa sessiliflora, Lithocarpus fenestrata, Quercus lamellosa,* and *Rhododendron arboretum*.

PHOTO 2: *Rhododendron barbatum* along trekking route

The vegetation at tree line above Tshoka village is represented by different shrubs species viz., *Rhododendron lanatum, Rhododendron wightii* and *Rosa sericea*. Krummholz vegetation in the rocky alpine habitat is dominated by *Rhododendron anthopogon, R. lepidotum, R. setosum,* and *J. recurva*, and herbaceous flora includes

Anaphalis spp., *Bistorta affinis*, *Rheum acuminatum, Aconitum* spp., *Primula* spp., *Potentilla peduncularis*, *Juncus* sp., and many more. At around 4200 m altitude, the thickets of *R. anthopogon, R. lepidotum, R. nivale, R. setosum, J. indica, J. recurva* are common. The common associates of *Rhododendron* scrub in the alpine habitat consist of *Cassiope fastigata, Gaultheria pyroloides*, etc. The altitude beyond 4200 m remains completely snow-covered throughout the year.

Many studies have been conducted on plant species diversity in different forest types of Sikkim Himalayan Region (Pradhan & Lachungpa 1990, Rai & Rai 1993, Singh & Chauhan 1998, Dash & Singh, 2002, Cowan & Cowan 1929, Subba *et al*., 2015, Subba & Lachungpa, 2016) and in north- eastern India (Bhuyan *et al*., 2003). However, the analysis of vegetation patterns and plant species diversity in different forest types along Yuksam – Dzongri – Gochela trekking route is lacking. Therefore, the present study was carried out with the objective to quantify and analyze the vegetation pattern and plant species distribution.

STUDY AREA

Rapid biodiversity survey was conducted during April-May 2013, along Yuksam–Dzongri–Goechela trekking route, covering a distance *ca.* 40 km long transect in KBR. The elevation of the study sites ranges between 1800 – 4200 m asl, lying between latitude 27°23' – 27°28' N and longitude 088°°13' - 088°10'E. Vegetation is characterized by different forest types from wet temperate mixed forest, to sub-alpine ecosystem. The KBR is endowed with rich biodiversity and is the highest biosphere reserve in the country covering 41.31%.

KBR also provides refuge to rare animals like Snow leopard, Blue sheep, Goral, Red Panda, Himalayan Thar, Serow; and avifauna such as, Blood pheasant, Himalayan Monal, Kalij Pheasant; Yellow billed-blue Magpie, etc.

METHODOLOGY

In April-May 2013, random sampling was done by laying 45 sampling plots. The plot of 20 X 20 m was laid in 45 plots at every 100 footstep distance, depending upon the site feasibility, covering a total area of 1.8 ha. Within the main plot, all the standing tree species were enumerated & measured (cbh) at 1.37 m from the ground. Within the subplots, 5 m X 5 m were laid (4 in the corner & 1 at centre) for recording the sapling & shrub. 1 m X 1m were laid for seedling species were enumerated, in the same plot was used for recording the

percent cover of herb species in the area. Plant species were identified through herbarium record and flora (Hooker JD, 1888-1890, Hooker JD 1849, Pradhan & Lachungpa, 1990, Kholia, 2010). The unidentified plants species in the field were photographed, and later identified by consulting plant taxonomy experts from GBPIHED (Sikkim Unit), & BSI and web references (www.efloras.org; www.flowersofindia.net), www.floraofchina were made and by referring to local people from the nearby villages. All the sampling plots were geotagged for reference under long-term monitoring and altitude was recorded.

The frequency, density, dominance and IVI were calculated following method given by Curtis and McIntosh (1950). The ratio of abundance to frequency for different life form was determined to get the picture of distribution patterns of the plant species in the study sites. The ratio indicates regular (<0.025), random (0.025 to 0.05) and contagious (>0.05) distributions (Curtis & Cottam 1956). All the statistical analysis were carried out with the support of Software Microsoft Office Excel 2007.

Frequency

Frequency indicates the degree of dispersion of individual species in an area and it expresses percentage of occurrence.

$$\text{Frequency (\%)} = \frac{\text{Number of quadrat in which the species occurred}}{\text{Total number of quadrat studied}} \times 100$$

Density

Density expressed as the numerical strength of a species, calculated as number of individuals per hectare

$$\text{Density} = \frac{\text{Total number of individuals of the species}}{\text{Total number of quadrat studied}}$$

Basal Cover

It is computed using girth of the tree (CBH) at 1.37 m above ground level and it determines dominance of the community.

$$\text{Relative basal Area} = \frac{\text{Total basal area of a species}}{\text{Total basal area of all species}} \times 100$$

Importance Value Index (IVI)

The importance value index (IVI) for the tree species was determined as the sum of the relative density, relative frequency and relative dominance (Curtis, 1959).

IVI= Relative dominance + Relative Density + Relative Frequency.

Distribution Pattern

The ratio of abundance to frequency for different species was determined to get the picture distribution patterns different life form. The ratio indicates regular (<0.025), random (0.025 to 0.05) and contagious (>0.05) distributions (Cottam & Curtis, 1956).

Distribution pattern (%) = Abundance of each species / Frequency of each species

Species Diversity Index

The Shannon-Weiner diversity index (Shannon and Weiner, 1963) is calculated using the species diversity in a community

$$H' = -\sum_{i=1}^{S} (ni/N) \log_2 ni/N)$$

Where, 'ni' represents total number of individuals of particular species, and 'N' represents total number of individuals of all species.

Species Richness

It is simply the number of species per unit area. Margalef's index of species richness (1958) was calculated by using formula.

$$I = (S-1)/\ln(N)$$

Where, 'S'= the number of species in the sample and 'N'= the total number of individuals in the sample.

RESULTS

Vegetation Structure

A total of 129 species belonging to 81 genera and 61 families were recorded from 45 transects in different forest types viz., wet temperate broad leaved forests, temperate conifer forest, sub-alpine forest, alpine scrubs and alpine meadows of Yuksam-Dzongri-Goechela sampling path. Herbaceous species were recorded maximum (48 species, 28 genera, 22 family) followed by tree (45 species, 29 genera, 21 family) and shrub-scrub (26 species, 14 genera, 9 family), six epiphytes, and two species from bamboo, one each from mosses and lichens respectively.

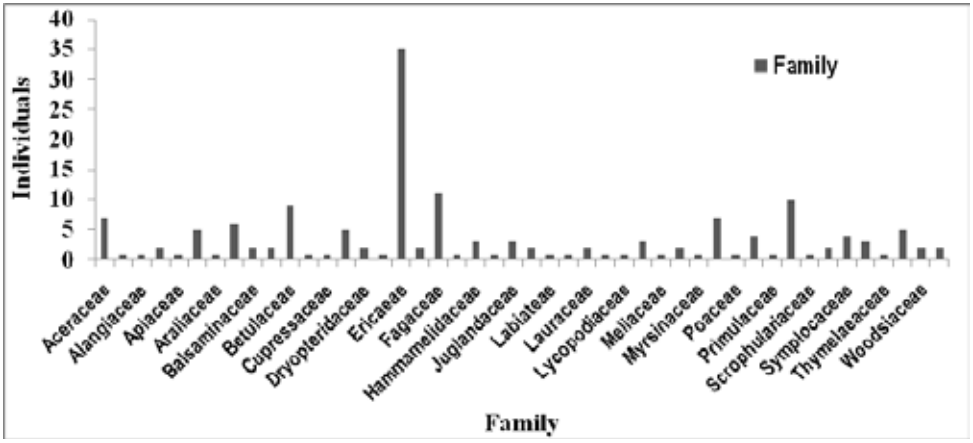

Figure 1: Family-wise species composition of Yuksam-Dzongri-Goechela sampling plot

A total of 61 families of containing 129 species represented the floral face of the study site. Maximum numbers of families were recorded from Ericaceae (35) followed by Fagaceae (11), Rosaceae (10), Betulaceae (9), Pinaceae & Aceraceae having (7 each family), Asteraceae (6), Above [**Figure 1].**

Diversity of plant species

TREE

Plant species diversity and regeneration pattern for sapling and seedlings were studied in different forest types. The percentage of high frequency from Plot 1; (29 species, 1867 m), followed by plot 3 (27 species, 1976 m) and plot 4 (24 species, 2023 m). The percentage of low frequency of occurrence was recorded from Plot 16-18, 23-25,27, 31,41 and Plot 43 – 44 with four species each respectively [**Figure 2].**

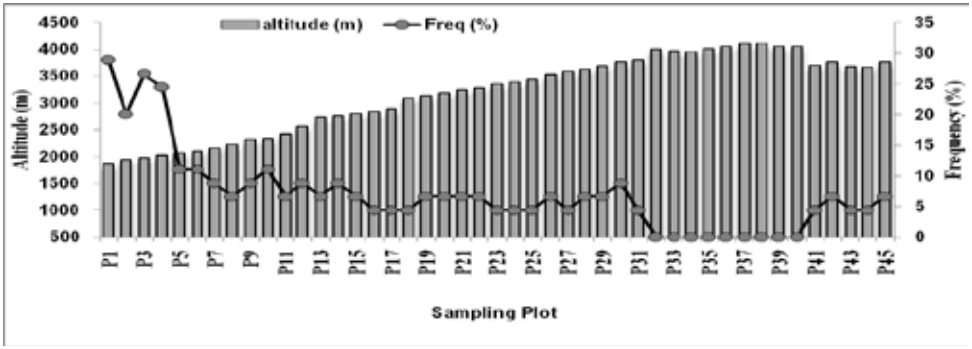

Figure 2: Altitudinal gradients and frequency (%) of tree species distribution at Yuksam-Dzongri- Goechela sampling plot in West Sikkim

High frequency of occurrence was recorded for tree of *Abies densa* (42.2) followed by *Rhododendron hodgsonii* (31.1) and *Betula utilis*, *Acer campbellii, Prunus nepalensis, Castanopsis tribuloides, Magnolia campbellii*, *Rhododendron falconeri* (15.6 each) respectively.

The seedling frequency for *Rhododendron hodgsonii* (10.6) was highest followed by *Abies densa* (9.86), *Castanopsis tribuloides* & *Rhododendron barbatum* (5.31 each.). The saplings frequency was highest for *Abies densa* (9.10) followed by *Rhododendron hodgsonii* (8.34) and *Acer campbellii* (6.83).

In general, diversity pattern for seedlings was maximum (H'=2.82) followed by sapling (H'=2.81) and adult (H'=2.79). The value of species richness was found to be 44.09 - 44.00 on the entire site. [**Table 1]**

Table 1: Structural data on the major species in the Yuksam-Dzongri – Gochela sampling path of Khangchendzonga Biosphere Reserve, West Sikkim

Sl. No	Species	Relative density	Relative frequency	Pi =ni/N	lnPi	Pi*lnPi	H
1.	*Acer campbellii* Hook. & Thom.	4.82	4.97	0.0482	-3.03	-0.1462	
2.	*Prunus nepalensis* (Ser) Stendel	4.11	4.97	0.0411	-3.19	-0.1311	
3.	*Castanopsis tribuloides* (Smith)	7.32	4.97	0.0732	-2.61	-0.1914	
4.	*Alnus nepalensis* D. Don.	0.71	1.42	0.0071	-4.94	-0.0353	
5.	*Betula alnoides* Don.	1.96	3.55	0.0196	-3.93	-0.0772	
6.	*Rhus insignis* Hook. f.	0.54	1.42	0.0054	-5.23	-0.0280	
7.	*Juglans regia* Linn.	0.54	1.42	0.0054	-5.23	-0.0280	
8.	*Cedrela febrifuga* Blume	0.54	1.42	0.0054	-5.23	-0.0280	
9.	*Macaranga pustulata* King.	0.54	1.42	0.0054	-5.23	-0.0280	
10	*Acer caudatum* Wallich.	2.68	3.55	0.0268	-3.62	-0.0970	2.79
11	*Rhododendron arboreum* var. *roseum*	6.25	4.26	0.0625	-2.77	-0.1733	
12	*Quercus glauca* Thunb	1.07	2.84	0.0107	-4.54	-0.0486	
13	*Cinnamomum impressinervium* Meisn.	0.54	1.42	0.0054	-5.23	-0.0280	
14	*Castanopsis hystrix* Hook & Thom. ex	1.61	1.42	0.0161	-4.13	-0.0664	
15	*Quercus lamellosa* Smith	2.50	2.84	0.0250	-3.69	-0.0922	
16	*Magnolia campbellii* Hook.f. & Thom.	9.46	4.97	0.0946	-2.36	-0.2231	
17	*Exbucklandia populnea* R.Br. Ex	0.36	1.42	0.0036	-5.63	-0.0201	
18	*Machilus edulis* King ex Hook. f.	0.71	2.13	0.0071	-4.94	-0.0353	

19	*Saurauia napaulensis* DC	0.36	1.42	0.0036	-5.63	-0.0201	
20	*Pieris ovalifolia* D Don.	1.07	2.13	0.0107	-4.54	-0.0486	
21	*Daphniphyllum himalayense* (Benth.)	0.54	1.42	0.0054	-5.23	-0.0280	
22	*Acer stachyophyllum* Heirn.	1.96	1.42	0.0196	-3.93	-0.0772	
23	*Elaeocarpus lanceaefolius* Roxb.	0.36	1.42	0.0036	-5.63	-0.0201	
24	*Rhododendron falconeri* Hook. f.	4.11	4.97	0.0411	-3.19	-0.1311	
25	*Tsuga dumosa* (D.Don) Eichler	1.07	2.84	0.0107	-4.54	-0.0486	
26	*Abies densa* Griffith. ex Parker	17.68	13.49	0.1768	-1.73	-0.3063	
27	*Rhododendron hodgsonii* Hook. f.	17.32	9.94	0.1732	-1.75	-0.3037	
28	*Betula utilis* D. Don	4.46	4.97	0.0446	-3.11	-0.1388	
29	*Rhododendron lanatum* Hook. f.	3.39	1.42	0.0339	-3.38	-0.1148	
30	*Rhododendron wightii* Hook. f.	0.54	1.42	0.0054	-5.23	-0.0280	

Density

The highest density was recorded for *Rhododendron hodgsonii* (915.6) followed by *Rhododendron barbatum* (540.0), *Abies densa* (535.6) and *Rhododendron falconeri* (424.4), respectively shown in **[Figure 3].** The maximum seedling density was encountered for *Rhododendron hodgsonii* (404.4) followed by sapling of *Rhododendron falconeri* (373.3) and adult of *Rhododendron hodgsonii* (295.6) were recorded.

PHOTO 3: Temperate Coniferous Forest

Some of the Rhododendron species found in Yuksam-Dzongri-Goechela trekking route in West Sikkim


PHOTO 4: Floret of *Rhododendron hodgsonii* & *Rhododendron griffithianum*


PHOTO 5: Floret of *Rhododendron falconeri* & *Rhododendron cinnabarinum*

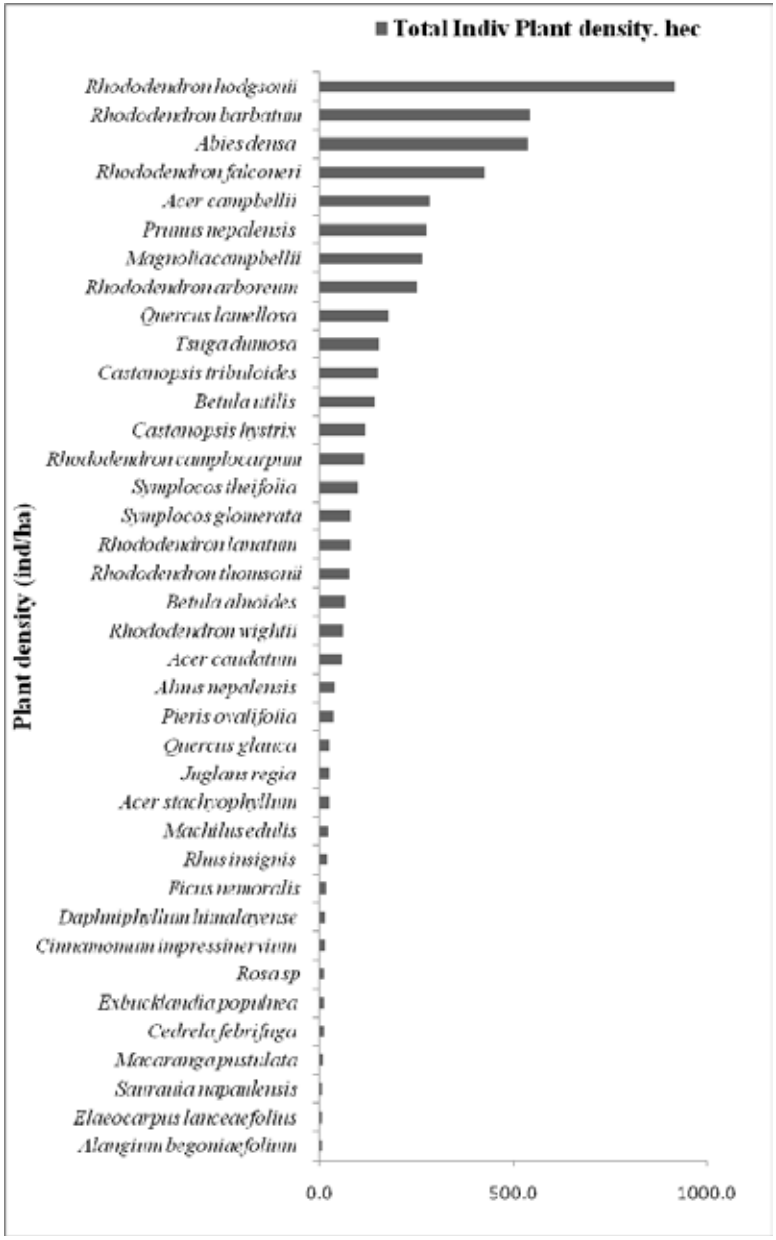

Figure 3: Plant density (ind/ha) along the sampling path

Importance Value index

The IVI values ranged 1.78 - 57.72 in different forest types in 45 sampling plots. The dominant species was recorded from *Abies densa* (57.72) followed by *Castanopsis tribuloides* (30.49), *Magnolia campbellii* (28.78) *Rhododendron arboreum* (16.39) and *Acer campbellii* (15.40) and *Quercus lamellosa* (15.03). The lowest IVI was recorded for *Saurauia napaulensis* (1.78) and *Exbucklandia populnea* (1.79) [(**Table 2)]**.

Table 2: Availability and distribution pattern of different life form in Yuksam-Dzongri Gochela sampling paths, West Sikkim

Name of the Species	Adult	Sapling		Seedling	
	IVI	Relative density	Relative frequency	Relative density	Relative frequency
Acer campbellii Hook. & Thom. Ex Hiern	15.40	7.86	6.83	2.50	2.28
Abies densa Griffith. ex Parker	57.72	5.44	9.10	9.58	9.86
Acer caudatum Wallich.	7.32	0.00	0.00	1.09	2.28
Acer stachyophyllum Heirn.	3.38	0.00	0.00	0.00	0.00
Alangium begoniaefolium (Roxb.) Baill	1.82	0.00	0.00	0.00	0.00
Alnus nepalensis D. Don.	2.25	1.01	1.52	0.33	1.52
Betula alnoides Buch. Ham. ex D. Don	5.72	1.51	2.28	0.33	1.52
Betula utilis D. Don	10.74	1.81	3.79	2.29	4.55
Castanopsis hystrix Hook & Thom.	6.89	4.13	6.83	0.33	1.52
Castanopsis tribuloides (Smith) A. DC	30.49	0.00	0.00	2.83	5.31
Cedrela febrifuga Blume	2.08	0.20	1.52	0.00	0.00
Cinnamomum impressinervium Meisn.	2.02	0.00	0.00	0.33	1.52
Daphniphyllum himalayense (Benth.) Mull.	1.98	0.30	1.52	0.00	0.00
Elaeocarpus lanceaefolius Roxb.	2.10	0.00	0.00	0.00	0.00
Exbucklandia populnea R.Br. Ex Griff	1.79	0.30	1.52	0.00	0.00
Ficus nemoralis Wall	0.00	0.20	1.52	0.54	1.52
Juglans regia Linn	2.01	0.50	1.52	0.33	1.52
Macaranga pustulata King.	2.03	0.00	0.00	0.00	0.00
Machilus edulis King ex Hook. f.	3.15	0.00	0.00	0.54	1.52
Magnolia campbellii Hook.f. & Thom.	28.78	3.23	3.79	3.70	3.79
Pentapanax leschenaultii Seem	2.00	0.00	0.00	0.00	0.00
Pieris ovalifolia D Don.	3.39	0.60	1.52	0.44	1.52
Prunus nepalensis (Ser) Stendel	13.93	4.03	3.03	6.53	4.55
Quercus glauca Thunb	5.24	0.40	1.52	0.22	1.52
Quercus lamellosa Smith	15.03	3.02	3.79	3.92	3.79

Rhododendron arboreum var. *roseum* Linn	16.39	2.42	3.79	5.88	3.79
Rhododendron barbatum Hook. f.	0.00	13.51	6.83	11.86	5.31
Rhododendron camplocarpum Hook. f.	0.00	2.42	3.79	3.05	3.79
Rhododendron falconeri Hook. f.	9.97	16.94	6.07	0.00	0.00
Rhododendron hodgsonii Hook. f.	30.03	13.41	8.34	19.80	10.62
Rhododendron lanatum Hook. f.	5.31	0.81	1.52	0.98	1.52
Rhododendron thomsonii Hook. f.	0.00	2.52	2.28	1.09	1.52
Rhododendron wightii Hook. f.	2.04	1.71	1.52	0.76	1.52
Rhus insignis Hook.f.	2.14	0.50	1.52	0.00	0.00
Rosa sp	0.00	0.50	1.52	0.00	0.00
Saurauia napaulensis DC	1.78	0.00	0.00	0.00	0.00
Symplocos glomerata King	0.00	2.62	3.03	1.09	3.03
Symplocos theifolia D. Don	0.00	4.13	3.79	0.33	1.52
Tsuga dumosa (D. Don) Eichler	5.56	2.72	3.03	3.81	1.52

Distribution patterns & Humus depth

Distribution patterns of plant species in different forest types were studied. In general, contagious distribution is common in the study sites. Correlation between the humus depths and the number of individual species were also studied to ascertain the regeneration pattern of seedlings and sapling and maximum number of species was recorded at 1.5 cm humus depth in entire sampling path.

SHRUB DIVERSITY

The common shrub/scrub encountered were *Polygonum molle, Anaphalis* sp., *Artemisia vulgaris, Berberis insignis, Daphne cannabina, Edgeworthia gardeneri, Mahonia sikkimensis, Rosa sericea, Rubus ellipticus, Rubus lineatus, Vaccinium nummularia , Viburnum cordifolium, Gaultheria* sp., and *Cassiope fastigata*. Among the shrub species maximum diversity was encountered in family Ericaceae (13) followed by Rosaceae (4) and Berberidaceae (2) **[Figure 5]**.

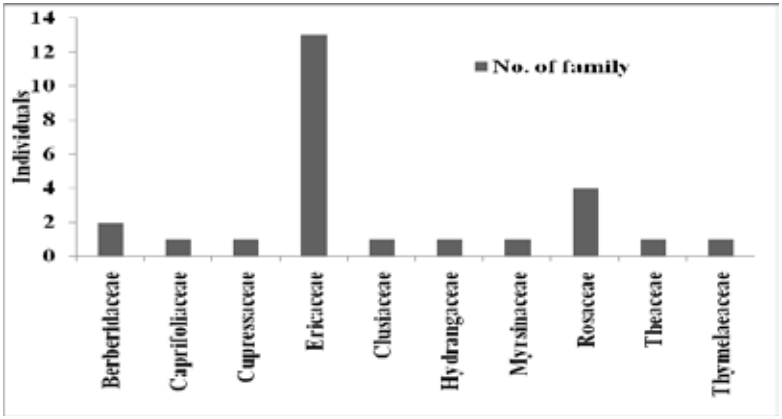

Figure 5: Family-wise species composition of shrub

HERB DIVERSITY

Herbaceous flora were dominant in family Asteraceae (6) followed by (5) Cyperaceae, Araceae, and Urticaceae [Figure 6]. The common herbs were *Arisaema* sp., *Bidens pilosa, Commelina benghalensis*, *Cyanodon dactylon, Elatostema* sp., *Eupatorium adenophorum, Gnaphalium* sp., *Hydrocotyle javanica*, *Juncus* sp., *Oxalis corniculata*, *Persicaria* sp, *Pilea* sp., *Pouzolzia* sp., *Swertia bimaculata*, *Swertia chirayita*. The ground surface is covered with the diverse fern species and rocky surfaces are fully covered by mosses (*sphagnum squarrosum*). The lichen *Usnea sikkimensis* can be seen hanging from branches of *Abies densa* and some of *Rhododendron* trees.

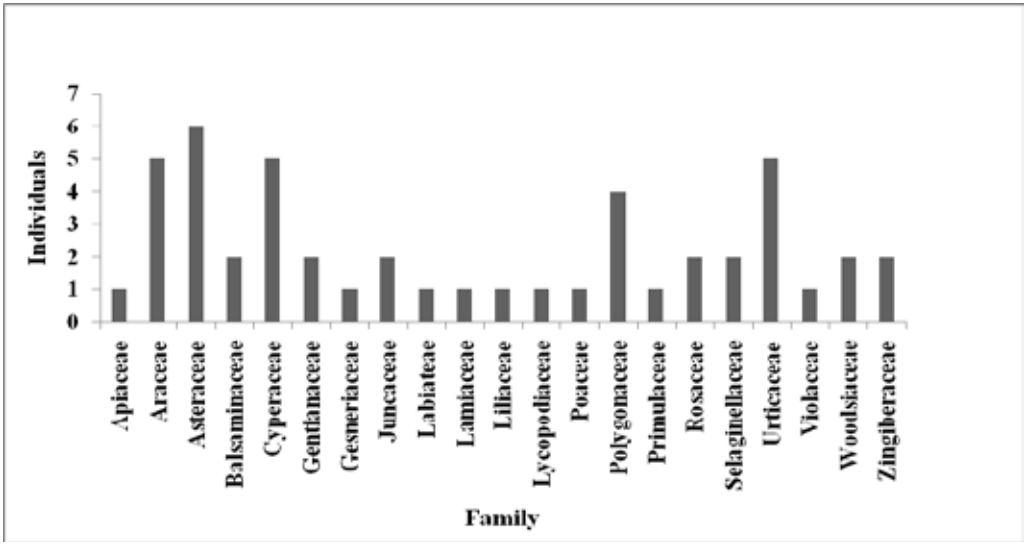

Figure 6: Family-wise species composition of herb & fern& fern-allies

DISCUSSION

The contribution of plant species richness from the study sites to the total floral diversity of KBR is considerable. The present account of 129 species belonging 61 families along the Yuksam-Dzongri-Goechela trekking routes and Khera *et al.,* (2001) reported 92 species different forest types. KBR is home to at least 140 endemic plant species spread over 41 families mention by Sharma *et al*. (2001). The species diversity and richness patterns of three different forest types were largely influenced by elevation. A downhill trend in species richness with altitude has previously been reported by several workers (Yoda 1967; Grytnes *et al*, 2002). A study area within the KBR is characterized by complex topography, which includes variation of slope, angle and aspect. The tree communities from temperate broad-leaved forest and temperate coniferous forest are characterized by high diversity of species richness as compared to alpine region. The diversity of tree species decreased with increased in elevation. It is clear that the forests in KBR are strongly influenced by elevation. Present study reported the maximum numbers of families from Ericaceae (35) followed by Fagaceae (11) and Rosaceae (10). This substantiates the similar studies made by earlier researchers in the region (Subba et al., 2015). This may be due to high diversity of *Rhododendron* species (20) in the region and contribution from associate species from family Ericaceae, viz., *Gaultheria, Cassiope, Pieris and Vaccinium.* In Sikkim, the most dominant families of flowering plants are Asteraceae (36%) as reported by (Singh & Sanjappa, 2011) & Subba *et al*., 2015). In present study, the maximum herbaceous species was recorded from Asteraceae (6) followed by (5) of Cyperaceae. The maximum shrub species diversity was reported from family Ericaceae (13) followed by Rosaceae (4) and Berberidaceae.

The higher frequency of tree was recorded within 1867 - 1976 m in temperate broad-leaved forest. There was total absent of adult tree species along 3930-4058 m in the alpine zone due to unfavorable climatic condition. Tree species viz., *Abies densa*, *Rhododendron hodgsonii, Acer campbellii, Prunus nepalensis, Castanopsis tribuloides, Magnolia campbellii*, *Rhododendron falconeri*, *Betula utilis* and *Rhododendron arboreum* var. *roseum* were recorded in the lower elevation zone.

Seedlings are the major structural and functional basis of temperate forest and can serve as robust indicator of regeneration practices which can balance forest (Philip *et al*., 1994). In the study sites, highest species diversity was recorded from seedlings followed by sapling and adult tree. This indicates that three forest types along trekking corridors might be under the influence of disturbance factors.

Contagious distribution pattern is common in the study sites. Tree species including seedlings and sapling showed contagious distribution pattern. This may be due to mountainous topography of the region. Contagious distribution is also influenced by local habitat, seasonality and reproductive behaviour. Odum (1971) also stated that random distribution is found in uniform environment and regular distribution occurs where competition between individuals are high.

The dominant species encountered in the study sites include *Abies densa* (57.72) followed by *Castanopsis tribuloides* (30.49), *Magnolia campbellii* (28.78), *Rhododendron arboreum* (16.39), and *Acer campbellii* (15.40) & *Quercus lamellosa* (15.03) in their descending order of IVI. The IVI potrays the phyto-siociological structure of a species in the community. The IVI also provide great help in giving the overall picture of the ecological significance of a species in the particular ecosystem. The highest IVI value of *A. densa* indicates that most of the available resources are used by this dominant species and residual resources are being trapped by the other associated competing species. The present rapid biodiversity assessment found that the temperate coniferous forest and broad-leaved forest have high plant diversity than the Alpine zone of Yuksam-Dzongri-Gochela sampling paths in West Sikkim. However, it warrants that rapid survey needs to be conducted on a seasonal basis to get the overall picture of alpha diversity of the species in the study sites.

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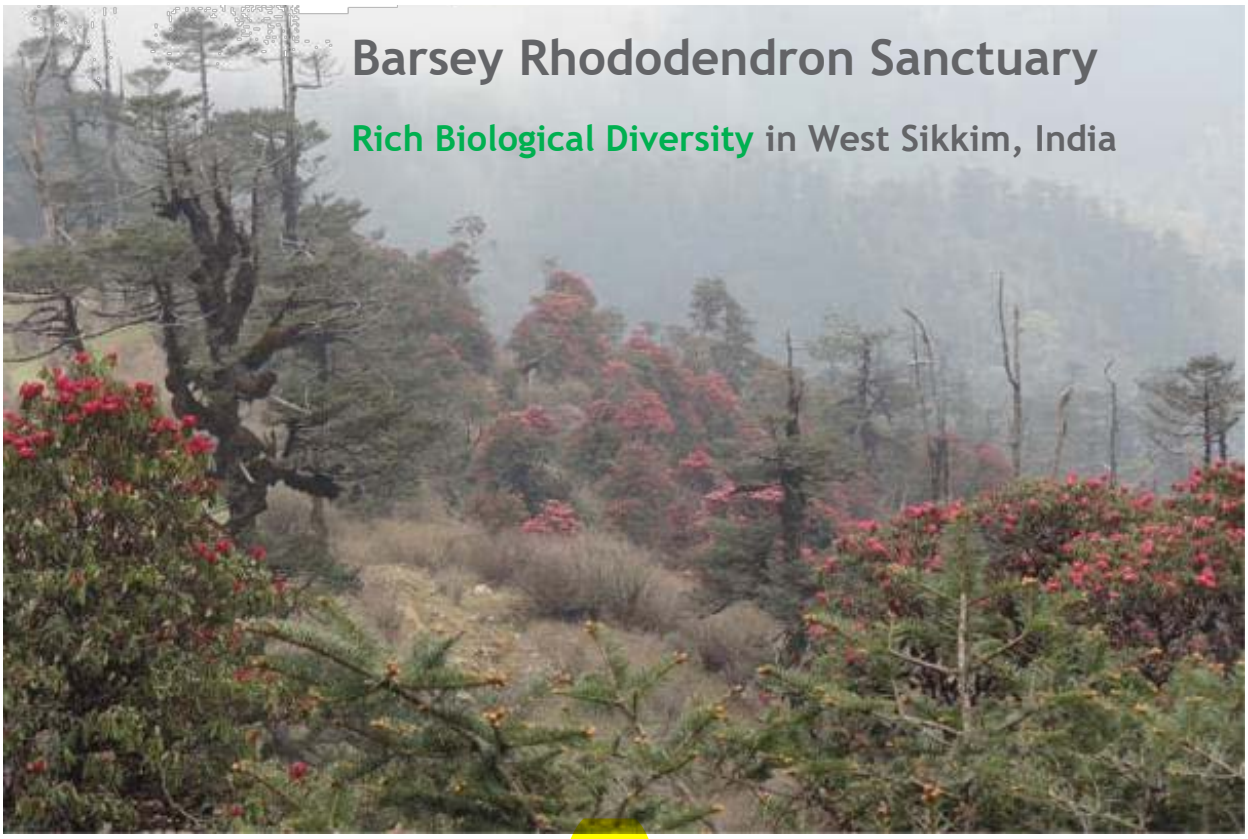

Barsey Rhododendron Sanctuary

Rich Biological Diversity in West Sikkim, India

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Barsey Rhododendron Sanctuary located in the West District of Sikkim, established in 1998, occupies an area of 104 km^2 sharing its border with Nepal in the west and West Bengal in the south over the Rambong Khola in the Singalila Range **(Photo 1)**. The altitudinal gradient of 2200–4100 m asl provides a wide range of topography leading to various forest types viz., sub-tropical moist deciduous forest (2200–2400 m), wet temperate forest (2400–2700 m), moist temperate forest (2700–3250 m), sub-alpine forest (3200–4000 m) and alpine meadows (>4000 m) as mentioned by Sharma (2001). The sanctuary harbours over dozen of rhododendron species, pure patches of *Lithocarpus pachyphylla* and many epiphytes, climbers, ferns and fern-allies, moss and lichens. Barsey Rhododendron Sanctuary is a biologically diverse sanctuary and famous for its rhododendron stand which blooms usually between April and May. The climate is wet and cold which is highly favorable for the growth of rhododendrons. July is the wettest month of the year and temperature is not less than 17°C. According to the In-charge of BRS, Mr. Samden Sherpa, Hilley gives the best view of sunrise while Barsey gives a splendid

Photo 1: Entry point of Barsey Rhododendron Sanctuary

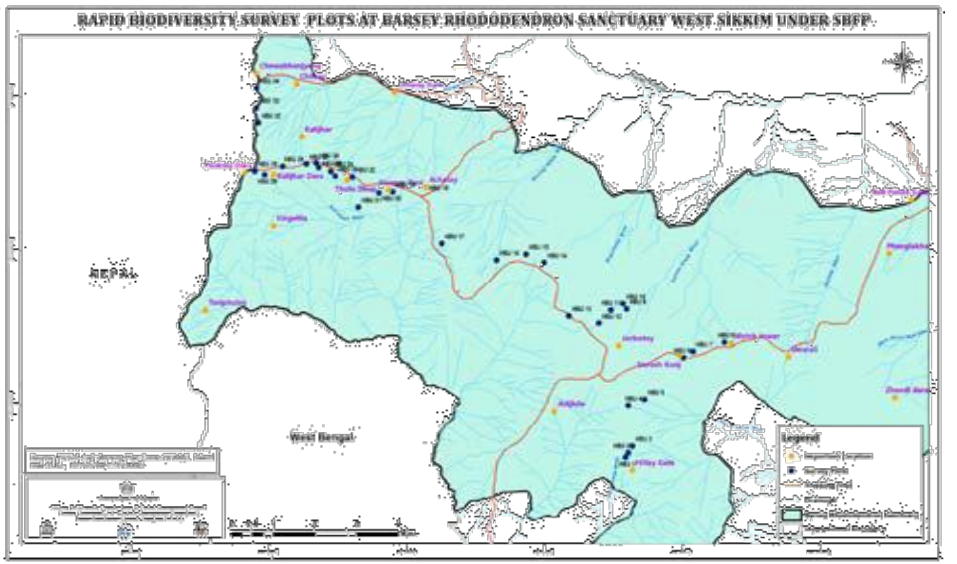
view of Mt. Kanchendzonga, Mt. Pandim and Mt. Sinolchu, etc., which becomes more picturesque between October and November. The sanctuary is also home to many faunal species, viz., Red panda, Wild Boar, Himalayan Black Bear, Barking Deer, Serow, etc. Barsey is famous for "Red panda" (*Ailurus fulgens*) which is the State Animal of Sikkim. The dense forests of *Lithocarpus pachyphylla* provides shelter as well as abundant fruits and as such are good indicators of faunal presence and richness **(Photo 2 & 3).**

Photo 2 & 3: Spotted Laughing Thrush and Verditer Flycatcher

RAPID BIODIVERSITY SURVEY

Rapid biodiversity survey was conducted along Hilley–Barsey–Sano Dhaap– ThuloDhaap–Kalijhar–Phoktay Dara–Chitray–Chewabhanjyang–Uttarey trekking route (ca. 40 km) in proximity to the Singalila Ridge. From Hilley to Chewabhanjyang, 33 random sampling plots were laid. We covered the temperate rhododendron forest, temperate coniferous forest and sub-alpine zone between 2700 m and 3600 m asl.This Sanctuary can be reached from three separate points, viz., Hilley, Dentam and Soreng and this work commenced from Hilley which is the main entry point for Barsey Rhododendron Sanctuary. Barsey is only four and a half km distance from this point. Hilley is a beautiful place with a variety of rhododendron and a magnificent mountain view. Early morning, we can effortlessly see the mesmerizing beauty of sun rising along with colorful birds singing in the background **(Photo 4)**.

Photo 4: Sun rise view from Hilley, West Sikkim



Map: Rapid Biodiversity Survey sites along Barsey Rhododendron Sanctuary sampling path

Additionally, avifauna were encountered, viz., Spotted Laughing Thrush, Himalayan Large-Billed Crow, and many other birds were seen during the survey, and the calls of birds were identified and recorded by the local guide. The vegetation from Hilley to Barsey is a trail of rhododendron diversity flowering along with many other medicinal plant species like *Paris polyphylla*, reed-bamboo, oaks and *Primula* species. The pure patches of *Lithocarpus pachyphylla* species were inventoried with *Rhododendron arboreum* (pinkish-rose and rosy-red forms). The *rhododendron* species available between Hilley and Barsey are *Rhododendron arboreum*var. *arboreum, R. griffithianum, R. falconeri* and *R. grande*along 2700–2800 m asl. Amongst these, *R. arboreum* (both pinkish-rose and rosy-red forms) has a broad range of distribution and was observed up to 3400 m asl at Kalijhar top (Phoktay Dara) along the trail (**Photo 5)**. Worldwide, this *R. arboreum* is also distributed along 1500–3800 m asl from Pakistan to SE Tibet in the Himalayas (www.eFloras.org).

Photo 5: *Rhododendron arboreum* in flowers at Kalijhar top (3400 m asl)

It is also an indicator of keystone species which is widely distributed from temperate forest to temperate coniferous forest along with many tree species viz., *Lithocarpus pachyphylla*, *Betula utilis*, *Magnolia campbellii*, *Acer* sp., *R. falconeri*, etc. The common shrubs which were inventoried during the entire sampling plots were *Viburnum erubescens, Daphne cannabina, Rosa sericea, Berberis* sp., etc.

Photo 6: Rhododendron arboreum floret at 3600 m asl

R. arboreum has high medicinal properties. The flower is used to cure tonsillitis, cough and cold. Common local belief is that the flower petal is used when fish bones get stuck in throat. After blooming, the petals fall in the ground and these are used to make wine and alcoholic beverages. It is in high demand in local market fetching Rs. 300 per bottle of wine and Rs. 200 per bottle of Raksi (local millet brew) which is considered beneficial for health too. The juice of the flower is used in the treatment of menstrual disorders **(Photo 6)**.

Barsey is not only famous for rhododendron but also for nature lovers owing to its rich biological diversity, beautiful view of landscape and for birds and butterflies too. As per the forest record, most of the visitors especially the local people usually trek up to Barsey and only 5% international tourists visit the area up to Singalila Ridge. At Barsey, we found the prized rhododendron species, viz., *Rhododendron barbatum* (Vulnerable status under IUCN) and pure stand of *Rhododendron falconeri* (**Photo 7 & 8)**.

Rhododendron arboreum, *R. barbatum* and *R. falconeri* are widely distributed along the sampling path. Next morning, we started our trek from Barsey to Sano Dhaap which is approximately 12 km stretch. On the way, we laid random sampling plots and inventorised the plant species enjoying the beautiful rhododendron flowers, beautiful landscape and the virgin undisturbed forest.The prominent rhododendron species available between Barsey and Sano Dhaap are *Rhododendron falconeri* and *R. arboreum* along with *Lithocarpus pachyphylla, Symplocos theifolia*, *Magnolia campbellii* with shrub species like *Vibrunum erubescens, Daphne cannabina* and *Ilex* sp. which are most prominent at 2835 m asl. Sano Dhaap or Deonigale Dhaap is famous for the reed-bamboo which is called as *Sinarundinaria macrophylla* (locally called "Deonigale") and widely distributed in Barsey trekking route in West Sikkim

(Photo 9). In Sikkim, this bamboo is found only in Barsey Rhododendron Sanctuary at DeonigaleDhap. It has high medicinal property where the smoke of leaves is used during headache and common cold as workedout by National Bamboo Mission, H&CCDD, Govt. of Sikkim.

Photo 7 & 8: *Rhododendron barbatum* and *Rhododendron falconeri*

Photo 9: Deonigale bamboo at Sano-Dhaap

Sinarundinaria macrophylla is densely tufted, shrubby bamboo, culm-sheaths deciduous, 10-11 cm long, leaves 5-10 cm long, leaf sheaths 4 cm long striate, ending above into narrow ciliate callus. The barking deer was sighted at the Sano-Dhaap area which is the habitat of *Sinuarundina macrophylla*.

Next morning above Sano Dhaap–ThuloDhaap, the first epiphytic rhododendron species were recorded along 2810 m asl, latitude 27◦13'48.5" & Longitude 88◦05'17.8". This was *Rhododendron dalhousieae* coming up on the common shrub *Vibrunum erubescens* and also on *Magnolia campbellii, Acer* sp., and *Rhododendron falconeri*. Similarly, in FambongLho Wildlife Sanctuary, this species is distributed along 1900–2000 m attached to the oak species and also reported at Bulbuley Reserve forest, East Sikkim.

Next morning, our destination was to reach Kalijhar from Thulo-Dhaap, on reaching elevation at 3000 m asl, temperate broadleaved forest plant species is replaced by temperate coniferous tree species, viz., *Abiesdensa, Magnolia campbellii,Betula* sp. The most pure habitat of *Rhododendron barbatum, R. arboreum, R. hodgsonii*were recorded along with other tree species such as *Lithocarpus pachyphylla, Tsuga dumosa, Acer campbellii*.

Most of the tourists, especially tourists from abroad take this route to reach the Singalila Range. On the way from Sano-Dhaap, there is different trek route that leads to Singalila range via Phalut&Sandakphu and another one is from Kalijhar via Chewabhanjang-Uttarey. The Singalila range which contains the Singalila National park is situated on the western side of the BRS and acts as the international border for Nepal and India (West Bengal; **Photo 10**).

Photo 10: Overview of Singalila Range along the trail

On reaching the higher elevation, *Magnolia campbellii* and *Rhododendron falconeri, Rhododendron arboreum*is widely distributed with *Acer pectinatum* and *Acer palmatum*. The seedling emergences of many species are very high as compared to other sanctuary. That means regeneration process in the forest is much higher for future plant communities and for healthy forest ecosystem. *Magnolia campbellii* was found in full bloom. Patches of *Gaultheria nummularioides* are commonly encountered which densely covers the ground surface along the trekking route. *Vaccinium* species is epiphytic in nature and was found to favour the *R. arboreum* tree. With increase in elevation, *R. arboreum* is seen in two colors of petals blooming i.e., pink rose and red form covering the entire forest making it look like ocean of rhododendron flowers (**Photo 11**).

Photo 11: View of flowering *Rhododendron arboreum* along the sampling path

The scrub species, viz., *Gaultheria nummularioides* is widely distributed along the entire path and herbs along with *Fragaria nubicola*, *Voila* sp., *Hemiphragma heterophyllum*, *Sambucus* sp., *Rubus* sp., *Primula* sp., etc. *Rhododendron hodgsonii* which was in full bloom was most widely distributed between 3000 m and 3400 m asl with scrub like *Berberis* sp., *Rhododendron lepidotum* was found in its vegetative stage, most common shrubs *Viburnum erubescens* and *Daphne cannabina* were also in full bloom.

Many beautiful avians can be encountered on the way to Kalijhar. In *Rhododendron hodgsonii* forest, we spotted the state bird of Sikkim, the Blood Pheasant, both male and female, at 3352 m asl**(Photo 12 & 13)**. This area has a dense presence of *R. hodgsonii* as well as *Abies densa*, *Viburnum erubescens, Daphne cannabina, Rosa sericea*, *Spiraea bella*, etc.

Photo 12: Sighting of Blood Pheasant **(male) at 3352 m asl**

At the point of Kalijhar, we came across the tree line. Within rhododendron variety, the two species i.e., *Rhododendron hodgsonii*& *Rhododendron lepidotum* were found in patches. Some of the *rhododendron* species is in vegetative stage and was difficult to identify. Scrubs of *Berberis* species were distributed in the entire area and also the herb, *Cirsium* sp. was found in plenty.

Above Kalijhar, there is a small hillock, the Phokteydara, which is the viewpoint for Singalila Range. Phoktey Dara is a rocky and windy place and *Cirsium* species was also recorded from here. Chewabhanjang is the end point and there is an international border between India and Nepal. Somewhat similar vegetation was recorded in and around the Chewabhanjang surrounding (**Table 1**).

Photo 13: Sighting of Blood Pheasant **(female) at 3352 m asl.**

Photo 14: *Rhododendron hodgsonii* **along the sampling path**

Table 1: Checklist of Tree species encountered in Barsey Rhododendron Sanctuary

SN	Botanical name	Local name	Family	Altitudinal Distribution (m asl)	IUCN/ Regional Status
1	*Abies densa* Griffith. ex Parker	Gobreysalla	Pinaceae	2800- 3700	LC
2	*Acer campbellii* Hook. & Thom. ex Hiern	Kapasay	Aceraceae	1800-2700	NA
3	*Acer palmatum*	Kapasay	Aceraceae	2500- 3000	NA
4	*Acer pectinatum* Wall. ex Nicholson	Lekhkapasay	Aceraceae	2300-3700	NA
5	*Betula utilis* Don	Bhojpatra	Betulaceae	2500-3800	LC
6	*Lithocarpus pachyphylla* (Kurtz.) Rehder	Sungureykatus	Fagaceae	1800-2700	NA
7	*Machilus* sp.	Kawlo	Lauraceae	1500-2100	NA
8	*Maddenia himalaica Hook. f. & Thom.*		Rosaceae	2400-3000	NA
9	*Magnolia campbellii* Hook. f. & Thom.	Ghogey champ	Magnoliaceae	2400-3100	LC
10	*Rhododendron arboreum* (CB Clarke) Ridley.	Laligurans	Ericaceae	1800-3600	NA
11	*Rhododendron barbatum* Wall. ex G. Don	Lal chimal	Ericaceae	3000-3700	Vulnerable
12	*Rhododendron dalhousieae Hook. f. & Thom.*	LahareChimal	Ericaceae	1500-2500	NA
13	*Rhododendron falconeri* Hook. f	Khorlinga	Ericaceae	2700-3000	NA
14	*Rhododendron grande* Wight	Patleykhorlinga	Ericaceae	2000-3000	NA
15	*Rhododendron griffithianum* Wight	SetoChimal	Ericaceae	1800-3200	NA
16	*Rhododendron hodgsoni* Hook. f	Khorlinga	Ericaceae	3000-4000	NA
17	*Sorbus* sp.	Lekpasi	Rosaceae	2700-5400	NA
18	*Symplocos theifolia*	Kharanay	Symplocaceae	1900-2500	NA
19	*Tsuga dumosa* (D. Don) Eichler	Tengresalla	Pinaceae	2500-3000	LC

NA -Not Assessed, LC -Least Concern

IMPORTANCE OF BARSEY RHODODENDRON SANCTUARY

Barsey Rhododendron Sanctuary is in-situ conservation of genetic resources in natural population is the process of protecting the endangered plant and animal species in its natural habitat. According to our observation, we could suggest five important aspects of Barsey Rhododendron Sanctuary:

1. Over a dozen of rhododendron species (with one under Vulnerable status of IUCN, i.e., *Rhododendron barbatum*) found in this area.
2. State Animal Red Panda Habitat.
3. State Bird Blood Pheasant Habitat.
4. Reed-bamboo Deonigale (*Sinuarundinaria macrophylla*) Habitat.
5. Best trekking route for Singalila Range.

CONCLUSION

There are two protected areas for the rhododendrons in Sikkim where Barsey is one of them which has rich biodiversity and less anthropogenic footprint as compared to the Shingba Rhododendron Sanctuary. The BRS forest community appears to be categorically rich in number of tree and shrub species compared to the Shingba Rhododendron Sanctuary. Seedling emergence is very high under the canopy and also all over the trail. This shows good regeneration potential for next generation providing a natural balance for the prevailing ecosystem. The species composition of forest depends on the regeneration of species in the forest. There are several indications presented by the present study in terms of conservation that must be addressed almost every time for the sustainability of nature and natural

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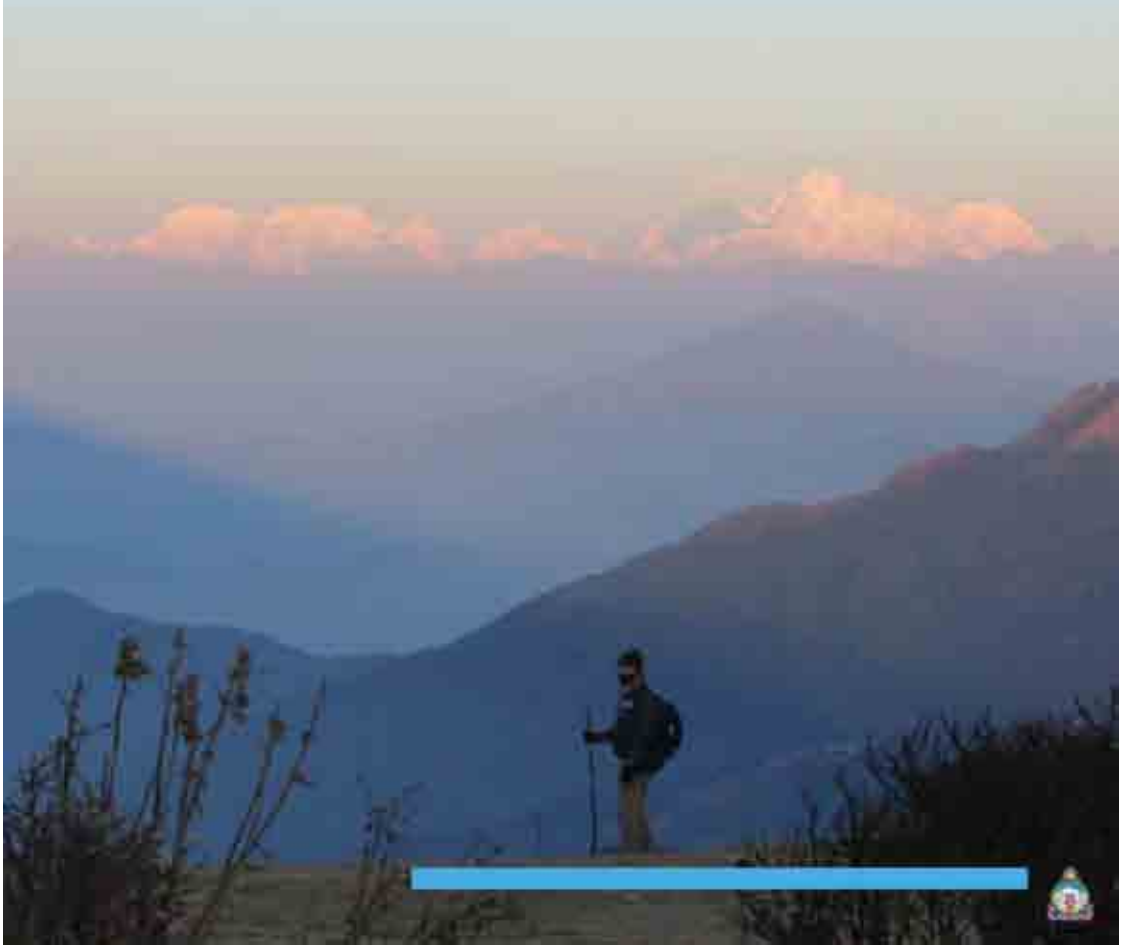

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RESEARCH ARTICLE

RAPID BIODIVERSITY SURVEY OF KYONGNOSLA ALPINE SANCTUARY, SIKKIM, INDIA

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ABSTRACT

Rapid Biodiversity Survey of Kyongnosla Alpine Sanctuary (3000 - 4200m) records an occurrence of 151 floral species, of which, population assessment of 71 species was done. There were only three trees species recorded from the sub-alpine area of the sanctuary, namely *Abies densa*, *Acer pectinatum* and *Betula utilis* out of which *Acer pectinatum* and *Betula utilis* were found rare in the area. Some high valued and globally threatened medicinal plants of the Himalayas including seven species of *Aconitums* were recorded namely *Aconitum violaceum*, *A.novoluridum*, *A.palmatum*, *A.disectum*, *A.ferox*, *A.spicatum* and *A.laciniatum,* of which *A.novoluridum, A.violaceum* and *A.laciniatum* were re-discovered after more than a century after the monographic work of Stapf during 1905 on Aconites of India, which was based on the collections made by earlier worker (Hooker, 1854). Some other threatened medicinal plants species such as *Neopicrorhiza scrophularia*, *Gymnadenia orchidis, Fritillaria cirrhosa, Sassurea gossipiphora, Sassurea obvallata, Rheum nobile, Allium prattii, Sinopodophyllum hexandrum, polygonatum singalilense, Valeriana jatamansii, V.hardwickii, Veratrilla baillonii, Gentiana elwesii,* etc. were recorded from the area with very less number of population, for which immediate conservation measures are recommended. Apart from floral species, an inventory of faunal species was done which records an occurrence of 9 mammalian species and 20 bird species through direct and indirect evidences.

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INTRODUCTION

India is known for rich repository of plant wealth having more than 17,500 wild plant species and of these over 4,000 species have medicinal values (Ayensu, 1996). Sikkim being an integral part of eastern Himalaya with an area of 7096km^2 falls under Himalayan (2) Bio-geographic zone and Central Himalaya (2c) biotic province. Its altitude varies from 225m in the south to 6100m in the north and north-east and 8598m in the north-west and constitutes a diverse habitat for both flora and fauna. India is one of the twelve mega diversity centers of the world. Himalayan region of India, especially the North-Eastern part including Sikkim state have been the repository of medicinal plants in conventional use since long directly or indirectly in the modern medicine system, hence plays an imperative role in the cultural and economic expansion of the region (www.nmpb.nic.in). Sikkim state harbour over 4500 species of flowering plants, 410 pteridophytes (Kholia, 2014), over 16 species of conifers, 39 species of Rhododendrons (Dahal *et al.,* 2017), Bamboos over 20 species, medicinal plants 490 species (Sharma & Sharma, 2010), Primulas over 30 species, Mammals over 144 species, Birds 550 species, fishes over 48 species, butterflies over 600 species. An account of the rich biodiversity of the state has been provided by Hooker JD (1872-1897), Stapf .O (1905), Kumar S and Singh V (2001), Gammie GA (1893), Polunin. O and Stainton. A (1984), Lucksom S.Z. (2007), Sharma & Sharma (2010), Hooker JD (1849), Arrawatia and Tambe (2011), Ali. S (1989), Kholia (2010), Kholia (2014), Das (2009), Maiti and Maiti (2007), S (2015-16)**,** Pradhan & Badola (2008), Pradhan KC (2008), Pradhan UC and Lachungpa ST (1990), Pradhan BK *et al* (2013), Pradhan BK *et al*. (2015), Dahal (2015-16) in the form of flora, orchids, medicinal plants, Rhododendrons, ferns and ferns allies, avifauna, mushrooms etc. In order to protect such a rich bio-resources of the state, 46.93% of the total geographical area of Sikkim has been brought under the Protected Area Network (PAN) within the four broadly classified vegetation zones viz.; Tropical, Temperate, Sub-alpine and Alpine regions. Recently during 2015, Forest, Environment and Wildlife Management, Government of Sikkim have come out with the Rapid Biodiversity Survey

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Report – I and Rapid Biodiversity Survey Report –II after conducting Rapid Biodiversity Survey along various sampling paths in Fambong Lho Wildlife Sanctuary (East Sikkim), Khangchendzonga Biosphere Reserve (West Sikkim & North Sikkim), Maenam Wildlife Sanctuary (South Sikkim), Shingba Rhododendron Sanctuary (North Sikkim) etc. Of the seven protected areas of Sikkim, Kyongnosla Alpine Sanctuary is the one having rich diversity of sub-alpine to alpine biological wealth, but has remain unexplored till date. Rapid Biodiversity Assessment approach is a tool developed by Conservation International for Systematic biodiversity data collection and has been well accepted throughout the world. It is a medium of quickly collecting information on the floral and faunal species present in a given area and provides key information that can be used to manage and protect species of conservation concern and overall biodiversity. Under Biodiversity Conservation Component of SBFP (Sikkim Biodiversity Conservation and Forest Management Project), Rapid Biodiversity Survey is being carried out in different protected areas, buffer zones and reserve forests of Sikkim to develop baseline information on key biological elements in the forest for long term monitoring and evaluation of the impacts of changes in the forest, and biodiversity management and to identify critical areas that require immediate protection and bring the data set so produced under the Geo Spatial platform. As sub - alpine and alpine forests are considered to be potentially prone to the adverse effects of climate change, present study also provide important baseline information for future evaluation of the impact of climate change on sub-alpine and alpine forest communities.

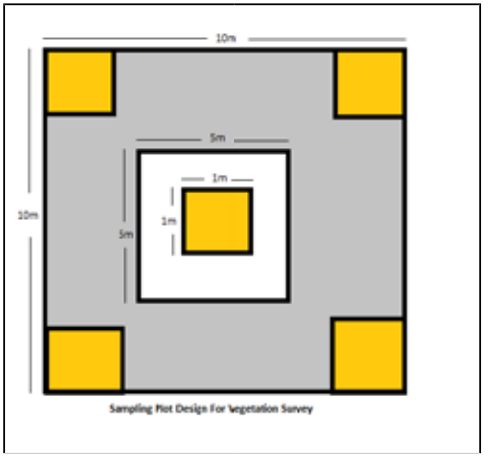
Study Area

The current field survey was carried out along Nakchok – 17th mile Sampling path in Kyongnosla Alpine Sanctuary in the Eastern Himalaya of Sikkim (Figure 1) during the month of August 2016. The area of the sanctuary is 31 km^2 and is located between 3000 meters to 4200 meters. The forest types of the sanctuary were represented by sub alpine – alpine type (Plate 1). In the east, the boundary of the sanctuary extend along the Rong-chu ridge upto Natso; in the west, it runs along the Kyongnosla ridge towards north ending near Kyongnosla police check post at J.N.Road; in the north, it runs from Natso peak along the bridge upto Kyongnosla ridge and in the south the sanctuary runs along the J.N.Road starting from 5th mile check post extending upto Rangchu ridge. The slope angle of the area ranged between mild (5 degree) to stiff (50 degree) and was faced towards E, N, NW and NE aspect (Annexure I). The sanctuary is one of the wildlife protected areas of Sikkim which was first notified as the Kyongnosla Alpine Wildlife Sanctuary by the Government of India vide Notification No. 45/WL/83/625 dated 29.08.84; extended vide 45/WL/F/92/ 1585/F & WL dated 05.12.1992. This sanctuary belongs to the bio-geographical zone 2C (Central Himalaya) as recognized by Wildlife Institute of India, Dehradun. The area around the sanctuary is notified as the Eco-Sensitive Zone by the Central Government with the purpose of protecting and conserving the biodiversity of the sanctuary and its environment. The extent of this zone varies from 25 m to 200 m from the boundary of the Sanctuary. It is bounded by 27°22'5" N latitude and 88°41'54" E longitude towards east; 27°23'41" N latitude and 88°42'48" E longitude towards west; 27°25'13" N latitude and 88°43'49" E longitude towards north; and 27°22'36" N latitude and 88°43'50" E longitude towards south. The sanctuary constitutes a diverse habitat for both flora and fauna and is an abode to the wide range of topographical landscape harbors some rare, endangered species, high value and the rare medicinal plants, and the lower elevation is occupied with tall *Junipers*, *Rhododendron* thickets with scattered *Abies densa* and somewhere with bamboo thickets. The major significance of this sanctuary is the number of scheduled animals it harbors [specified in Schedule I of the Wildlife (Protection) Act, 1972] which are given maximum protection in the National level as well as having the main inhabitant in the form of Red Panda and different species of Gallinaceous Birds and Pheasants.

Methodology

Inventory and monitoring of the biodiversity of Kyongnosla Alpine Sanctuary were done using Rapid Biodiversity Survey Techniques (RBST). Prior to field work, literatures were scrutinised to have a general idea about the biodiversity of the area (Polunin and Stainton, 1984; Stainton, 1988; Hooker, 1871-1897; Sharma and Sharma, 2010; Dahal S. 2015-16; Arrawatia & Tambe, 2011; Lachungpa *et al*., 2007; Kholia, 2010 & 2014; Das 2009; etc.) including web references such as (www.efloras.org; www.flowersofindia.net etc.). The checklist of the species (both flora and fauna) was prepared and was taken to the field to confirm their presence in the study area. During the field work, general listing of all the species occurring in the area (both flora and fauna) were made to have fair knowledge on the biodiversity of the area.

In the field, the quantitative as well as qualitative data on floral biodiversity was recorded using a Standard Quadrat Sampling method, wherein, a random plot of 10m x 10m were established which was followed by lying of plot after every 0.5 to 0.6 km approximate distance. Within the plot, all the tree species were listed and the individual tree width CBH> 30 cm (1.3 m above the ground) was measured. Within the mother plot, a quadrat of 5m x 5m was laid in the centre to record the number of saplings present; the same quadrat was used to record the percent cover of the shrub species. 5 number of 1m x 1m quadrat were laid; 2 at the alternate corners of the 5m x 5m quadrat and 1 at the centre for recording the percent cover of the herb species; the same quadrat was used to record the number of seedlings.



Sampling Plot Design For Vegetation Survey

General listing of all the species (flora) encountered along the sampling plots as well as outside were also done to have fair idea on the species availability in the area. Parameters such as coordinates and altitude of each sample plots were recorded using hand held GPS; slope aspect and slope angle of each plots were also recorded.

In case of trees, recorded data were analyzed for density, frequency, abundance, basal area etc. Importance value index (IVI) was determined as the sum of percentage density and percentage basal area. Species diversity for each plot was determined with the Shannon and Wiener information function, which reads as $H'=-\Sigma(ni/N) \log_2 ni/N$, where 'ni' represents total number of individuals of particular species, and 'N' represents total number of individuals of all species. Species richness was calculated using Margalef's index as $I=(S-1)/\ln(N)$, where 'S'=the number of species in the sample and 'N'=the total number of individuals in the sample. Species evenness was determined by Shannon index of evenness as, $E=H/Ln(S)$ where 'H'=Shannon' Index of diversity and 'S'=number of species in the sample. Concentration of dominance was measured by Simpson's Index, which reads as, $D=\Sigma(n_i/N)^2$ where, 'n_i'represents total number of individuals of particular species and 'N' represents total number of individuals of all species. In case of shrubs and herbs, populations were calculated in terms of Average Percent Cover.

To record the faunal element occur in the area, trail sampling (walking through the trail) and sign surveys (records of digging sign, foraging sign, hoof mark, etc.) were made. During the survey, direct evidences like call sound and indirect evidences like feather, pellets, scats, droppings etc. were recorded. Photo capture was also done, depending upon the feasibility.

RESULTS

Flora

During the survey, a total of 21 plots were laid covering 0.21 ha area (Annexure I; Figure 1), from which 2 tree, 6 small tree/ large shrubs, 13 shrubs / shrublets and 107 herb species were recorded and are marked with (*) in Annexure II. A general checklist of 151 species of the area (including the areas outside of the plots) were prepared of which, herbs represented the highest number of species (127 species) followed by small trees / shrubs / shrublets (23 species). Trees were very sparse; hence only 3 species were recorded from the area namely *Abies densa, Betula utilis and Acer pectinatum* (Table 1). Family wise analysis revealed that belonging to the herb category Asteraceae was the dominant family, followed by Polygonaceae, Geraniaceae, Scrophulariaceae, Rosaceae (Graph 1), while in the case of small trees /shrubs/shrublets, Ericaceae appeared as the dominant family followed by Berberadaceae, Salicaceae, Cupressaceae and Grossulariaceae. Distribution of number of species along the altitudinal gradient shows no any significant relation; however the highest number of species (13 nos) were recorded in the altitude of 3601m (Graph 2). The number of species per plot for tree, small tree / large shrub, shrub / scrub and herb species ranged between 0 and1, 0 and 2, 0 and 4 and 2 and 10 respectively; nonetheless, species were completely absent from 71.43% (Tree), 42.46% (small tree / large shrub), 23.81% (shrub / scrublets) and 0.00% (herb) of the total plots (Graph 3). Out of three species of trees recorded from the area, from sub-alpine part of the sanctuary, only *Abies densa* and *Betula utilis* were recorded from the sample plots. *Abies densa* was thinly scattered in the area, hence, only 11 individual recorded from the entire sampling site; present only in 4 plots (plot 7, plot 11, plot 12, plot 13) of the 21 plots. Its cumulative adult stem density found comparatively low (52.38 ±58.35ind/ha; Rel. Den.: 78.57%; IVI: 237.64). In case of *Betula utilis*, only 3 individual were recorded, which was only from the lower sub-alpine belt, and was recorded from 2 plots (Plot 19 & plot 21). In the remaining plots, the trees were completely absent. The cumulative adult stem density of *Betula utilis* were 14.29 ±33.81 ind/ha; Rel.Den.: 100%; IVI: 207.58 [Table 2] as well as the total basal cover (TBC: 9.22m^2/ha; Rel. Dom.: 7.58%).

Table 1. Diversity of Floral species in Kyongnosla Alpine Sanctuary, East Sikkim

Habit	Species	Genus	Family
Trees	3	3	3
Small trees / large shrubs	6	5	4
Shrubs/ shrublets	18	7	5
Herbs (Climber/ Epiphytes/ Bamboos/ Ferns)	129	75	34
Total	130	84	42

Table 2. Availability and distribution of Tree species in Kyongnosla Alpine Sanctuary, East Sikkim

Species	Adult			
	Density (Ind/ha) ± SE	TBC (m2/ha)	A/F ratio	IVI
Abies densa Griff.	52.38 ±58.35	112.33	0.14	237.6496
Betula utilis.D.Don	14.29 ±33.81	9.22	0.16	55.0885

Table 3. Species diversity and distribution in Kyongnosla Alpine Sanctuary, East Sikkim

Parameters	Trees
Diversity Index (H)	0.52
Concentration of Dominance (D)	0.01
Species richness index (I)	1.62
Species evenness index (E)	-0.75

Table 4. Availability and distribution of large shrubs or Small Trees in Kyongnosla Alpine Sanctuary, East Sikkim

Species	Average % Cover / 25 m^2	Frequency %
Salix sikkimensis	0.48	4.76
Juniperus sp. (Tall Juniper)	7.14	33.33
Rhododendron hodgsonii	2.86	4.76
Rhododendron thomsonii	9.05	28.57
Lyonia ovalifolia	1.19	4.76

Table 5. Availability and distribution of shrubs and shrublets in Kyongnosla Alpine Sanctuary, East Sikkim

Sl.No	Species	Average % Cover / 5 m^2	Frequency %
1	*Rhododendron lanatum* Hook.f.	0.48	4.76
2	*Rhododendron campanulatum* D.Don subsp *aeruginosum* (Hook.f.)	0.95	14.29
3	*Rhododendron anthopogon* D.Don	2.62	19.05
4	*Rhododendron setosum* D.Don	0.71	9.52
5	*Cassiope fastigiata* (Wall.) D.Don	1.19	14.29
6	*Berberis insignis* Hook.f.& Thomson	0.24	4.76
7	*Berberis angulosa* Wall.ex Hook.f. & Thomson	3.81	19.05
8	*Rhododendron hypenanthum* Balf.f.	2.14	9.52
9	*Juniperus coxii* A.B.Jackson	2.38	14.29
10	*Juniperus recurva* Buch.-Ham.ex D.Don	0.48	4.76
10	*Rosa sericea* Lindl.	5.24	42.86

Table 6. Availability and distribution of herbs in Kyongnosla Alpine Sanctuary, East Sikkim

Sl. No.	Species	% cover	% frequency
1	*Aconitum palmatum* D.Don	0.48	4.76
2	*Aconitum novoluridum* Munz.	0.71	4.76
3	*Aconitum violaceum* Jacquem.ex Stapf	0.24	4.76
4	*Aconitum disectum* D.Don	0.48	9.52
5	*Aconitum laciniatum* (Bruhl) Stapf.	0.95	14.29
6	*Anaphalis contorta* D.Don	0.95	9.52
7	*Anaphalis triplinervis* (Sims) Cl.	1.19	19.05
8	*Arisaema jacquemontii* Bl.	0.71	14.29
9	*Bergenia purpurascens* (Hook. & Thoms.) Engler	0.71	9.52
10	*Bistorta affinis* (D.Don) Greene	0.71	9.52
11	Cerastium sp	0.48	9.52
12	*Dracocephalum heterophyllum* Edgeworth ex Benth.	0.95	9.52
13	*Codonopsis foetans* Hook. & Thoms.	0.71	9.52
14	*Codonopsia clematidea* (Schrenk) Cl.	1.43	19.05
15	*Clematis napaulensis* DC	0.48	9.52
16	Ferns	6.19	33.33
17	*Fragaria nubicola* Lindley ex Lacaita	0.71	9.52
18	*Gentiana elwesii* Cl.	0.48	4.76
19	*Geranium wallichianum* Don ex. Sw.	0.71	9.52
20	*Acomastylis elata* var. *elata* Wall. ex G. Don	1.67	23.81
21	*Impatiens racemosa* DC.	1.43	9.52
22	*Impatiens urticifolia* Wall.	0.48	9.52
23	*Iris clarkei* Baker ex Hook.f.	11.19	33.33
24	*Juncus alpinoarticulatus* Chaix.	1.76	19.05
25	*Juncus himalensis* Klotzsch.	2.14	28.57
26	*Juncus thomsonii* Buchenau	1.19	19.05
27	*Lagotis crassifolia* Prain	1.43	4.76
28	*Ligularia fischeri* (Ledeb.) Turcz.	1.90	14.29
29	*Lobelia* sp.	0.95	9.52
30	*Nardostachys jatamansi* (D.Don) DC.A.	0.24	4.76
31	*Pedicularis oederi* Vahl	0.48	4.76
32	*Pedicularis longiflora* Rudolph.	0.24	4.76
33	*Pedicularis siphonantha* D.Don	2.38	23.81
34	*Pedicularis trichoglossa* Hook.	0.24	4.76
35	*Pleurospermum hookeri* Cl.	0.24	4.76
36	*Persicaria wallichii* Greuter & Burdet	3.33	28.57
37	*Polygonum vaccinifolium* Wall. ex Meisner	1.90	19.05
38	*Ponerorchis chusua* D.Don	0.48	4.76
39	*Potentila arbuscula* D.Don	0.71	4.76
40	*Potentila cuneata* Wall. ex Lehm.	0.71	9.52
41	*Potentila peduncularis* D.Don	0.71	9.52
42	*Rheum acuminatum* Hook.f.& Thoms .ex Hook.	1.43	4.76
43	*Rhodiola cretinii* (Raymond-Hamet)	0.71	9.52
44	*Veratrilla bailonii* Franchet	1.19	9.52
45	*Sedum roseum* (L.) Scop.	0.24	4.76
46	*Saxifraga brachypoda* D.Don	0.95	4.76
47	*Sassurea nepalensis* Sprengel	0.24	4.76
48	*Sassurea obvallata* (DC.) Edgew.	1.90	4.76
49	*Selenium wallichianum* (DC.) Raizada &	0.48	9.52
50	*Senecio graciliflorus* DC.	0.48	4.76
51	*Senecio raphanifolius* Wall.ex DC.	3.10	14.29
52	*Soroseris hookeriana* (Cl.) Stebbins	0.24	4.76
53	*Thalictrum reniforme* Wallich	0.71	9.52
54	*Valeriana hardwickii* Wall.	0.71	14.29

In terms of frequency of occurrence, *Abies densa* were recorded occurring more frequently than *Betula utilis* i.e., Rel. Freq. of *Abies densa* is 66.67% and of *Betula utilis* is 26.07%. In case of trees, the sampled area was not much rich in terms of tree species richness (I = 1.62) and recorded low species diversity (H = 0.52) [Table 3). The abundance to frequency ratio revealed that, the adult individuals of *Abies densa* (A/F ratio: 0.14) and of *Betula utilis* (A/F ratio: 0.16) shows contagious distribution. Saplings and seedlings of the trees were not recorded from the sampling plots.

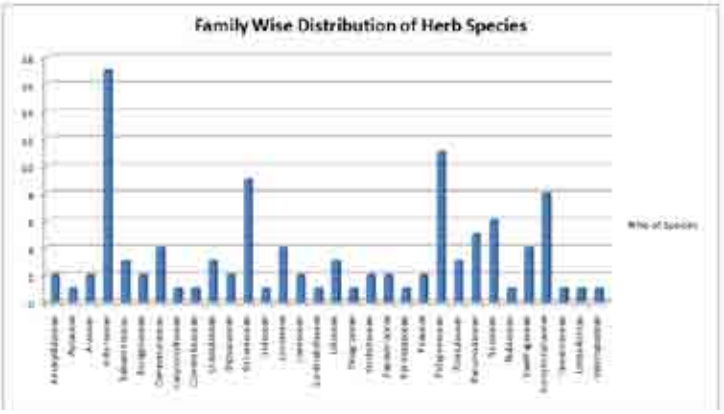
The small tree/large shrub recorded from the sample plots are *Lyonia ovalifolia, R. hodgsonii, R. thomsonii, Juniperus* sp. and *Salix sikkimensis*. Of the 5 small tree / large shrub species present, *Juniperus* sp. (Tall Juniper) had the highest frequency of occurrence (33.33%) followed by *Rhododendron thomsonii* (28.57 %) and the species like *Salix sikkimensis, Lyonia ovalifolia, Rhododendron hodgsonii* had the lowest frequency of occurrences (3.13% each) [Table 4, Graph 4]; In respect to percent cover, *Rhododendron thomsonii* was dominant (average percent cover /25 m^2: 9.05 % followed by *Juniperus* sp. (7.14%), *Rhododendron hodgsonii* (2.86%), and *Lyonia ovalifolia* (1.19%). *Salix sikkimensis* (0.48%) had very low average percent cover. Of the 10 shrubs or shrublets recorded from the sample plots, *Rosa sericea* had wide availability in the area and was recorded from 42.86% of the sampled area. The density in terms of percent cover for the recorded shrubs or shrublets were comparatively low i.e. 5.28% (*Rosa sericea*), 3.81% (*Berberis angulosa*), 2.62% (*Rhododendron anthopogon*) 2.14% (*Rhododendron hypenanthum*), 1.19% (*Cassiope fastigiata*) to 0.48% (*Juniperus recurva* and *Rhododendron lanatum*) [Table 5, Graph 5]. In the case of herbaceous species, a total of 54 species were recorded from 21 plots, of which, *Iris clarkei* and the different species of ferns had the highest frequency of occurrences (33.33%) followed by *Juncus himalensis, pedicularis siphonantha* and *Persicaria wallichii* (28.57%). Other species such as *Soroseris hookerana, Senecio gracilifolium, Sassurea obvallata, Sassurea nepalensis, Ponerorchis chusua, Potentila arbuscula, Rheum acuminatum, Pleurospermum hookeri, Pedicularis trichoglossa, Nardostachys jatamansi, Lagotis crassifolia, Gentiana elwesii* etc. had low frequency of occurrences upto 4.76%. With regard to average density in terms of percent cover, *Iris clarkei* (average percent cover /m^2: 11.19%) was dominant over other herbs species; however, species such as *Aconitum palmatum, A.laciniatum, A.disectum, A.novoluridum, A.violaceum, Gentiana elwesii, Anaphalis contorta*, *Dracocephalum heterophyllum, Clematis napaulensis, Codonopsis foetans, Nardostachys jatamansi, Pedicularis oederi, Pedicularis longiflora, Pedicularis trichoglossa, Pleurospermum hookeri, Ponerorchis chusua, Sassurea nepalensis, Sassurea obvallata, Senecio gracilifolium, Soroseris hookerana, Valeriana hardwickii* etc. (average percent cover /m^2 ranging from 0.24% to 0.95%) (Table 6) appeared rarely with very less number of populations in the study area.

Fauna

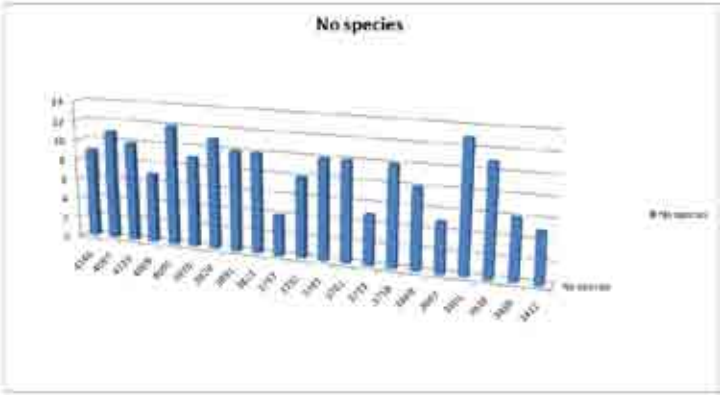
During the survey, the existence of a total of 20 bird species belonging to 3 order and 11 families were recorded (Table 7). Similarly existence of total number of 9 mammalian species was witnessed through direct and indirect evidences (Table 8). The maximum numbers of scats encountered in the area gives an evidence of the existence of good number of population of red fox and yellow-throated marten.

DISCUSSION

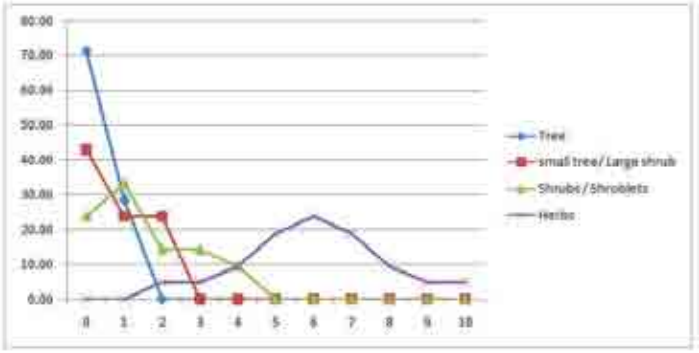
Till today, Kyongnosla Alpine Sanctuary remain unexplored which, during the present study, found to be rich in terms of the diversity of the species. Wide range of habitat diversity the sanctuary harbour, in the form of several rare, endangered species along with high value medicinal plants, tall *Junipers*, scattered *Abies densa* and thickets of *Rhododendrons*. The lower elevation is occupied mainly with bushy bamboo thickets and junipers.



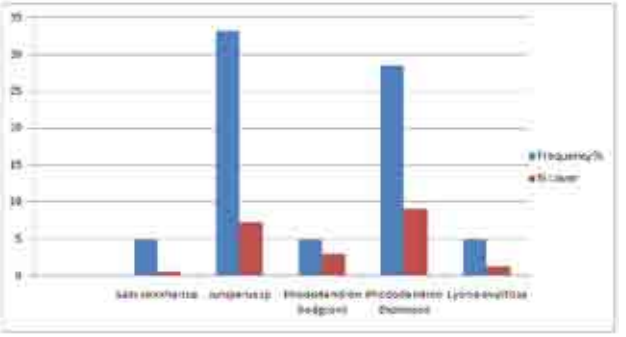
Graph 1. Family-wise distribution of herb species



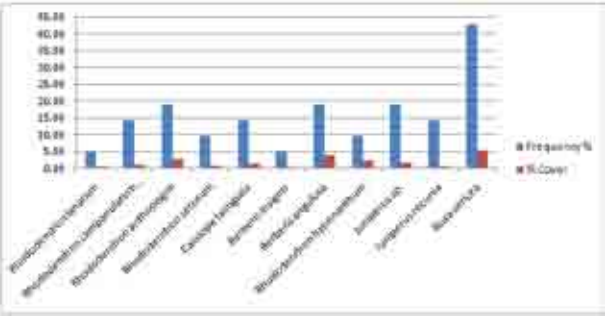
Graph 2. Altitudinal distribution of species in the sampling site



Graph 3. Species availability in the different sampling site



Graph 4. Status of large shrubs or small trees in the sampling site



Graph 5. Status of Shrubs or shrublets in the sampling site

Table 7. Checklist of Avi-fauna in Kyongnosla Alpine Wildlife Sanctuary

Sl. No	Common Name	Scientific Name	Family	Order	Evidence
1.	Blood pheasant	*Ithaginis cruentus*	Phasianidae	Galliformes	PC, DS
2.	Satyr tragopan	*Tragopan satyra*	Phasianidae	Galliformes	PC,
3.	Black-faced Laughingthrush	*Garrulax affinis*	Turdidae	Passerriformes	PC, DS
4.	Red-headed Bullfinch	*Pyrrhula erythrocephala*	Fringillidae	Passerriformes	PC
5.	Dark breasted Rosefinch	*Carpodacus nipalensis*	Fringillidae	Passerriformes	PC
6.	Plain Mountain Finch	*Leucosticte nemoricola*	Fringillidae	Passerriformes	PC
7.	White-capped Redstart	*Phoenicurus leucocephalus*	Muscicapidae	Passerriformes	PC
8.	Fire-tailed Sunbird	*Aethopyga ignicauda*	Nectariniidae	Passerriformes	PC
9.	House Crow	*Corvus splendens*	Corvidae	Passerriformes	PC, DS
10.	House Sparrow	*Passer domesticus*	Passeridae	Passerriformes	PC, DS
11.	Green-backed tit	*Parus monticolus*	Paridae	Passerriformes	PC
12.	Blue Whistling Thrush	*Myophonus caeruleus*	Muscicapidae	Passerriformes	PC, DS
13.	Common Myna	*Acridotheres tristis*	Sturnidae	Passerriformes	PC, DS
14.	Rock Dove	*Columba livia*	Columbidae	Columbiformes	PC, DS
15.	Oriental turtle dove	*Streptopelia orientalis*	Columbidae	Columbiformes	PC, DS
16.	Green Pigeon	*Treron*	Columbidae	Columbiformes	PC, DS
17.	Kalij Pheasant	*Lophura leucomelanos*	Phasianidae	Galliformes	PC
18.	Ashy Throated Warbler	*Phylloscopus maculipennis*	Sylviidae	Passerriformes	PC
19.	Red Billed Chough	*Pyrrhocorax pyrrhocorax*	Corvidae	Passerriformes	PC
20.	Snow Pigeon	*Columba leuconota*	Columbidae	Columbiformes	PC

PC: Photo Capture, **DS:** Direct Sighting

Table 8. Checklist of other faunal species of Kyongnosla Alpine Sanctuary

Sl. No.	Common Name	Scientific Name	Family	Evidence[1]	IUCN Status[2]
1.	Musk Deer (Kasturi mriga)	*Moschus chrysogaster*	Moschidae	SI	EN
2.	Barking deer (Mriga)	*Muntiacus muntjak*	Cervidae	P	LC
3.	Bear (Bhalu)	*Ursus thibetanus*	Ursidae	SI	VU
4.	Red panda (Pude kudo)	*Ailurus fulgens*	Ailuridae	SI	EN
5.	Red fox	*Vulpes vulpes*	Canidae	S	LC
6.	Yellow-throated Marten (Malsapra)	*Martes flavigula*	Mustelidae	SI, S	LC
7.	Pika	*Ochotona sp.*	Ochotonidae	DS	LC
8.	Goral	*Naemorhedus goral*	Bovidae	SI	NT
9.	Serow (Thar)	*Capricornis thar*	Bovidae	HM, P	NT
10.	Wild dog (Dhole)	*Cuon alpinus*	Canidae	SI	EN

[1]**SI**: Secondary Information, **DS**: Direct Sighting **HM:** Hoof mark, **P:** Pellet, **S**: Scat
[2] **EN:** Endangered, **LC:** Least concern, **VU:** Vulnerable, **NT:** Near threatened

Forest being sub alpine to alpine type, herbs are the most predominant taxa in the area, followed by shrubs and shrublets. Commonly available herbaceous species in the sanctuary are *Bergenia purpurescens*, *Bistorta amplexicauli*, *Rheum acuminatum, Nardostachys jatamansi*, *Sassurea nepalensis, Potentila arbuscula, P.peduncularis, Pedicularis siphonantha, Rhododendron hodgsonii, R.thomsonii, R.campanulatum, R.lanatum, Juniperus recurva, J.coxii, Codonopsis clematidea*, *Clematis napaulensis, Arisaema jacquemontii, Acomastylis elata* var *elata, Iris clarkei, Ligularia fischeri, Juncus himalensis, Juncus thomsonii, Juncus alpinoarticulatus, Persicaria wallichii, Polygonum vaccinifolium, Senecio raphanifolium, Valeriana hardwickii,* etc. which are abundantly flourishing in the area. Several species of rare and high value medicinal herbs were also recorded from the area during the present survey such as *Aconitum ferox, A.disectum, A.novoluridum, A.violaceum, A.palmatum*, *Gentiana elwesii, Neopicrorhiza scrophularia*, *Sassurea obvallata*, *Lagotis crassifolia*, *Bergenia purpurascens*, *Valeriana jatamansi, V.hardwickii*, *Codonopsis foetans*, *Polygonatum cirrhifolium, Polygonatum verticillatum*, *Panax bipinnatifidus* etc. Small trees or the large shrubs available in the area are *Rhododendron hodgsonii, Rhododendron thomsonii, Juniperus* sp.*, Salix sikkimensis*, *Lyonia ovalifolia* etc. The commonly available shrubs and/ or shrublets were *Rhododendron campanulatum* subsp *aeruginosum*, *Rhododendron campanulatum* subsp *campanulatum*, *Rhododendron lanatum, Rhododendron anthopogon, Rhododendron hypenanthum, Rhododendron ciliatum, Berberis angulosa, Berberis insignis, Cassiope fastigiata, Gaultheria trichophylla, Gaultheria nummularioides* etc. Some species such as *Aconitum*, the taxa of the highly potential medicinal plant of the Himalayas but not much attention paid by the taxonomist so far have been re-discovered from the area after more than a century after the monographic work of Stapf, O. during 1905 with seven species namely *Aconitum laciniatum, Aconitum novoluridum, Aconitum bisma, Aconitum disectum, Aconitum ferox, Aconitum violaceum* and *Aconitum spicatum* with comparatively good number of population except few such as *A.novoluridum* and *A.violaceum,* which were observed very rare in the area. *Aconitum laciniatum* was re-discovered from Tamzey valley and surrounding areas (Dahal *et al*. 2017), which is very near to the present study area. This species was reported earlier from the subalpine and alpine Himalayas of Sikkim and adjoining Tibet (Stape, 1905). During the present study, *Aconitum novoluridum* and *A.violaceum* were rediscovered after the monographic work of Stape, 1905, along with the other aconitum species including *A.laciniatum.* The present collection of these species after more than a century reveals rarity of this species in its natural habitat. High altitude Gentians (Gentianaceae) such as *Gentiana elwesii, G.algida, G.prolata, G.sikkimensis, G.stylophora, Swertia hookeri, Veratrilla baillonii* and *Halenia elliptica* were recorded from the area. A population of *Veratrilla baillonii, a* Tibetan medicinal herb, discovered from the area (ca. 4100m), which was recently discovered for the first time from Sikkim Himalaya from Tamze valley by one of the author (Dahal *et al*. 2017) during the course of the floristic study of MPCAs of Sikkim. Till date the species was reported only from the western Himalaya. *Gentiana elwesii,* a rare medicinal herb witnessed in the area during the present study; on scrutiny of literature, its record of occurrence found only in Lachung to Yumthang in North Sikkim (Hooker, 1885) and in Tamze valley in East Sikkim (Dahal *et al*. 2017). Species of Sassurea viz. *Sassurea gossipiphora, S.obvallata, S. scandens &, S. nepalensis* were recorded of which *S.obvallata* and *S.gossipiphora* are the highly threatened medicinal herbs of the Himalayas which are also found occurring in upper part of Kyongnosla Alpine Sanctuary, and in Tamze valley. However, some herbs including high value medicinal herbs such as *Neopicrorhiza scrophularia*, *Gymnadenia orchidis, Fritillaria* sp.*, Sassurea gossipiphora, Sassurea obvallata, Rheum nobile, Allium prattii, Sinopodophyllum hexandrum, polygonatum singalilense, Valeriana jatamansii, V.hardwickii* etc. were recorded very rare in the area. The occurrence of very few individual of *Betula utilis* and *Acer pectinatum* (which is only from the area outside the sample plots) reveals rarity of this species in the area.

Other than floral species, the sanctuary also provides diverse habitat for faunal species such as Serow, Musk Deer, Goral, Himalayan Black Bear, Blood Pheasant, Leopard, Lesser Cats and Himalayan Marmot. In addition, the sanctuary is also home to Satyr Tragopan, Common Langur, Tibetan Fox, Martens Weasel and Impeyan Pheasant. A wide variety of avifauna, which includes Blood Pheasant, Monal Pheasant, Tragopan, Rose finches, Red-billed Chough, Forktails and Laughing Thrushes also resides in the area. Direct sightings of House Crow, House Sparrow, Blue Whistling Thrush, Common Myna, Rock Dove, Oriental turtle dove, Green Pigeon, Kalij Pheasant, Ashy Throated Warbler, Snow Pigeon, and Red Billed Chough were achieved during the present Rapid Biodiversity Survey. Checklist of other faunal species such as Musk Deer, Barking deer, Bear, Red panda, Red fox, Yellow-throated Marten, Pika, Goral, Serow and Wild dog were prepared through secondary information, direct sightings, hoof marks, pallets, scats etc.

Conclusion

From the conservation point of view the present study has remarkable relevance in preservation of subalpine and alpine gene bank of Sikkim in the form of protected area, as present survey witnessed an occurrence of more then 151 floral species, including some globally rare and threatened species (both medicinal and otherwise) such as species of *Aconitum, Gentiana elwesii, Veratrilla bailonii, Rheum nobile, Nardostachys jatamansi*, *Neopicrorhiza scrophularia*, *Gymnadenia orchidis, Sassurea obvallata, S.gossipiphora* etc. Since the area is far away from the human habitation, the anthropogenic pressure is still not marked and hence biodiversity of the area still remain intact to some extent. However, some of the species were recorded very rare in the area which may be due to some natural factors; hence proper management is needed to maintain the gene bank of these species in their natural habitat. Natural disturbances including the impact of climate change needs to be studied well, which will be useful for the policy makers and forest managers in framing effective strategies in managing and conserving the species and their natural habitat. The better conservation of biological resources can be done by *ex-situ* conservation through tissue culture, and in case of medicinal plants, awareness should be done among the growers on establishment of herbal nurseries, developing cultivation technologies and commercial cultivation of rare and high value species.

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Annexure I. Site characteristics of the sampling plots along Nakchok -17th Mile at Kyongnosla Alpine Sanctuary, East Sikkim. (KAS= Kyongnosla Alpine Sanctuary)

Plots code	Forest Type	Altitude (M)	GPS		Slope (degree)	Slope Aspect	Disturbances
			Lat	Long			
KAS 1	Alpine Forest	4146	27°23'49.7"	88°46'25.1"	15	E	Nil
KAS 2	Alpine Forest	4097	27°23'48.5"	88°46'014"	30	E	Nil
KAS 3	Alpine Forest	4123	27°23'49.7"	88°46'04.8"	40	E	Nil
KAS 4	Alpine Forest	4069	27°23'45.4"	88°46'02.6"	20	E	Nil
KAS 5	Alpine Forest	4005	27°23'48.2"	88°45'47.8"	15	N	Nil
KAS 6	Sub-Alpine Forest	3970	27°23'37.8"	88°45'02.3"	10	NW	Nil
KAS 7	Sub-Alpine Forest	3920	27°23'39.7"	88°45'13.2"	10	NW	Nil
KAS 8	Sub-Alpine Forest	3891	27°23'42.4"	88°45'07.2"	30	N	Nil
KAS 9	Sub-Alpine Forest	3821	27°23'40.5"	88°45'02.5"	40	N	Nil
KAS 10	Sub-Alpine Forest	3757	27°23'33.8"	88°44'58.8"	30	NE	Nil
KAS 11	Sub-Alpine Forest	3792	27°23'27.9"	88°44'53.2"	40	NE	Nil
KAS 12	Sub-Alpine Forest	3781	27°23'02.4"	88°44'43.2"	30	E	Nil
KAS 13	Sub-Alpine Forest	3761	27°23'25.9"	88°44'35.7"	35	E	Nil
KAS 14	Sub-Alpine Forest	3713	27°23'27.3"	88°44'33.1"	20	E	Nil
KAS 15	Sub-Alpine Forest	3718	27°23'22.4"	88°44'27.6"	45	N	Nil
KAS 16	Sub-Alpine Forest	3669	27°23'18.1"	88°44'18.1"	30	NW	Nil
KAS 17	Sub-Alpine Forest	3607	27°23'12.9"	88°44'06.1"	5	E	Nil
KAS 18	Sub-Alpine Forest	3601	27°23'03.5"	88°43'59.2"	40	E	Nil
KAS 19	Sub-Alpine Forest	3538	27°22'05.9"	88°43'54.3"	45	E	Nil
KAS20	Sub-Alpine Forest	3489	27°22'54.8"	88°43'50.8"	50	E	Nil
KAS21	Sub-Alpine Forest	3412	27°22'45.1"	88°43'46.2"	10	E	Nil

Annexure – II: Floral species recorded in Kyongnosla Alpine Sanctuary and surrounding areas in East Sikkim

S.No.	Botanical name	Family	Altitudinal range (m)
	TREE		
1	**Abies densa* Griff.	Pinaceae	2450-4000
2	*Acer pectinatum* wall.ex G.Nicholson	Aceraceae	2300-3800
3	**Betula utilis* D.don	Betulaceae	2500-3800
	SMALL TREES / LARGE SHRUBS		
1	**Juniperus* sp.	Cupressaceae	-
2	**Lyonia ovalifolia* (Wallich) Drude	Ericaceae	300-3400
3	**Rhododendron hodgsonii* Hook.f.	Ericaceae	3000-4000
4	**Rhododendron thomsonii* Hook.f.	Ericaceae	2900-4000
5	**Salix sikkimensis* Andersson	Saicaceae	3700-4500
	SHRUBS / SHRUBLETS		
1	**Berberis angulosa* Wall.	Berberidaceae	3400-4500
2	**Berberis insignis* Hook.f.& Thomson	Berberidaceae	2000-4000
3	**Cassiope fastigiata* (Wallich) D.Don	Ericaceae	2800-4500
4	*Cassiope selaginoides* Hook. & Thoms.	Ericaceae	3000-5000
5	*Gaultheria nummularioides* D.Don	Ericaceae	2700-4500
6	*Gaultheria trichophylla* Royle	Ericaceae	2700-4500
7	**Juniperus coxii* A.B.Jackson	Cupressaceae	
8	**Juniperus recurva* Buch-Ham ex D.Don	Cupressaceae	2500-4600
9	**Rhododendron anthopogon* D.Don	Ericaceae	3500-4500
	Rhododendron barbatum Wall. ex G.Don	Ericaceae	300-3700
10	**Rhododendron campanulatum* D.Don subsp sp.*campanulatum* D.Don	Ericaceae	3300-4000
11	*Rhododendron campanulatum* D.Don subsp *aeruginosum* Hook.f.	Ericaceae	4000-4500
12	**Rhododendron hypenanthum* Balf.f.	Ericaceae	3500-4500
13	**Rhododendron lanatum* Hook.f.	Ericaceae	3000-4000
14	**Rhododendron setosum* D.Don	Ericaceae	3500-5500
15	*Rhododendron lepidotum* Wall. ex G.Don	Ericaceae	2500-5000
16	*Ribes griffithii* Hook.f.& Thomson	Grossulariaceae	2600-4200
17	*Ribes himalense* Royle ex Decne.	Grossulariaceae	1500-4200
18	**Rosa sericea* Lindley	Rosaceae	2100-4500
	HERBS		
1.	**Acomastylis elata* var. *elata* Wall. ex G. Don	Rosaceae	3500-5400
2.	*Aconitum disectum* D.Don	Ranunculaceae	3300-4800
3.	*Aconitum ferox* Wall.ex Ser.	Ranunculaceae	2100-3600
4.	**Aconitum laciniatum* (Bruhl) Stapf	Ranunculaceae	3200-4000
5.	*Aconitum novoluridum* Munz.	Ranunculaceae	3800-4500
6.	*Aconitum palmatum* D.Don	Ranunculaceae	3000-5000
7.	*Aconitum violaceum* Jacquem.ex Stapf	Ranunculaceae	3600-4800
8.	*Aletris pauciflora* (Klotzsch) Hand.- Mazz.	Liliaceae	3000-4300
9.	*Allium prattii* C.H.Wright	Amaryllidaceae	2400-4300
10.	*Allium wallichii* Kunth	Amaryllidaceae	2800-4300
11.	**Anaphalis contorta* D.Don	Asteraceae	2200-3800
12.	**Anaphalis triplinervis* (Sims) C.B.Clarke	Asteraceae	1800-3300
13.	*Arisaema erubescens* (Wall.) Schott	Araceae	2300-3000
14.	*Arisaema griffithii* Schott	Araceae	2400-3200
15.	**Arisaema jacquemontii* Schott	Araceae	2400-3000
16.	*Artemisia* sp	Asteraceae	-
17.	*Astilbe rivularis* Buch.-Ham. Ex D.Don	Saxifragaceae	1800-3300
18.	*Bergenia ciliata* (Haw.) Sternb.	Saxifragaceae	1800-4300
19.	**Bergenia purpurascens* (Hook. & Thomson) Engler	Saxifragaceae	2700-4800
20.	**Bistorta affinis* (D.Don) Greene	Polygonaceae	4000-4900
21.	*Bistorta amplexicaulii* (D.Don) Greene	Polygonaceae	2100-4800
22.	*Calceolaria tripartita* Ruiz & Pav.	Scrophulariaceae	1800-3200
23.	**Cerastium* sp	Asteraceae	-
24.	**Clematis napaulensis* DC.	Ranunculaceae	ca.3000
25.	**Codonopsis clematidea* (Schrenk) Cl.	Campanulaceae	2000-4000
26.	**Codonopsis foetens* Hook. & Thoms.	Campanulaceae	3900-4600
27.	*Corydalis elegans* Wallich ex Hooker	Papaveraceae	3800-5000
28.	*Cynanthus inflatus* Hook.f.& Thoms.	Campanulaceae	1900-4900
29.	*Cynoglossum zeylanicum* (Vahl) Thunb. ex Lehm	Boraginaceae	1200-4100
30.	*Cynotis vaga* (Loureiro) Schultes	Commelinaceae	Upto 3300
31.	**Dracocephalum heterophyllum* Edgeworth ex Bentham	Lamiaceae	1100-5000
32.	*Dubyaea hispida* Candolle	Asteraceae	2700-4500
33.	*Epilobium wallichianum* Hausskнecht	Onagraceae	1800-4100
34.	*Erigeron multiradiatus* (Lindl.ex DC.) Benth.ex Cl.	Asteraceae	2300-4600
35.	*Euphorbia wallichii* Hook.f.	Euphorbiaceae	1800-4500
36.	**Fragaria nubicola* Lindley ex Lacaita	Rosaceae	1800-3800
37.	*Fritillaria cirrhosa* D. Don	Liliaceae	3200-4600
38.	*Galinsoga parviflora* Cavanilles	Asteraceae	850-3900
39.	*Galium* sp	Rubiaceae	
40.	*Gentiana algida* Pallas	Gentianaceae	1200-5200
41.	**Gentiana elwesii* C.B.Clarke	Gentianaceae	ca.4097
42.	*Gentiana prolata* I.B.Balfour	Gentinaceae	3400-4500
43.	*Gentiana sikkimensis* C.B.Clarke	Gentianaceae	ca.3900
44.	*Gentiana stylophora* C.B.Clarke	Gentinaceae	3000-4400
45.	**Geranium wallichianum* Don ex. Sw.	Geraniaceae	2900-4000
46.	*Gymnadenia orchidis* Lindl.	Orchidaceae	2800-4200

Continue……

47.	*Halenia elliptica* D.Don	Gentianaceae	700 -4100
48.	*Impatiens bicornuta* Wall.	Balsaminaceae	2500-3100
49.	**Impatiens racemosa* Candolle	Balsaminaceae	1200-3400
50.	*Impatiens radiata* Hook.	Balsaminaceae	2100-3500
51.	**Impatiens urticifolia* Wallich	Balsaminaceae	2700-3800
52.	**Iris clarkei* Baker ex Hook.f.	Iridaceae	3000-4000
53.	*Juncus inflexus* L.	Juncaceae	1800-3200
54.	**Juncus alpinoarticulatus* Chaix	Juncaceae	ca.3200
55.	**Juncus himalensis* Klotzsch	Juncaceae	2400-4300
56.	**Juncus thomsonii* Buchenau	Juncaceae	2800-5000
57.	*Jurinea dolomiaeia* – Bioss Boiss	Asteraceae	3200-4000
58.	**Lagotis crassifolia* Prain	Scrophulariaceae	3900-5000
59.	*Ligularia amplexicaulis* DC	Asteraceae	300-4300
60.	*Ligularia fischeri* (Ledebour) Turczaninow	Asteraceae	ca.3100
61.	*Lilium nanum* Klotzsch & Garcke	Liliaceae	3300-4300
62.	**Lobelia* sp	Campanulaceae	-
63.	*Maharanga emodi* (Wallich) A de Candolle	Boraginaceae	1800-3300
64.	*Meconopsis horridula* Hook.f.& Thoms.	Papaveraceae	3500-5500
65.	*Meconopsis paniculata* (D.Don) Prain	Papaveraceae	3000-4400
66.	*Meconopsis simplicifolia* (D.Don) Walpers	Papaveraceae	3300-5300
67.	*Myricaria rosea* W.W.Smith	Tamaricaceae	2600-4800
68.	**Nardostachys jatamansii* (D.Don) Candolle	Valerianaceae	2500-5000
69.	*Neopicrorhiza scrophulariiflora* (Pennell	Scrophulariaceae	3600-4400
70.	*Nepeta floccosa* Benth.	Lamiaceae	2700-4400
71.	*Oxyria digyna* (L.) Hill	Polygonaceae	2400-5000
72.	*Parnassia nubicola* Wall.ex Royle	Parnassiaceae	3000-4500
73.	**Pedicularis longiflora* Rudolph	Scrophulariaceae	2100-5300
74.	*Pedicularis megalantha* D.Don	Scrophulariaceaee	2300-4300
75.	**Pedicularis oederi* Vahl.	Scrophulariaceae	2600-5400
76.	**Pedicularis siphonantha* D.Don	Scrophulariaceae	3000-4600
77.	**Pedicularis trichoglosa* Hook.	Scrophulariaceae	3500-5000
78.	**Persicaria wallichii* Greuter & Burdet	Polygonaceae	2500-3500
79.	**Pleurospermum hookeri* C.B.Clarke	Apiaceae	2700-5400
80.	*Polygonatum cathcartii* Baker	Polygonaceae	2500-3500
81.	*Polygonatum cirrhifolium* (Wallich) Royle	Polygonaceae	1500-3800
82.	*Polygonatum singalilense* H.Hara	Asparagaceae	ca.3800
83.	*Polygonatum verticellatum* (L.) All.	Polygonaceae	1500-3700
84.	**Polygonum vaccinifolium* Wall. ex Meisner	Polygonaceae	300-4200
85.	**Ponerorchis chusua* D.Don	Orchidaceae	500-4500
86.	**Potentila arbuscula* D.Don	Rosaceae	2500-5500
87.	**Potentila cuneata* Wallich ex Lehm.	Rosaceae	2400-5500
88.	**Potentila peduncularis* D.Don	Rosaceae	3000-4500
89.	*Primula capitata* Hook.	Primulaceae	2800-4300
90.	*Primula primulina* (Spreng.)H.Hara	Primulaceae	3600-4500
91.	*Primula reticulata* Wallich	Primulaceae	3300-4800
92.	*Primula sikkimensis* Hook.f.	Primulaceae	3300-4400
93.	**Rheum acuminatum* Hook.f.& Thoms.ex Hook.	Polygonaceae	3600-4300
94.	*Rheum nobile* Hook.f. & Thoms.	Polygonaceae	3600-4500
95.	**Rhodiola cretinii* (Raymond-Hamet)	Crassulaceae	3700-4400
96.	**Rhodiola. himalensis* (D. Don) S. H. Fu	Crassulaceae	2800-4500
97.	*Sassurea gossipiphora* D.Don	Asteraceae	4300-5600
98.	**Sassurea nepalensis* Sprengel	Asteraceae	3200-4900
99.	**Sassurea obvallata* (DC.) Edgew.	Asteraceae	3600-4500
100.	*Sassurea simpsoniana* (Field & Gard.) Lipschitz	Asteraceae	4000-5200
101.	*Satyrium nepalense* D.Don	Orchidaceae	1500-4000
102.	**Saxifraga brachypoda* D.Don	Saxifragaceae	3600-4800
103.	*Saxifraga engleriana* Harry Smith	Saxifragaceae	4000-5000
104.	*Saxifraga stenophylla* Royle	Saxifragaceae	3600-5000
105.	*Scutellaria discolor* Colebr.	Lamiaceae	ca.3100
106.	**Sedum roseum* (L.) Scop.	Crassulaceae	ca.3800
107.	**Selenium wallichianum* (DC.) Raizada & H.O.Saxena	Umbelliferae	2700-4000
108.	**Senecio graciliflorus* DC.	Asteraceae	2400-4000
109.	**Senecio raphanifolius* Wall.ex DC.	Asteraceae	2700-4400
110.	*Senecio scandens* Buch.Ham. ex D. Don	Asteraceae	1800-3600
111.	*Silene nigrescens* L.	Caryophyllaceae	300-4800
112.	*Sinopodophyllum hexandrum* (Royle) T.S.Ying	Lardizabalaceae	2400-4500
113.	**Soroseris hookeriana* (C.B. Clarke) Stebbins	Asteraceae	4300-5500
114.	*Stellaria* sp.	Caryophyllaceae	-
115.	*Swertia hookeri* C.B.Clarke	Gentianaceae	3600-4300
116.	*Tanacetum* sp.	Asteraceae	-
117.	*Taraxacum officinale* Weber	Asteraceae	3800-5000
118.	*Thalictrum cultratum* Wallich	Ranunculaceae	2400-4200
119.	*Thalictrum foliolosum* DC.	Ranunculaceae	1500-3500
120.	**Thalictrum reniforme* Wallich	Ranunculaceae	2800-3500
121.	*Thamnocalamus* sp.	Poaceae	
122.	*Torenia* sp.	Scrophulariaceae	
123.	**Valeriana hardwickii* Wallich	Dipsacaceae	1500-4000
124.	*Valeriana jatamansii* Jones	Dipsacaceae	1500-3600
125.	**Veratrilla bailonii* Franchet	Gentianaceae	3200-4600

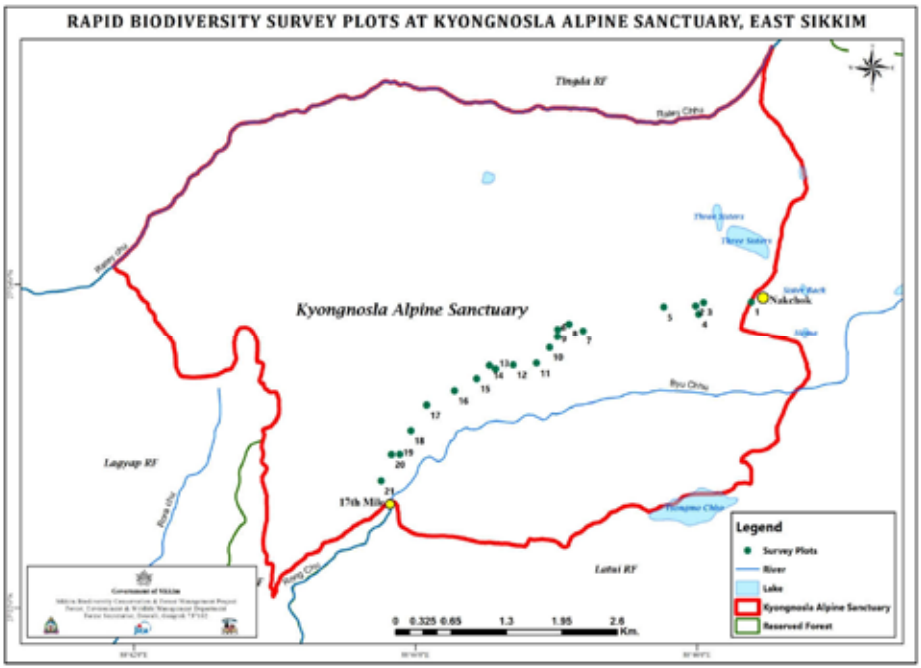

Plate 1: Forest types of Kyongnosla Alpine Sanctuary, East Sikkim

A. Alpine Pasture at Nagchok; Lake: Jhor Pokhari

B. Sub-Alpine Forest dominated by Rhododendrons and Iris, and scattered *Abies densa*

C. Sub-alpine forest dominated by *Rhododendron hodgsonii* and *R. thomsonii*

D. Lower belt (Sub-alpine) dominated by shrubby Bamboo and Juniper.

Rheum nobile **Hook.f. & Thoms.**

Sassurea obvallata **(DC.) Edgew.**

Plate 2: Activities of SBFP Survey Team at Kyongnosla Alpine Sanctuary

A: Taking field observation and capturing photographs; B: Measuring CBH of tree; C: Collecting sample of an unidentified species.

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RESEARCH ARTICLE

MEDICINAL PLANTS GENETIC RESOURCES OF KYONGNOSLA ALPINE SANCTUARY, SIKKIM, INDIA

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ABSTRACT

Medicinal Plants Genetic Resources of Kyongnosla Alpine Sanctuary and adjacent areas were studied during the year 2016-17, which records an occurrence of 120 species of medicinal plants, of which herbs represent the highest number of species (103 species) followed by shrubs / shrublets (16 species). Trees were sparse in the area and only two tree species of medicinal value *viz., Abies densa* and *Betula utilis* were recorded. Enumeration of species includes scientific names along with common name(s), local name(s), family, part (s) used, uses and system(s) of medicine where they are used. 79 species were found to be used in Tibetan System of Medicine, 48 species in Traditional Nepali Medicine and 13 species in Lepcha Traditional Medicine and 8 species were found to be used by local Folk healers. Some of the globally rare and threatened alpine medicinal plants such as *Sassurea gossipiphora, Gentiana elwesii, Neopicrorhiza scrophulariiflora, Veratrilla bailonii, Nardostachys jatamansii* etc. were recorded during the present study. *Aconitum,* the highly potential and globally threatened taxa of medicinal plant of the Himalayas, of which six species were recorded during the present study. From the conservation point of view Kyongnosla Alpine Sanctuary has remarkable relevance in preservation of subalpine and alpine gene bank of Sikkim in the form of protected area. For better conservation and management of rare and threatened medicinal plants in their natural habitat, the sanctuary and the surrounding area can be recommended to keep untouched in terms of tourism and any kind of construction works. The better management of the rare and threatened species especially of sub-alpine and alpine areas can be done by *ex-situ* conservation through tissue culture.

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INTRODUCTION

The state of Sikkim is located on the Eastern Himalaya in between 27°5' - 28° 10' N latitudes and 88°4'-88°55' E longitudes covering an area of 7096sq. It falls under Himalayan (2) Bio-geographic zone and Central Himalaya (2c) biotic province. Its altitude varies from 225m in the south to 6100m in the north and north-east and 8598m in the north-west. The state is a rich repository of biological diversity harbouring tropical, subtropical, temperate, sub alpine and alpine vegetations. The population of Sikkim comprise of Lepcha, Bhutia and Nepali communities. The Nepalese are numerically dominant community and comprises of a number of groups and tribes such as Chettri, Bahun, Rai, Manger, Limboo, Tamang, etc. Bhutias are the next numerically larger community in the state which are people of Tibetan origin and mainly settled in the northern region. The people of Sikkim have great faith in the traditional system of medicine. A large section of the population in rural areas still relies on native systems of medicine for their healthcare management. The native system of healing is practiced by the Amchi, Lama and Pow in the Bhutia community. Amchi, a Tibetan herbal practitioner and Lama, a Buddhist priest, practices ritual therapies which are highly respected and accepted by the Bhutia community. Baidhay are the Nepali traditional herbal practitioners. In the western part of Sikkim majority of the people believes in magico-ritual therapies practiced by Dhami or Jhakri, a traditional folk healers of Nepali community. The Lepcha traditional practitioners are known as Bungthing. The Lepchas are animistic and are mainly settled in the Dzongu valley in North Sikkim. Similarly, traditional ethno-veterinary practices are also in vogue in the rural areas of the state for the treatment of various ailments of their live stocks such as bone fracture, poisonous bites, retention of placenta, fever of cattle, dog bites of cattle, diarrhoea, etc. (Sharma *et al.,* 2012). India is known for rich repository of plant wealth having more than 17,500 wild plant species and of these over 4,000 species have medicinal values (Ayensu 1996). Himalayan region of India, especially the North eastern part including Sikkim state have

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been the source of traditional medicine in conventional use since long directly or indirectly in the modern medicine system, hence plays an imperative role in the cultural and economic expansion of the region (www.nmpb.nic.in). Sikkim being an integral part of eastern Himalaya is known as one of the mega hot spot zones of country and has more than 490 species of medicinal and aromatic plants (Sharma and Sharma, 2010). Despite being the store house of medicinal and aromatic plants and the related traditional knowledge, their documentation especially in the sub-alpine and alpine regions is yet to be accomplished properly. Hence, present work was initiated as an attempt to document the medicinal plants of Kyongnosla Alpine Sanctuary along with their uses in different traditional systems of medicine in Sikkim.

Study Area

Sikkim has always been an attraction for the local, national as well as the international visitors due to its uniqueness in terms of landscape like snow covered mountains ending to cold deserts. There lies a famous Kyongnosla Alpine Sanctuary, Barsey Rhododendron Sanctuary, Shingba Rhododendron Sanctuary, Kitam Birds Sanctuary, beautiful valleys of Yumthang - Yumey Samdong, Tamzey, Tsomgo – Nathula, several high altitude lakes *viz*., Gurudongmar, Tsho Lhamu, Johr Pokhari, Hans pokhari, Gyam Tshona Lake, (the only high altitude brackish water lake) and others. The state of Sikkim have always been an explorers paradise since many centuries and have been visited by the famous explorers like Sir J.D. Hooker (1847-49), G. Gammie (1892), J.C. White (1887 - 1908) and others, the account of which is beautifully described in *Himalayan Journal, Account of Botanical Tour in Sikkim during 1892.* Present study area Kyongnosla Alpine Sanctuary, is located in the Eastern Himalaya of Sikkim in between 27°22' N – 27°24' N latitude and 88°44' E – 88°45' E longitude (Figure 1). The area of the sanctuary is 31 km^2 with sub-alpine – alpine forests (Figure 2a, 2b) and the altitude ranges from 2900 m to 4400 m. The area around the sanctuary is, however, notified as the Eco-Sensitive Zone by the Central Government with the purpose of protection and conservation of biodiversity of the sanctuary and its environment. The extent of this zone varies from 25 m to 200 m from the boundary of the Kyongnosla Alpine Sanctuary. The Eco-Sensitive Zone is bounded by 27°22'5" N latitude and 88°41'54" E longitude towards east, 27°23'41" N latitude and 88°42'48" E longitude towards west, 27°25'13" N latitude and 88°43'49" E longitude towards north and 27°22'36" N latitude and 88°43'50" E longitude towards south. The significance of this sanctuary is that it harbours a good number of scheduled animals (specified in Schedule I of the Wildlife Protection Act, 1972) which includes Red Panda and different species of Gallinaceous Birds and Pheasants. The wide range of habitat diversity of the sanctuary harbours several rare, endangered species along with high value medicinal plants *viz., Aconitum violaceum, A. novoluridum, A. disectum, A.bisma, Neopicrorhiza scrophulariflora, Nardostachys jatamansii, Valeriana jatamansii*, *V. hardwickii*, *V. grandiflora*, *Panax bi-pinnatifidus, Sassurea gossipiphora, S. obvallata, Rheum acuminatum, R. novile, Gentiana elwesii*, several species of *Junipers*, *Rhododendrons,* etc. The lower elevation is occupied by bushy bamboo thickets and junipers.

MATERIALS AND METHODS

Field works were undertaken in the Sanctuary during the month of August 2016 with the aim to develop a database on the medicinal plants of the area along with their traditional medicinal uses. Prior to field work, literatures were scrutinised to have a general idea about the vegetation of the area (Polunin and Stainton, 1984; Stainton, 1988; Hooker, 1871-1897; Sharma and Sharma, 2010, Sabita Dahal et al. 2017, Dahal S, Sharma TP & Borthakur SK, 2017 etc.) including web references such as (www.efloras.org*;* www.flowersofindia.net etc.). The checklist of the species (both medicinal and otherwise) was prepared and was taken to the field to confirm their presence in the study area. During the field work, all the species occurring in the area (both medicinal and otherwise) were recorded to have fair knowledge on the vegetation of the area. Important medicinal plants were collected and made into herbarium specimens following standard herbarium techniques (Jain and Rao, 1977) and were deposited in the herbaria at Botanical Survey of India, Sikkim Circle (BSHC) for future references. Specimens collected were identified with the help of literature (Polunin and Stainton, 1984; Stainton, 1988; Hooker, 1871-1897; Sharma and Sharma, 2010, etc.) and by consulting herbarium specimens deposited in BSHC and web references (www.efloras.org*;* www.flowersofindia.net etc.. Information on traditional usage, parts used, local names, etc. were recorded with the help of the local herbal practitioners in the field, which were further authenticated through cross verifications and personal observations.

RESULTS AND DISCUSSION

An enumeration of 120 medicinal plants occurring in the area is provided here with their scientific names along with common names, local names, families, altitudinal range, part(s) used and uses (Table 1). Herbs represent the highest number of species (103 species) followed by shrubs/shrublets (16 species). Trees were sparse in the area and only two tree *viz., Abies densa* and *Betula utilis* of medicinal value were recorded from the area. The forest being sub-alpine and alpine type, herbs were predominating in the area and the species include *Rheum nobile, R. acuminatum, Sassurea obvallata, S. nepalensis, S. gossypiphora, Juncus thomsonii, Potentila arbuscula, P. peduncularis, Geum elatum, Tanacetum coccineum, Iris clerki, Gentiana* sps*., Geranium polyanthes, Impatiens* sps . During the present study, the sanctuary has been found to be a rich repository of potential and rare medicinal shrubs and herbs including 6 species of *Aconitum* namely *A. novoluridum*, *A.violaceum*, *A.bisma*, *A. ferox*, *A.laciniatum* and *A.disectum* (Plate 1). Despite being the highly potential medicinal plant of the Himalayas**,** no much attention has been paid by the taxonomist so far to study the taxon *Aconitum* occurring in the area. There are six species with gregarious growth and comparatively good number of populations except *A.novoluridum* was recorded from the area. However, among all the Aconites *A.novoluridum* is very rare in the area. There are no authentic literatures on the Aconites of the area except the publication of Stape (1905). In case of *Polygonatum*, 3 species were recorded from the area viz. *P.verticellatum*, *P. Singalilense, and P. Cirrhifolium*. High altitude Gentians (Gentianaceae) such as *Gentiana elwesii, G.algida, G.prolata, G.sikkimensis, G.stylophora, Swertia hookeri, Veratrilla baillonii* and *Halenia elliptica* occur in the sanctuary. Of all the Gentians *viz., Gentiana elwesii* is a threatened medicinal and recorded for the first time from the area during the study. Since its record of occurrence in Lachung to Yumthang in North Sikkim in 1885 there is no record of its occurrence from any other areas of Sikkim (Hooker 1885).

Table 1. Habit diversity of species recorded in Kyongnosla Alpine Sanctuary, East Sikkim

Habit	Species	Genus	Family
Trees	2	2	2
Shrubs / Shrublets	16	7	4
Herbs	102	61	32
Total	120	70	38

Table 2. A list of medicinal plants including highly potential, rare and threatened species of Kyongnosla Alpine Sanctuary, East Sikkim

Sl.no	Botanical name	Common / Local names	Family	System of Medicine	Part(s) used	Medicinal uses/ Other uses
Trees						
1.	*Abies densa* Griff.	Himalayan Fir Gobre Salla (N)	Pinaceae	AU, NTM, LTM	Leaves and leaf juices	Leaves astringent, carminative, expectorant, stomachic and tonic. The leaf juice used in the treatment of asthma, bronchitis, etc. An essential oil obtained from the leaves is used to treat colds, rheumatism and nasal congestion.
2.	**Betula utilis* D.Don	Himalayan Birch / Bhoj Patra (N)	Betulaceae	AU, NTM, TMS, LTM	Bark	Useful to treat wounds, skin diseases, ear diseases, ear problems, epilepsy, hysteria, diarrhea and dysentery. In Ayurveda, the species have been reported to be useful for Kapha diseases, ear diseases, pitta and rakta diseases and various psychological disorders.
Shrubs / Shrublets						
1.	*Berberis angulosa* Wall.	Large Flowered Barberry / Karay chutro (N); Kyer Pa Nag Po (Ti).	Berberidaceae	TMS, NTM	Root, flower fruit	Roots antibacterial, used for cough, cold, fever and dysentery. Cures conjunctivitis accompanied by pain and redness of the eyes. Treats irritation of urinary tract, heals sores and skin infection.
2.	*Cassiope fastigiata* (Wall.) D.Don	Himalayan Heather / Sunthangni (N); Pelawa (B).	Ericaceae	NTM	Leaves Flowers	Leaf paste is applied to cuts and itches. Flower paste is applied to skin allergies. It is a herb having potent anti-herpes viral activity.
3.	*C.selaginoides* Hook. & Thoms.	Himalayan Heather / Sunthangni (N); Pelawa (B).	Ericaceae	NTM	Leaves	Leaf past is applied to cuts and itch. Flowers paste is applied to skin allergies. It is a herb having potent anti-herpes viral activity.
4.	*Gaultheria nummularioides* D.Don	Coinwort Snowberry / Kaaligedi (N)	Ericaceae	NTM	Leaves	Fruits edible. Leaf juice is taken to cure painful urination.
5.	*G.trichophylla* Royle.	Himalayan Snowberry / Kaaligedi (N)	Ericaceae	NTM	Fruit	Presence of important phyto-constituents such as gallic acid, rutin and quercetin has been reported, which has strong antioxidant properties and use in foods and medicines to replace synthetic antioxidants. Ripe fruits edible. Traditionally, the leaves and fruits are used to treat wounds, cough and cold.
6.	*Juniperus recurva* Buch.-Ham. Ex D.Don	Drooping Juniper Dhoop (N)	Cupressaceae	TMS, AU, NTM, LTM	Leaves, twigs, berries and wood	In Tibetan Medicine, Junipers are used to prevent and treat cancer. Throughout the Himalayan region, Juniper is considered to be a sacred . In Nepali and Tibetan culture the woods, leaves and twigs are used as incense because of the beliefs that it can recharge with energies both indoor and outdoor of households.
7.	*J. coxii* A.B.Jackson Syn., *J. recurva* var. *coxii* (A.B.Jackson) Melville	Dhoop (N),	Cupressaceae	TMS, AU, NTM, LTM	Leaves, twigs, berries and wood	In Tibetan Medicine System, Junipers are used to prevent and treat cancer. Throughout the Himalayan region, Juniper is considered to be a sacred tree. In Nepali and Tibetan culture the woods, leaves and twigs are used as incense because of the beliefs that it can recharge with energies both indoor and outdoor of households.
8.	*Lyonia ovalifolia* (Wall.) Drude	Oval Leaved Staggerbush Angeri (N)	Ericaceae	AU, NTM	Tender leaves and shoots	Tender leaves and buds have antioxidant and antimicrobial properties and are considered as toxic, Infusion of leaves and buds is used externally to treat skin diseases. Leaves have insecticidal properties. Fresh juice of leaves and tender shoots are used externally in infestation of ticks in dog and calf. (Sharma et al., 2012).

9.	*Rhododendron anthopogon* D.Don	Dwarf Rhododendron / Sunpati (N), Palu (B).	Ericaceae		TMS, NTM	Whole plant except roots	Infusion of tender leaf is taken to treat cough, cold and fever. Wood, leaves and twigs used as incense.
10.	*R.campanulatum* D.Don subsp. *aeruginosum* (Hook.f.), Syn. *Rhododendron aeruginosum* Hook.f.	Aeruginose Rhododendron / Nilo Patey Chimal (N)	Ericaceae		Poisonous plant	Whole plant	All parts of this plant contain poison called grayanotoxin, eating this plant leads to severe stomachache, liver damage and pneumonia.
11.	*Rhododendron campanulatum* subsp.*campanulatum* D.Don	Bell-flowered Rhododendron Nilo Chimal (N)	Ericaceae		TNM	Stems, leaves	In Nepal, powder of dried stem and leaves is used as snuff to cure cold and hermicrania. Also used in curing chronic rheumatism and syphilis. Dried twigs and wood are used by the Nepalese against phthisis and chronic fever (Rajeshkoirala.worldpress.com)
12.	*R.hypenanthum* Balf. f.	Yellow Dwarf Rhododendron	Ericaceae		TMS	Stems, leaves	Antitussive, digestive, febrifuge, diaphoretic and tonic and are used as appetizer and to treat cough and cold, pulmonary disorders and various skin diseases. The dried leaves are used as incense.
13.	*R.lepidotum* Wall.ex G.Don	Scaly Rhododendron / Bhaley Sunpati (N)	Ericaceae		Folk, AU, TMS	Ariel parts	Used locally as an incense by the Buddhist in monasteries. It is one of the major ingredients of an Ayurvedic herbal oil "*Pinda Thailam*, a cooling massage oil" which is particularly useful for rheumatoid arthritis.
14.	*Rhododendron thomsonii* Hook.f.	Dr. Thomson's Rhododendron Dr. Thomson ko Gurans (N)	Ericaceae		Poisonous plant	Leaves, stems	Used as insecticide, reported toxic to human beings (Rajeshkoirala.worldpress.com). Alcoholic extraction from the vegetative parts is used as an effective insecticide in North Sikkim (Pradhan and Lachungpa, 1990)
15.	*R.setosum* D.Don	Bristly Rhododendron / Jhusey Sunpati (N), Tsalluo (B)	Ericaceae		TNM, Folk, AU	Whole plant except roots	Useful in inflammation of throat and muscle tissues, also heals sexually transmitted infections (Wangchuk *et al*. 2016). Paste of tender leaves is applied to wounds. Wood, leaves and twigs are used as incense.
16.	*Rosa sericea* Lindley	Silky Rose	Rosaceae		Folk, TMS, AU	Root and Flowers	Root paste is applied to wounds. Decoction of petals is used to wash the eyes in ophthalmia and used aso an aphrodisiac. It slows down ageing, increases smoothness, reduces wrinkles on the face and keeps complexion glowing.
Herbs							
1.	*Aconitum laciniatum* (Bruhl) Stapf. Syn., *A.ferox* var.*laciniata* Bruhl	Kalo Bikhma (N)		Ranunculaceae	AU, TMS, NTM	Tuberous root	Efficacious remedy in many fabric diseases, particularly fever of children resulting from inflammation, such as tonsillitis, laryngitis, pharyngitis, quinsy ,etc. In Ayurveda, *Aconitum* is used to increase pitta (fire, bile), dosha.
2.	*Aconitum violaceum* Jacquem.ex Stapf	Dudhia (N)		Ranunculaceae	AU, TMS, NTM	Tuberous root	In Ayurveda, *Aconitum* is used to increase pitta (fire, bile), dosha.
3.	*Aconitum bisma* (Buch.-Ham.) Rapaics	Bikh, Bikhma		Ranunculaceae	AU, TMS, NTM	Tuberous root	In Ayurveda, *Aconitum* is used to increase pitta (fire, bile), dosha.
4.	*Aconitum ferox* Wall.ex Ser.	Bikh, Bikhma		Ranunculaceae	AU, TMS, NTM	Tuberous root	In Ayurveda, *Aconitum* is used to increase pitta (fire, bile), dosha.
5.	*Aconitum disectum* D.Don			Ranunculaceae	AU, TMS, NTM	Tuberous root	In Ayurveda, *Aconitum* is used to increase pitta (fire, bile), dosha.
6.	*Aconitum novoluridum* Munz.	Tchendook (B), Surya Banshi (N)		Ranunculaceae	AU, TMS, NTM	Tuberous root	In Ayurveda, *Aconitum* is used to increase pitta (fire, bile), dosha.
7.	*Aletris pauciflora* (Klotzsch) Hand.-Mazz.	Few Flowered Colic Root		Nartheciaceae	TMS	Aerial parts	Used to cure lung and liver disorders, respiratory diseases, pneumonia, bronchitis, cuts and wounds.
8.	*Allium prattii* C.H.Wright	Jangali piaz (N); Gok Pa, Ruk Pa (Ti).		Amaryllidaceae	NTM	Leaves	Warmed leaf juice is used as body massage to get relieve from body ache. It is also used as a flavouring agent.
9.	*A.wallichii* Kunth	Himalaya Onion / Banlasun (N)		Amaryllidaceae	NTM	Leaves	Infusion of leaves is used against vomiting.
10.	*Anaphalis contorta* D.Don	Eared Leaf Pearly Everlasting / Buki phul (N)		Asteraceae	TMS, NTM	Whole plant	Root paste is applied to boil. Plant paste is taken with honey to cure cough. Essential oil extracted is used medicinally in various ailments.
11.	*A.triplinervis* (Sims) Cl.	Woolly Pearly Everlasting / Ta.god (Ti)		Asteraceae	TMS, NTM	Whole plant	Treats illnesses caused by compounded poison, anaemia and relieves swelling.
12.	*Arisaema erubescens* (Wall.) Schott	Blushing Cobra Lily / Sanp ko makai (N)		Araceae	AU, TMS	Corm	Used in bone diseases. For its irritant effect applied to skin diseases with infection and swelling; it damages the bacteria and stimulates healing.

13.	*Arisaema griffithii* Schott	Griffith's Cobra Lily / Sanp ko Makai (N)	Araceae	AU, TMS	Corm	Used in bone diseases. For its irritant effect applied to skin diseases with infection and swelling; it damages the bacteria and stimulates healing.
14.	*Arisaema jacquemontii* Bl.	Jacquemont's Cobra Lily / Sanp ko makai (N)	Araceae	TMS	Corm	Used in bone diseases. For its irritant effect applied to skin diseases with infection and swelling; it damages the bacteria and stimulates healing
15.	*Bergenia ciliata* (Haw.) Sternb.	Frilly Bergenia, Winter begonia, Pakhenbed (N)	Saxifragaceae	AU, TMS, NTM, LTM	Whole plant	Useful in treating urinary troubles, cough and cold, asthma, boils , ophthalmia, backache and dissolve kidney stones.
16.	*Bergenia purpurascens* (Hook. & Thoms .) Engler	Purple Bergenia / Lekhko Pakhanbed (N)	Saxifragaceae	AU, TMS, NTM	Whole plant	It has antibacterial property. Decoction of rhizome is used against body and stomach pain. Fresh rhizome is chewed to cure cough and toothache. Leaf juice is taken orally to dissolve kidney stone. In Tibetan medicine, the plant is used for the treatment of neuropsychiatric disorders. It is a source of drug *Bergenin.*
17.	*Bistorta affinis* (D.Don) Greene	The Himalayan Bistort / La.gang Men. Pa (Ti).	Polygonaceae	AU, TMS	Roots	Cures hoarseness of voice, pulmonary and intestinal diseases. Also used in emaciation, senility and pulmonary affections.
18.	*B.amplexicaulii* (D.Don) Greene	Red Bistort	Polygonaceae	AU, TMS, LMS		Cures hoarseness of voice , pulmonary and intestinal diseases
19.	*Codonopsis foetens* Hook. & Thoms.	Stinging Bunnet Bellflower / Luptic (B).	Campanulaceae	AU, TMS	Whole plant	Decoction is used against constipation and gastritis.
20.	*Codonopsia clematidea* (Schrenk) Cl.	Clematis Bonnet Bellflower	Campanulaceae	AU, TMS,	Whole plant	Useful to treat rheumatism. Seed paste is used externally to treat inflammation of body parts.
21.	*Clematis napaulensis* DC.	Anemone clematis	Ranunculaceae	Folk, AU, TMS, LMS	Leaves, stems	Useful in treatment of epilepsy and fever. Stimulate menstrual discharge and promote lactation.
22.	*Cynoglossum zeylanicum* (Vahl) Thunb. ex Lehm	Ceylon Forget Me Not / Kanike Kuro (N)	Boraginaceae	TMS, NTM, AU	Leaves	Leaf paste is applied to cuts and wounds.
23.	*Dracocephalum heterophyllum* Edgeworth ex Benth.	White Dragonhead	Lamiaceae	TMS, AU	Leaves, Young shoots	Essential oil extracted from the plant posses various pharmacological properties such as anti-hepatitis, antioxidant, anti-inflammatory, etc.
24.	*Erigeron multiradiatus* (Lindl.ex DC.) Benth.ex Cl.	Himalayan Fleabane	Asteraceae	TMS	Whole plant	Useful to treat various diseases related to inflammation (Yakugaku Zasshi, 2008)
25.	*Euphorbia wallichii* Hook.f.	Wallich Spurge	Euphorbiaceae	TMS, Folk.	Roots	Effective in treating skin diseases. Possess considerable anti-cancer and anti-oxidant potential (Ihsan Ul-Haq *et al.* 2012.)
26.	*Fragaria nubicola* Lindley ex Lacaita	Himalayan Strawberry / Bhui Aiselu (N)	Rosaceae	TMS, AU	Leaves, flowers and fruit	Unripe fruit is chewed to treat blemishes on the tongue. Leaves juices are used to treat profuse menstruation.
27.	*Fritillaria cirrhosa* D. Don	Yellow Himalayan Fritillary / Kakoli (N).	Liliaceae	AU	Bulb leaves	Dried bulb or decoction of bulb is taken to prevent and cure asthma and bronchitis. Leaves are eaten to cure stomach pain. The plant is used as a substitute of *Lilium polyphyllum*, one from the *Astavarga* group in preparation of an Ayurvedic formulations such as Astavarga churna, Chyavanprash rasayana, etc.
28.	*Galinsoga parviflora* Cavanilles	Gallant Soldier/ Udasay (N)	Asteraceae	AU, TMS	Leaves	Leaf juice or paste is applied to burn injuries and to wound and cuts.
29.	*Galium* sp.		Rubiaceae	NT M	Whole plant	Treats painful urination.
30.	*Gentiana algida* Pallas	Whitish Gentian	Gentianaceae	AU, TM	Leaves	Leaf paste is applied to cuts and wounds. It is also used in stomach complaints.
31.	*G. elwesii* Cl.	--	Gentianaceae	NTM	Young shoots, leaves	Leaf decoction is taken as tea to reduce high altitude sickness. As such medicinal uses of this species have not been recorded so far.
32.	*G. prolata* I.B.Balfour	--	Gentinaceae	NTM	Young shoots, leaves	Leaf decoction is taken as tea to reduce high altitude sickness. As such medicinal uses of this species have not been recorded so far.
33.	*G.sikkimensis* Cl.	--	Gentinaceae	NTM	Young shoots, leaves	Leaf decoction is taken as tea to reduce high altitude sickness. As such medicinal uses of this species have not been recorded so far.
34.	*G.stylophora* Cl.	Yellow Gentian Lily	Gentinaceae	NT M	Root	Root paste is applied as a poultice to cure wounds and swellings.
35.	*Geranium wallichianum* Don ex. Sw.	Wallich Geranium / Rakla Mool (N)	Geraniaceae	AU,TMS, NTM	Whole plant except root	The plant has astringent properties. Decoction of whole plant is taken against back and joints pain.
36.	*Acomastylis elata* var. *elata* Wall. ex G. Don	High Avens / Belocha (N)	Rosaceae	AU, TMS	Leaves	Used as an astringent in diarrhoea and dysentery. In Ayurveda, used as an ingredient in an Anti-Cancer Herbal Formulations.
37.	*Gymnadenia orchidis* Lindl.	Himalayan Fragrant Orchid / Panch amlay (N)	Orchidaceae	AU, TMS	Tubers	Astringent, demulcent and highly nutritious. Eaten with honey as an aphrodisiac and tonic. It is also useful in gastric, liver and urinary disorders.

38.	*Halenia elliptica* D.Don	Spurred Gentian / Tikta (N)	Gentianaceae	AU, TMS	Whole plant	Reported to be of anti-oxidant, anti-amoebic and anti-inflammatory. Useful in the treatment of liver inflammations, stomach complaints and fever due to contagious diseases.
39.	*Impatiens urticifolia* Wall.	Garden Balsam / Tiuree (N)	Balsaminaceae	AU, TMS	Whole plant	Fermented extract of flower is reported to possess marked antibiotic activity against some pathogenic fungi and bacteria. It is an astringent, expectorant and diuretic and used in urinary disorders, diarrhoea, etc.
40.	*Impatiens racemosa* DC.	Yellow Long-Tailed Balsam / Anchirna (N)	Balsaminaceae	TMS, AU (Vaterinary)	Whole plant	Stem juice is an antidote to poison ivy. Impatiens contain 2-methoxy-1,4-napthoquinone, an anti-inflammatory and fungicide napthoquinone which constitutes an active ingredient in some formulations (Morris *et al.* 2006.).
41.	*Impatiens radiata* Hook.f.	Spreading Rays Balsam	Balsaminaceae	AU, TMS (Vaterinary)	Whole plant	Stem juice is an antidote to poison ivy. Some of the species of *Impatiens* contain 2-methoxy-1,4-naphthoquinone, an anti-inflammatory and fungicide naphthoquinone that which constitutes an active ingredient in some formulations (Morris & Keilty 2008)
42.	*Impatiens bicornuta* Wall.	Horned Balsam / Raja Babu (N)	Balsaminaceae	AU, TMS (Vaterinary)	Whole plant	Some of the species of *Impatiens* contain 2-methoxy-1,4-naphthoquinone, an anti-inflammatory and fungicide naphthoquinone that which constitutes an active ingredient in some formulations (Morris & Keilty 2008)
43.	*Iris clarkei* Baker ex Hook.f.	Clark's Iris	Iridaceae	AU		Bibenzyl derivatives (methoxy-hydroxy-dihydrostilbenes including alfoliol, gigantol), is a compound obtained synthetically from it used against cancer (Aggarwal *et al.* 2004.)
44.	*Jurinea dolomiaeia* Boiss	Jhari – Dhoop (N)	Asteraceae	Folk, AU, TMS	Roots	The plant is used as incense. Roots are stimulant and given in fever after childbirth. Bruised roots are applied to skin eruptions. Aromatic oil extracted from the root is useful in arthritic pain.
45.	*Ligularia fischeri* (Ledeb.) Turcz.	Fischer's Ligularia	Asteraceae	AU	Leaves	Leaves are used to treat jaundice, scarlet – fever, rheumatoid arthritis, and hepatic diseases. Extract of the plant has been reported to be having number of biological activities, including anti-mutagenic activities and anti - genotoxic activities and cancer prevention activities.
46.	*Ligularia amplexicaulis* DC.	Stem Clasping Ligularia / Ri. Sho (Ti).	Asteraceae	AU, TMS	Shoots, leaves and roots	Astringent, digestive, emetic and cooling ; used in the treatment of vomiting due to indigestion.
47.	*Lilium nanum* Klotzsch & Garcke	Tiny Lily, Dwarf Lily	Liliaceae	AU, NTM	Whole plant	Antidote against poisonous bites; also heals bone fracture and injuries.
48.	*Maharanga emodi* (Wall.) DC. A.		Boraginaceae	AU, TMS, NTM	Roots, Flowers and seeds	Cooling, laxative and anthelmintic. Useful in eye diseases, ear problems, oil from seeds is applied as hair tonic.
49.	*Meconopsis paniculata* (D.Don) Prain	Panicled Yellow Poppy / Gyashur (N)	Papaveraceae	NTM, TMS	Flower, leaves, roots	Used for the treatment of swelling, diarrhoea, fever and cough.
50.	*M.simplicifolia* (D.Don) Walpers	Common Blue Poppy	Papaveraceae	---------		----------
51.	*M.horridula* Hook.f.& Thoms,	Prickly Blue Poppy	Papaveraceae	TMS, NTM	Whole plant	Leaf paste is applied to wounds. Infusion of flower is taken in fever, cough and cold. Plants are used as antidote against poisonous bites and also to treat lungs and skin diseases.
52.	*Myricaria rosea* Sm. W. (W.)	Rose False Tamarisk / Jillethi (N)	Tamaricaceae	TMS	Leaves and flowers	Used to treat fever, headache, stomachache, uterinary bleeding and food poisoning. .
53.	*Nardostachys jatamansii* (D.Don) DC.A.	Spikenard Jatamansi (N.); Pong-phe (B).	Valerianaceae	AU,TMS, NTM	Roots and rhizomes	Root eaten as tonic. Root oil is well known hair tonic and also applied over the paralysis and swelling. Rhizome paste is applied to treat piles. Plant is also used as incense.
54.	*Neopicrorhiza scrophulariiflora* Pennell	Figwort Picrorhiza / Kutki (N); Lhaie-tikta (B).	Scrophulariaceae	AU, NTM, TMS, LTM	Rhizome	Useful in dropsy, fever, anaemia and jaundice. Decoction of rhizome is taken as an antipyretic.
55.	*Nepeta floccosa* Benth.	Wolly Catmint	Lamiaceae	AU	Aerial parts	Anti-oxidant Flavonoids were reported to be extracted from the plant (Ali *et al.* 2015.)
56.	*Oxyria digyna* (L.) Hill	Mountain Sorrel / Lug. -Sho (Ti).	Polygonaceae	T MS	Leaves, flowers and stems	Useful in fever, sore throat and smallpox.
57.	*Paris polyphylla* Sm.	Himalayan Paris / Satua (N)	Melanthiaceae	AU, NTM,	Whole plant	Plant is analgesic, antipyretic, antispasmodic, depurative, febrifuge and narcotic and is useful in treatment of snake bites, boils, ulcers, cuts and wounds.

58.	*Pedicularis megalantha* D.Don		Orobanchaceae	TMS	Whole plant	Used as an antidote and for intestinal disorder in Bhutan (Phurba Wangchuk *et al*. 2016)
59.	*Pedicularis oederi* Vahl	Oeders Lousewort / Dhuk-zer (Ti).	Orobanchaceae	TMS	Stems, leaves, flowers and seeds	Heals water retention, constipation and breathlessness. Good for malnutrition, heals sores and relives severe pain due to serous fluids.
60.	*Pedicularis siphonantha* D.Don		Orobanchaceae	TMS	Whole plant	Antidote, anti-diarrheal and febrifuge ,used for stomach disorders (Phurba Wangchuk *et al*. 2016)
61.	*Parnassia nubicola* Wall.ex Royle	Himalayan Bog Star / Mamira (N)	Saxifragaceae	TMS		
62.	*Pleurospermum hookeri* Cl.		Apiaceae	TMS	Whole plant	Antidote against poisonous bites, anti-inflammatory, and cures heart disorders (Phurba Wangchuk et al. 2016).
63.	*Sinopodophyllum hexandrum* (Royle) T.S.Ying	Himalayan May Apple / Panchpatey (N), Yomha-si-se (B).	Lardizabalaceae	AU, NTM,TMS,LTM	Roots, rhizomes, leaves and fruits	Rhizomes and roots are considered purgative, stimulant, hepatic and blood purifier. Leaf juice is taken to vermifuge. Ripe fruit is eaten as laxative.
64.	*Polygonatum cirrhifolium* (Wall.) Royle	Coiling Leaf Solomon's Seal / Meda (N).	Asparagaceae	AU, NTM	Rhizome	Rhizome used as tonic and carminative. Used against loss of vigour, pain in the kidneys and hips, accumulation of fluids in bone joints.
65.	*P.singalilense* H.Hara	--	Asparagaceae	AU	--	--
66.	*P. verticellatum* (L.) All.	Whorled Solomon's Seal / Meda (N).	Asparagaceae	AU, NTM	Rhizomes	The plant has Tracheorelaxant and anti-inflammatory activities (H.Khan *et al*. 2013). Rhizome paste is given to dogs as a health tonic.
67.	*Polygonum vaccinifolium* Wall. ex Meisner	Rose Carpet Knotweed / Pulunge Jhar (N).	Polygonaceae	NT M	Whole plant	Useful in dysentery and fever
68.	*Ponerorchis chusua* D.Don	Chusua Orchis	Orchidaceae	AU, TMS	--	---
69.	*Potentila arbuscula* D.Don	Conquefoil	Rosaceae	TMS	Ariel parts	Useful in, fever, cough and cold
70.	*P.cuneata* Wall. ex Lehm.	Five Finger Cinquefoil	Rosaceae	TM S	Ariel parts	Useful in fever, cough and cold.
71.	*P.peduncularis* D.Don	East Himalayan Cinquefoil	Rosaceae	T MS	Ariel parts	Useful in fever, cough and caugh
72.	*Primula capitata* Hook.	Capitata Primrose	Primulaceae	TMS, AU	Flowers	Flowers of *Primula* treats vascular diseases and controls fever. It is particularly effective against fever and diarrhea in children.
73.	*Primula sikkimensis* Hook.f.	Sikkim Primrose / Shang. Dril Ser. Po (Ti)	Primulaceae	TMS, AU	Flowers	Flowers of *Primula* treats vascular diseases and controls fever. It is particularly effective against fever and diarrhea in children.
74.	*P. primulina* (Sprengel)H.Hara	Hairy Throated Primrose	Primulaceae	TMS, AU	Flowers	Flowers of *Primula* treats vascular diseases and controls fever. It is particularly effective against fever and diarrhea in children.
75.	*P. reticulata* Wall.		Primulaceae	TMS, AU	Flowers	Flowers of *Primula* treats vascular diseases and controls fever. It is particularly effective against fever and diarrhea in children.
76.	*Rheum acuminatum* Hook.f.& Thoms .ex Hook.	Ornamental Rhubarb / Padamchal (N)	Polygonaceae	TMS, LTM, NTM	Rhizome	Used against diarrhea and dysentery.
77.	*R.nobile* Hook.f. & Thoms.	Sikkim Rhubarb / Padamchal(N), Tchuka (L), Tsu.pa.ka (B).	Polygonaceae	TMS, LTM	Flower, Rhizome and leaves	Decoction of rhizome is taken against gastritis, piles and dysentery. Leaf juice is applied to cuts and wounds.
78.	*Rhodiola cretinii* Raymond-Hamet	Cretin's Rhodiola	Crassulaceae	TMS		Used in the treatment of lungs diseases
79.	*R. himalensis* (D. Don) S. H. Fu	Himalayan Rhodiola	Crassulaceae	TMS		Used in the treatment of lungs diseases
80.	*Sedum roseum* (L.) Scop.	Golden Root	Crassulaceae			
81.	*Rumex* sp.	Sho.mang (Ti)	Polygonaceae	TMS	Roots	Useful in fever, constipation, relieves swelling and diphtheria.
82.	*Sassurea gossipiphora* D.Don	Snowball Plant / Kasturi Kamal	Asteraceae	AU, NTM, TMS, LTM	Inflorescence	Decoction taken against body ache, sexual problems and stomach disorders. It is useful in cuts and wounds.
83.	*S. nepalensis* Sprengel	Nepal Saw-Wort	Asteraceae	--	--	---
84.	*S.obvallata* (DC.) Edgew.	Brahma Kamal (N)	Asteraceae	AU, NTM, TMS, LTM	Flower, rhizome, leaves	Used in arthritis, intestinal ailments, as antiseptic, in cough and cold, urinary tract problems, cardiac affections, etc.
85.	*Satyrium nepalense* D.Don	Nepal Satyrium	Orchidaceae	AU, NTM	Tubers	Used as an energizing tonic (www.flowersofindia.net)
86.	*Saxifraga brachypoda* D.Don	Saxifrage	Saxifragaceae	--		
87.	*Saxifraga engleriana* Harry Smith	Engler's Saxifrage	Saxifragaceae	--		
88.	*Saxifraga stenophylla* Royle	Ladakh Saxifrage	Saxifragaceae	TMS	Whole plant	Used to purify blood
89.	*Selenium wallichianum* (DC.) Raizada & H.O.Saxena	Milk Parsley / Bhut Kesh(N); Soreep (L).	Apiaceae	NTM, AU	Whole plant	Decoction of roots is taken against cough and fever. Leaves are carminative.
90.	*Senecio graciliflorus* DC.	Graceful Senecio	Asteraceae	AU,	Leaves, flowers	Used to treat Dermatitis and Stomachache by the Mongol tribe (Bhat T A, Nigam G. & Majar M. 2012). The plant has been reported to be of Cancer prevention and cure.

91.	*Senecio raphanifolius* Wall.ex DC.	Radish leaved Senecio	Asteraceae	--	--	Most of the *Senecio* species has been reported to be poisonous (E.Roeder, H.Wiedenfeld. 2009).
92.	*S. scandens* Buch.Ham. ex D. Don	Climbing senecio	Asteraceae	TMS, NTM	Whole plant	Diuretic, febrifuge, ophthalmic. Used in the treatment of epidemic influenza, malaria boils and abscesses. It contains an toxic alkaloids neoplatyphylline.
93.	*Silene nigrescens* L.		Caryophyllaceae	TMS	Roots	Used in deafness, nasal blockage and constipation.
94.	*Soroseris hookeriana* (Cl.) Stebbins	Hooker's Soroseris	Asteraceae	TMS	Whole plant	Relieves fever due to poisoning, also used in bone fracture (Phurba Wangchuk et all, 2009.
95.	*Streptopus simplex* D.Don	Simple Twisted Stalk	Liliaceae	AU	--	--
96.	*Swertia hookeri* Cl.	Indian Gentian / Lekh Chiraito (N).	Gentianaceae	AU,NTM, TMS	Roots	Sedative, nervine tonic, febrifuge. Roots used for treating bone fracture. Decoction of roots taken against fever and body ache.
97.	*Taraxacum officinale* Weber	Common Dandelion / Tukiphool (N).	Asteraceae	TMS	Roots and leaves	Roots juice taken against jaundice. Leaf juice useful in gastritis.
98.	*Thalictrum cultratum* Wall.	Knife Like Meadow Rue / La. Wa Sad Ma (Ti).	Ranunculaceae	AU, TMS, Folk	Whole plant	Treats infectious diseases, diphtheria and fever. Heals sores, dries serous fluids and is effective against intestinal fever.
99.	*T.foliolosum* DC.	Leafy Meadow Rue	Ranunculaceae	AU,TMS, Folk	Roots, leaves	Root paste taken to expel intestinal worms. Useful in treating eye diseases, indigestion, toothache.
100.	*Valeriana hardwickii* Wall.	Indian Valerian / Nakali Jatamasi (N).	Caprifoliaceae	AU,NTM, LTM	Roots and leaves	Decoction of roots is taken to cure mental disorder and also used as a hair tonic. Leaf paste is applied on boils.
101.	*V.jatamansii* Jones	Valerian / Jatamasi (N) Pong-phe (B).	Caprifoliaceae	AU,NTM, LTM	Rhizomes	Rhizome paste applied to treat gout and also taken against hysteria, epilepsy and nervous disorders. Used locally as incense in religious rites.
102.	*Veratrilla baillonii* Franchet		Gentianaceae	AU		An ethanol extract has been reported to reduce blood glucose in animals (Huang et al. 2016.). In Chinese Medicine System, it is used for treating liver-related disorders. Its antitoxic effect on mice induced by *Aconitum brachyopodum* Diels has also been reported (Ge YB et al. 2015).

TMS: Tibetan Medicinal System, **NTM**: Nepali Traditional Medicine, **LTM**: Lepcha Traditional Medicine, **AU**: Ayurveda

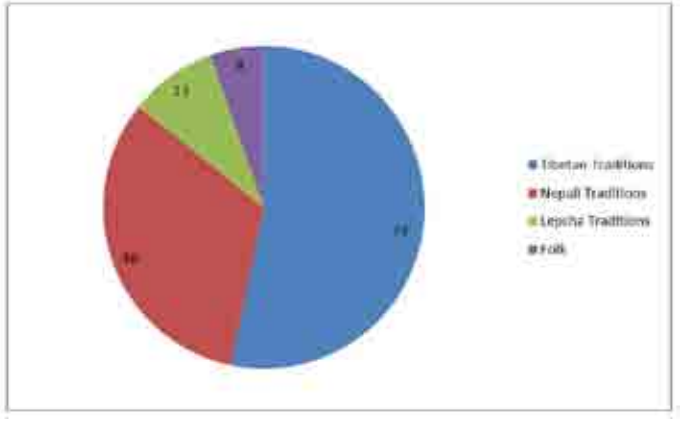

Chart 1. Number of species used in different systems of medicine in Kyongnosla Alpine Sanctuary

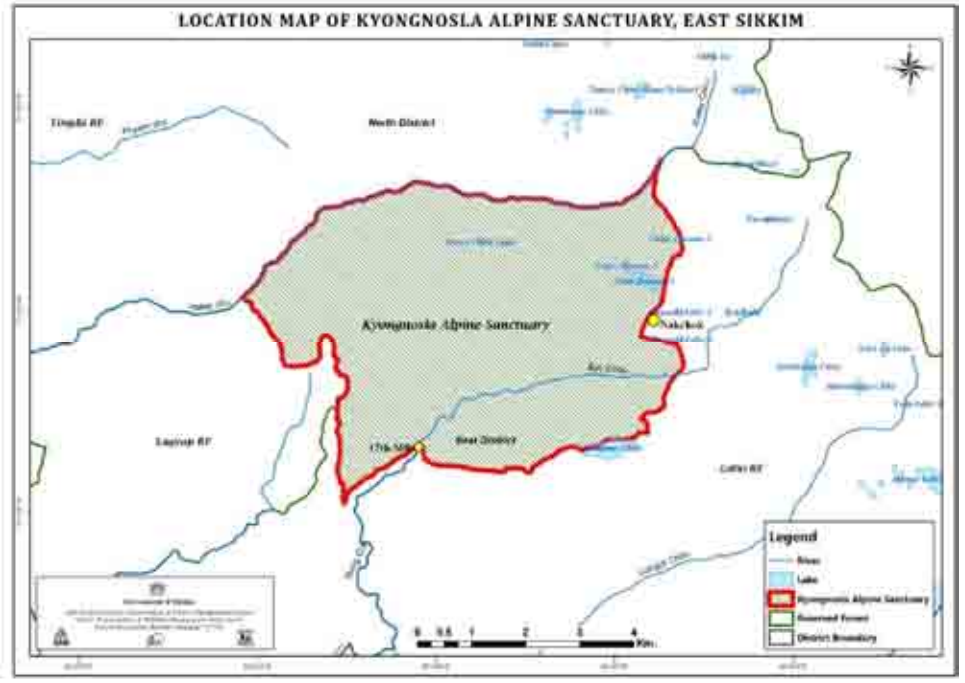

Figure 1. Location map of Kyongnosla Alpine Sanctuary, East Sikkim

Figure 2a. Alpine pasture at Nakchok in Kyongnosla Alpine Sanctuary with Jhor Pokhari Lake

Figure 2b. Sub-Alpine Forest dominated by bushy Rhododendrons and Iris and scattered Abies densa

Plate 1. Aconitum species in Kyongnosla Alpine Sanctuary, East Sikkim India

Plate 2. Some important Medicinal Plants of Kyongnosla Alpine Sanctuary

The Sanctuary is also a habitat of some high value medicinal herbs such as *Neo-picrorhiza scrophularia*, *Sassurea obvallata*, *S.gossipiphora*, *Lagotis crassifolia*, *Bergenia purpurascens*, *B.ciliata*, *Valeriana jatamansi, V. hardwickii*, *Codonopsis foetans*, C. *Clematidea, Panax bipinnatifidus*, *Paris polyphylla*, *Meconopsis horridula*, *M.simplicifolia*, *M.paniculata*, *Ligularia fischeri, L. Amplexicaulis, Jurinea dolomiaeia* etc. *Sassurea gossipiphora* and *S. obvallata,* both are highly threatened medicinal herbs of the Himalayas are also found occurring along the banks of rivers and streams in the area. Occurrences of other two species of *Sassurea viz.*, *Sassurea nepalensis* and *S. simpsoniana* have also been recorded from the area. *Lagotis crassifolia* found growing abundantly in association with *Sassurea obvallata. Rheum nobile*, a threatened Tibetan Medicinal herb inhabit the area towering all the shrubs and herbs and visible from miles away across the valley. *Rheum acuminatum* is the common Rhubarb available in the region. Other important medicinal herbs in the area are *Rhodiola cretinii, R.himalensis*, *Sedum roseum*, *Potentila arbuscula*, *P.cuneata*, *P.peduncularis*, *Primula capitata*, *P.sikkimensis*, *P.primulina*, *P.reticulata*, *Ponerorchis chusua, Polygonum vaccinifolium, Sinopodophyllum hexandrum, Pleurospermum hookeri, Parnassia nubicola, Pedicularis siphonantha, p. Oederi, P. Megalantha, Oxyria digyna, Nepeta floccosa, Myricaria rosea, Maharanga emodi, Lilium nanum, Impatiens radiata, I.bicornuta, I. racemosa, I.urticifolia, Acomastylis elata, Geranium wallichianum*, *Fritillaria cirrhosa, Fragaria nubicola*, *Euphorbia wallichii, Erigeron multiradiatus, Dracocephalum heterophyllum*, *Cynoglossum zeylanicum, Clematis napaulensis, Bistorta affinis*, *Arisaema jacquemontii, A. Griffithii, Arisaema erubescens, Anaphalis contorta, A.triplinervis, Allium prattii, A.wallichii* etc. Important medicinal shrubs available in the area are *Gaultheria nummularioides*, *G.trichophylla*, *Cassiope fastigiata*, C.*selaginoides*, *Berberis insignis, Berberis angulosa, Juniperus recurva, J.coxii, Rhododendron anthopogon, R.campanulatum* subsp *campanulatum, R.campanulatum* subsp *aeruginosum, R.hypenanthum, R.lepidotum, R.thomsonii* and *Rosa sericea*. Some important medicinal plants of the sanctuary are shown in Plate 2. *Rhododendron hypenanthum*, a Tibetan Medicinal shrub has also been recorded from the area for the first time from the Sikkim Himalaya, resulting in addition to the previous list of 38 species of Sikkim Himalayan Rhododendrons (Dahal, S. 2015-16).

As far as the uses of the recorded medicinal plants is concerned 79 species has been recorded to be used in Tibetan Medicine System,48 species in Traditional Nepali Medicine, 13 species in Lepcha Traditional Medicine and 8 species were recorded to be used by local healers of the area which are presented by Chart 1. Most of the listed species (Table 2) have been used in Ayurvedic system of medicine. Since this is the first attempt to enumerate the floral diversity of Kyongnosla Alpine Sanctuary and documentation of medicinal usages of the species in different healing traditions of different communities of Sikkim an in depth study is required to have a complete database of medicinal plants resources of the area.

Conclusion

Kyongnosla Alpine Sanctuary has been found to be the rich repository of medicinal plants genetic resources. Traditional herbal practices are vibrant traditions among all the communities inhabited in Sikkim. Very few medicinal plants used by the local healers of the state are scientifically validated through phyto-chemical and pharmacological studies and hence their detail ethno-medicinal as well as phyto-chemical and pharmacological studies are essential. Since the present study area is away from the human habitations, the anthropogenic pressures is still not pronounced and for which biodiversity of the area still remain intact to a considerable extent. Species such as *Juniperus recurva*, *J.coxii*, *Rhododendron campanulatum*, *R. campanulatum* subsp.*aeruginosum, Rhododendron hypenanthum, R. anthopogon*, *R. lepidotum, Iris clarkei, Bergenia purpurescens*, *Bistorta amplexicaulii*, *Rheum acuminatum, Nardostachys jatamansi*, *Sassurea nepalensis, Juncus* spp., etc. are flourishing well in the area with good number of populations. However, some high valued and rare medicinal herbs of the area *viz., Aconitum laciniatum, Aconitum novoluridum, Aconitum bisma, Aconitum disectum, Neopicrorhiza scrophularia*, *Gymnadenia orchidis, Fritillaria cirrhosa, Sassurea gossipiphora, S. obvallata, Rheum nobile, Allium prattii, Bergenia ciliata, Sinopodophyllum hexandrum, Swertia hookeri, Lilium nanum, Codonopsis foetans, Gentiana elwesii, G. algida*, *G. prolata*, *G. stylophora*, *Acomastylis elata, Meconopsis horridula, Polygonatum cirrhifolium*, *P. verticellatum,* etc. observed to be very rare in the area, which may be due to an unauthorized trade of commercially important species through porous national and international border along West Bengal, Nepal, China and Bhutan (Source: traders-collectors survey), and prooting of entire plants, immature plants, etc.; hence proper management and conservation strategies is needed to maintain the gene bank of these precious wealth of the Himalayas along with their natural habitat. Towards the conservation initiatives of some threatened species of the Himalayas, such as *Nardostachys jatamansi, Podophyllum hexandrum, Bergenia ciliata*, *Valeriana jatamansi, V. Hardwickii, Panax bipinnatifidus, Paris polyphylla* etc. have been given priority for commercial cultivation by National Medicinal Plants Board through Sikkim State Medicinal Plants Board, under the Department of Forest, Environment and Wildlife Management, Government of Sikkim. The practice of domestication, cultivation and commercialization of the high value medicinal plants preferably some rare and threatened species are recommended for their sustainability, instead of practicing unsustainable harvesting from the wild. Natural disturbances of habitat including the effect of climate change needs to be addressed as well.

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Rediscovery of *Aconitum novoluridum* (Ranunculaceae) from Sikkim Himalaya, India

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Abstract

Aconitum novoluridum Munz, a rare medicinal plant, has been rediscovered after a gap of more than a century from Tamze valley and upper ridges of Kyongnosla Alpine Sanctuary of Sikkim Himalaya. Detailed description and photographs are provided.

Keywords: *Aconitum novoluridum*, Alpine Slopes, Rediscovery, Sikkim

Introduction

The genus *Aconitum* L. comprising of *c*. 250 species is distributed in the subalpine and alpine regions of the world (Lane, 2004). In India, the genus is represented by 27 species (Rau, 1993), of which 11 species are reported to be occurring in Sikkim. During the course of the floristic study of alpine Medicinal Plants Conservation Area at Tamzey valley near Kyongnosla Alpine Sanctuary in the Eastern Sikkim Himalaya in June 2015, the authors have collected an interesting specimen of *Aconitum* in vegetative stage with poorly developed root system. Later, in August 2016 while undertaking a rapid biodiversity survey as part of Sikkim Biodiversity Conservation and Forest Management Project in Kyongnosla Alpine Sanctuary, plant specimens were collected with flowers along with well-developed root system. On scrutiny of literature (Stapf, 1905; Kadota, 1987; Yang, 1990; Chaudhary & Rao, 1998; Samant *et al*., 1998; Wencai *et al*., 2001) the specimens were identified as *Aconitum novoluridum* Munz. The species was occurring along the east facing slope at an elevation of 4069 m. *Aconitum novoluridum* Munz was first collected by J.D. Hooker from the Tankra Pass and Cho-la in the Eastern Sikkim in 1849 and subsequently described as *Aconitum luridum* Hook.f. & Thomson in 1855. Later, Munz (1945), proposed a new name for this species as *Aconitum novoluridum* since the name *A. luridum* Hook.f. & Thomson was already preoccupied by *A. luridum* Salisb. Lauener (1964), recorded this species from Nepal based on the collection by Stainton (*Stainton* 1152) in 1956, from Tamur valley, Kambachen, Eastern Nepal. There is no representation of this species in any of the Indian herbaria (CAL, BSD, DD and BSHC). The present collection of the species after more than a century from Sikkim reveals the rarity of this species in its natural habitat in India. Presently, the occurrence of this species is confined to Juniper – Rhododendron scrub on alpine slopes and cliffs of Tamzey Medicinal Plant Conservation Area and Kyongnosla Alpine Sanctuary in the Eastern Himalaya of Sikkim, conserved under the Protected Area Network. However, an extensive field survey is required to find out the natural habitats of the species in other parts of Sikkim Himalaya.

Aconitum novoluridum Munz, Gentes Herbarum 6: 472. 1945; Lauener, Notes Roy. Bot. Gard. Edinburgh 26: 9. 1964; Grierson in Grierson & D.G. Long, Fl. Bhutan 1(1): 317. 1984; M.A. Rau in B.D. Sharma *et al*., Fl. India 1: 21. 1993; L.Q. Li & Kadota in Wu *et al*., Fl. China 6: 160. 2001. *A. luridum* Hook.f. & Thomson, Fl. Ind. 1: 55. 1855 & Fl. Brit. India 1: 28. 1872, non Salisb. 1816. **Fig. 1**

Root perennial, descending, elongate, cylindric, ultimately breaking up into separate or anastomosing strands. Stems erect, from a simple or, 2 to many-headed collar covered with brown, dilated bases of the old petioles, unbranched, to 80 cm high, softly hairy to tomentose or sometimes glabrate towards the base, hairs spreading, rarely curved and adpressed. Leaves few from the collar

Fig. 1. *Aconitum novoluridum* Munz: a. Habit; b. Section of root; c. Root breaking up into an anastromosing strands.

on very long (to 30 cm) petioles which are dilated at the base; 3–6, rarely more, from the stem, distant, similar to the basal, but gradually smaller with narrower divisions and the upper with rapidly decreasing petioles, basal and lower blades hairy on both surfaces (especially on veins beneath), orbicular-cordate or reniform in outline, with a narrow or more often wide sinus (1–2 cm deep), 2.5–6.5 cm from the sinus to the tip, 5–7, rarely more, 5-palmati partite to 3/4ths of the length, inner divisions obovate-cuneate, 1.5–3 cm wide, 3-lobed, outermost trapezoidal, 2-lobed, lobes sparingly and acutely inciso-dentate or apiculate-crenate. Inflorescence racemose, to 40 cm long, narrow, rather dense, rarely with a few additional branches from the base, with the same indumentum as the stem, lowest bracts 3-partite, others lanceolate or the uppermost sublinear, exceeding the pedicels; pedicels erect, short, except the lowest (2.5–3.5 cm); bracteoles, if present, small, linear. Sepals lurid, reddish or brownish red to purple, yellowish inside, hairy, upper sepal helmet-shaped, broad, hemi-elliptic in profile in the upper part, 5–7 mm high, gradually descending into an obtuse beak of equal or more than equal length; lateral sepals somewhat obliquely obovate, scarcely clawed, 9–11 × 7–7.5 mm; lower sepals deflexed, oblong, 8–9 mm long, obtuse. Nectaries hammer-shaped, glabrous; claw erect, 4–5 mm long; hood at a right angle to the claw, obliquely oblong, obtuse; lip horizontal or slightly deflexed, shortly 2-lobed. Filaments 6–9 mm long, glabrous, broadly winged up to or beyond middle; wings abruptly contracted. Carpels 3, contiguous and oblique to horizontal in the flower, obliquely oblong, densely hairy, rarely almost glabrous, shortly contracted into the somewhat shorter styles. Follicles erect, contiguous, oblong, subtruncate, 10–12 mm long, glabrescent; seeds triquetrous, oblong, to 3 mm long, blackish brown; angles unequally winged, dorsal face transversely wrinkled, ventral faces smooth.

Flowering & fruiting: August–September.

Habitat: It occurs in Juniper-Rhododendron scrub on alpine slopes and cliffs. The associated species are *Saussurea obvallata* (DC.) Edgew., *Rhodiola himalensis* (D. Don) S.H. Fu, *Bergenia purpurascens* (Hook.f. & Thomson) Engl., *Rhododendron lanatum* Hook.f., *R. anthopogon* D. Don, *R. lepidotum* Wall. ex G. Don, *Juniperus coxii* A.B. Jacks. and *Rheum acuminatum* Hook.f. & Thomson.

Distribution: Bhutan, China (Southeast Xizang), India (Sikkim) and Nepal, 3800–4500 m.

Specimens examined: INDIA, **Sikkim**: Tamze, June 2015, *T.P. Sharma* SD 301 (BSHC); Kyongnosla Alpine Sanctuary, August 2016, *S. Dahal* SD 370 (BSHC).

Note: The present collection of this species has remarkable relevance in preservation of alpine gene bank of Sikkim in the form of Protected Area since its occurrence is witnessed only in Medicinal Plants Conservation Area at Tamze valley and Kyongnosla Alpine Sanctuary, in the Eastern Himalaya of Sikkim. Since the area is far away from the human habitation, no anthropogenic pressure in the habitat has been observed. Natural disturbances including the impact of climate change needs to be studied well, which will be useful for the policy makers and forest managers in framing effective strategies in managing and conserving the species.

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FLORISTIC STUDY OF SUB ALPINE – ALPINE HIMALAYA OF EAST SIKKIM

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Abstract

Floristic studies conducted at Sub-alpine to Alpine Himalaya of East district of Sikkim in between 3000-4500m including Kyongnosla Alpine Sanctuary, Tamze valley, Tsomgo – Baba Mandir (and surrounding areas) and sub - alpine to alpine belt of Pangolakha Wildlife Sanctuary records the occurrence of over 150 species, of which, herbs represented the highest number of species (118 species) followed by small trees / shrubs / shrublets (29 species). Trees were very less prevalent in the area; hence only 3 trees were recorded i.e., *Abies densa, Acer pectinata* and *Betula utilis* from the sub-alpine part. Of over 150 species recorded, 120 species were recorded as medicinal plants. Aconitum, the taxa of the highly potential medicinal plant of the Himalayas but not much attention paid by the taxonomist so far have been re-discovered from the area after more than a century after the monographic work of Stapf, O. during 1905 with seven species namely *Aconitum laciniatum, Aconitum novoluridum, Aconitum bisma, Aconitum disectum, Aconitum ferox, Aconitum violaceum* and

Aconitum spicatum with comparatively good number of population except few such as *A.novoluridum*, which were observed very rare in the area. High altitude gentians (Gentianaceae) such as *Gentiana elwesii, G.algida, G.prolata, G.sikkimensis, G.stylophora, Swertia hookeri, Veratrilla baillonii* and *Halenia elliptica* were recorded from the area. Species of Sassurea viz. *Sassurea gossipiphora, S.obvallata, S. scandens &, S. nepalensis* were recorded of which *S.obvallata* and *S.gossipiphora* are the highly threatened medicinal herbs of the Himalayas which are also found occurring in Tamze valley and in upper part of Kyongnosla Alpine Sanctuary, also the sanctuary were found to be a rich repository of high value medicinal plants of the Himalaya. Some high altitude herbs such as *Neo-picrorhiza scrophularia*, *Lagotis crassifolia*, *Bergenia purpurascens*, *B.ciliata*, *Valeriana jatamansi, V. hardwickii*, *Codonopsis foetans*, C. *Clematidea, Panax bipinnatifidus*, *Paris polyphylla*, *Meconopsis horridula*, *M.simplicifolia*, *M.paniculata*, *Ligularia fischeri, L. Amplexicaulis, Jurinea dolomiaeia* etc. were also recorded from the area. *Veratrilla baillonii,* and *Rhododendron hypenanthum* discovered for the first time from the Sikkim Himalaya during the present study. *Gentiana elwesii* a rare medicinal herb reported in 1885 was also re-discovered from the area during the present study. Presently, the record of most of the species was mainly confined to protected area (Kyongnosla Alpine Sanctuary, Pangolakha Wildlife Sanctuary, and Tamze (Medicinal Plants Conservation Area) in the Eastern Himalaya of Sikkim which is conserved under the protected area network. However, an extensive field survey is required to find out the natural habitats of these species in other parts of Sikkim Himalaya. Since the present study area is away from the human habitations, the anthropogenic pressure is still not marked and hence biodiversity of the area still remain intact to some extent. However, some of the species were observed very rare in the area; hence proper management is needed to maintain the gene bank of these species in their

natural habitat. Natural disturbances on the habitat including the effect of climate change needs to be studied well.

SUB ALPINE - ALPINE FLORA OF EASTERN SIKKIM

Contd....

Gentiana clivorii C.B.Clarke
(Gentianaceae)
Re-discovered this rare medicinal Gentian from Sikkim after Hooker's collection during 1885 from Lachung - Yumthang, North Sikkim.

Iryanthia hallii Franchet
(Gentianaceae)
Discovered for the first time from Sikkim (from Kyongnosla Alpine Sanctuary ca. 3600m)

Swertia hookeri C.B.Clarke
(Gentianaceae)
Commonly called as **Indian Gentian,** a threatened, high value medicinal herb.

Cassiope fastigiata (Wallich) D.Don
(Himalayan Heather)
Ericaceae

Potentilla arbuscula D.Don
(Conquefoil)
Rosaceae

Allium prattii C.H.Wright
(Wild Onion)
Amaryllidaceae

Rosa sericea Lindley
(Silky Rose)
Rosaceae

Pedicularis siphonantha D.Don
Orobanchaceae

Rhododendron setosum D.Don
(Bristly Rhododendron)
Ericaceae

Rhododendron thomsonii Hook.f
(Dr. Thomson Rhododendron)
Ericaceae

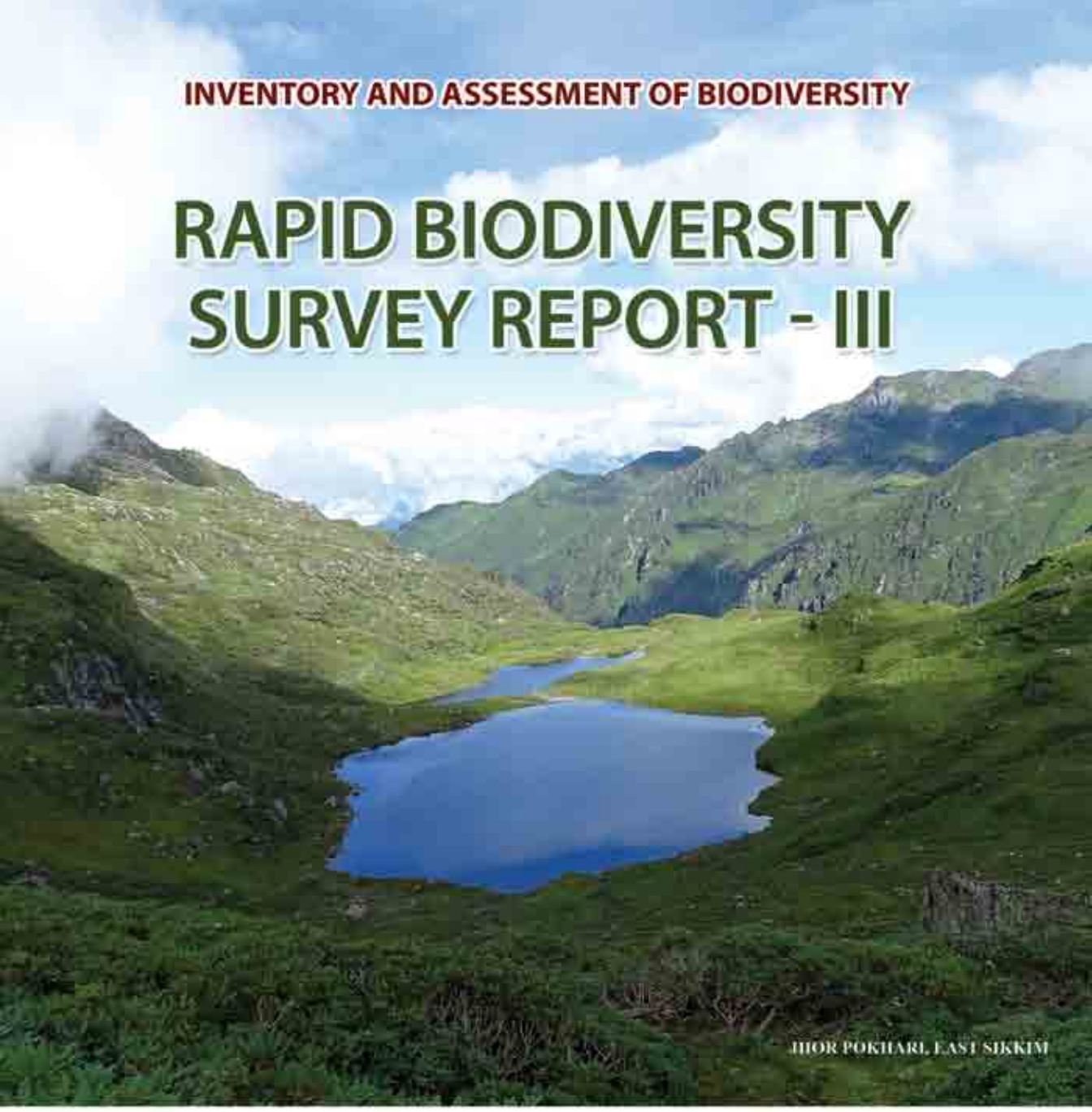
Rhododendron hypenanthum Balf.f
(Yellow Dwarf Rhododendron)
Ericaceae

Rhododendron campanulatum D. Don subsp *aeruginosum* (Hook.f)
(Aeruginose Rhododendron)
Ericaceae

Kyongnosla Alpine Sanctuary with full bloom *Sassurea obvallata*, a rare medicinal plant of the Himalaya.

INVENTORY AND ASSESSMENT OF BIODIVERSITY

RAPID BIODIVERSITY SURVEY REPORT - III



JHOR POKHARI, EAST SIKKIM

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