

# Chapter-VII



## Chapter-VII

# Discussion

### 7.1. ANALYSIS OF THE FLORA

The Pangolakha Wildlife Sanctuary (PWS) is one of the less disturbed sanctuaries in Sikkim Himalaya. After the comprehensive floristic survey of the sanctuary, it is noted that the sanctuary is bestowed with immensely rich flora. A total of 890 species under 425 Genera belonging to 137 families of angiosperms, 6 genera and 6 species of gymnosperms under 3 families, besides 68 species of fern and fern allies under 39 genera belonging to 20 families are recorded from PWS during the present exploration. The reason for sustentation of enormous richness in floral diversity within the area is because of favorable factors like unique climatic, variation in edaphic, altitudinal and their natural complex inter-relationships within the species. The another reason could be of its sufficient rainfall varying from 200 – 500 cm distributed almost throughout the year due to close proximity to the Bay of Bengal with direct exposure to the southwest monsoon.

The vegetation of the the PWS uphold an integral part of “Himalaya Biodiversity Hotspot” in the East Himalayan region. It provides an enormous variety of habitats and this is reflected in the richness of its flora.

The detailed analysis of the total angiosperm flora of the sanctuary revealed that the distribution and variation in dicots have more dominance over the monocots. A clear picture emerged in the variation of the distribution and dominance of the different taxa belonging to different families. It has been recorded that the family Asteraceae with 66 species is the largest and dominant family of angiosperms occurring mainly on sub-alpine region of PWS. Other dominant families as observed during the present survey includes *Poaceae* (39 sp.), *Rosaceae* (34 sp.), *Primulaceae* (33 sp.), *Orchidaceae* (31 sp.), *Cyperaceae* (31 sp.), *Ericaceae* (28 sp.), *Apiaceae* (26 sp.), *Ranunculaceae* (25 sp.), *Polygonaceae* (21 sp.) etc.

As the sanctuary covers both temperate as well as alpine region it upholds a huge numbers of very important plant species potential to serve the humanity. It is also observed that the herbaceous species are more dominant than the shrubs and the trees in both temperate and alpine region. A very fair amount of species of useful trees represents the dense canopy of the sanctuary.

The populations of the species of temperate or sub-temperate families such as *Asteraceae*, *Poaceae*, *Rosaceae*, *Primulaceae*, *Ericaceae*, *Cyperaceae*, *Urticaceae*, *Orchidaceae*, etc. are dominating the vegetation of the PWS.

An analysis of the flora of PWS further revealed the existence of numerous important plant species which are directly or indirectly beneficial for the human sustenance. Many of the species have been recorded for having varied potential as food, medicines, etc. for humanity, besides an extraordinary rich repository of various plant resources including the large number of valuable and durable timber-yielding trees. Many of the species have also been regarded as sacred for various rites and religion by the local people.

A huge area of temperate to alpine favored the growth of different species of *Rhododendron*, and a diverse population of epiphytes, including orchids, ferns and fern allies and other plant species representing non-vascular lower groups.

The species recorded during the survey under the flora of PWS represents the Himalayan origin with major representative taxa of Sino-Himalayan, followed by South-East Asian and of Malaysian origin. Comparatively a very less number of cosmopolitan species of plants are recorded from the sanctuary. There are also records of the existence of taxa of exotic origin, migrated or may be introduced that have adapted to this part of Himalayas so far known from the countries like N. America, China, Japan, Australia, Africa, Mexico, W. Indies, South America etc.

### 7.1.1 Numerical Distribution of Taxa

The present floristic work on PWS deals with an account of 117 Angiospermic families, out of which 100 are dicotyledonous and the remaining 17 are monocotyledonous; 655 species under 289 genera are recorded from 100 dicot families and 164 species belonging to 88 genera in 17 monocot families. Only 6 species of gymnosperm belonging to 3 families and a total of 68 species of ferns and fern-allies were recorded under 39 genera belonging to 20 families (Table 7.1).

**Table 7.1:** Numerical representation of the taxa of PWS

TAXA	FAMILIES	GENERA	SPECIES
Dicotyledons	100	287	655
Monocotyledons	17	89	163
Gymnosperms	03	06	06
Pteridophytes	20	39	68
<b>Total</b>	<b>140</b>	<b>421</b>	<b>892</b>

The following tables [7.2-(a, b); 7.3 & 7.4] provide accounts of family-wise numerical distribution of Taxa of the PWS.

**Table 7.2: Family wise numerical representation of Angiospermic taxa for the flora of PWS**

**(A) DICOTYLEDONAE**

FAMILY	GENUS	SPECIES
ACANTHACEAE	4	7
ACERACEAE	1	7
AMARANTHACEAE	2	3
ANACARDIACEAE	3	5
APIACEAE	15	26
AQUIFOLIACEAE	1	3
ARALIACEAE	7	10
ARISTOLOCHACEAE	1	2
ASCLEPIADACEAE	3	6
ASTERACEAE	30	66
BALSAMINACEAE	1	12
BEGONIACEAE	1	8
BERBERIDACEAE	1	4
BETULACEAE	3	4
BORAGINACEAE	2	5
BRASSICACEAE	4	6
BUDDLEJACEAE	1	3
BURSERACEAE	1	1
BUXACEAE	1	1
CAMPANULACEAE	3	10
CAPRIFOLIACEAE	4	11
CARYOPHYLLACEAE	7	10
CELASTRACEAE	3	8
CHENOPODIACEAE	1	1
CONVOLVULACEAE	2	3
CORNACEAE	3	3
CRASSULACEAE	2	4
CUCURBITACEAE	4	4
CUSCUTACEAE	1	1
DAPHNIPHYLLACEAE	1	1
DIPSACEACEAE	2	3
DROCERACEAE	1	1
ELAEAGNACEAE	2	2
ELAEOCARPACEAE	2	2
ERICACEAE	4	28
EUPHORBIACEAE	1	4
FABACEAE	5	5
FAGACEAE	4	6
FLACOURTIACEAE	1	1
FUMARIACEAE	2	12
GENTIANACEAE	4	13
GERANIACEAE	1	3
GESNERIACEAE	5	9
GROSSULARIACEAE	1	2
HYPERICACEAE	1	5
HYDRANGEACEAE	2	4
JUGLANDACEAE	1	1
LAMIACEAE	11	18
LARDIZABALACEAE	1	1
LAURACEAE	7	11
LEEACEAE	1	1
LENTIBULARIACEAE	1	1

LINACEAE	1	1
LOBELIACEAE	2	4
LORANTHACEAE	2	2
MAGNOLIACEAE	2	4
MALVACEAE	1	1
MELASTOMATACEAE	4	6
MIMOSACEAE	2	2
MENISPERMACEAE	1	2
MONOTROPACEAE	1	1
MORACEAE	2	4
MORINACEAE	2	2
MYRSINACEAE	2	4
NYSSACEAE	1	1
OLEACEAE	3	3
ONAGRACEAE	2	9
OXALIDACEAE	1	3
PAPAVERACEAE	2	3
PARNASSIACEAE	1	4
PHYTOLACCACEAE	1	1
PIPERACEAE	2	5
PLANTAGINACEAE	1	2
PODOPHYLLACEAE	1	1
POLYGONACEAE	6	21
PRIMULACEAE	3	33
RANUNCULACEAE	7	25
RHAMNACEAE	1	1
ROSACEAE	10	34
RUBIACEAE	9	14
RUTACEAE	4	8
SALICACEAE	2	4
SAMBUCACEAE	1	1
SANTALACEAE	1	1
SAURAUJACEAE	1	1
SAXIFRAGACEAE	3	9
SCHISANDRACEAE	1	1
SCROPHULARIACEAE	9	18
SOLANACEAE	2	2
SONNERATIACEAE	1	1
STACHYURACEAE	1	1
STAPHYLEACEAE	1	1
SYMPLOCACEAE	1	5
THEACEAE	1	2
THYMELAEACEAE	2	4
URTICACEAE	9	20
VACCINIACEAE	2	5
VALERIANACEAE	2	2
VIOLACEAE	1	5
VITACEAE	2	2
<b>TOTAL Families: 100</b>	<b>288</b>	<b>655</b>

**(B): MONOCOTYLEDONAE**

FAMILY	GENUS	SPECIES
ARACEAE	5	12
COMMELINACEAE	3	3
CONVALLARIACEAE	4	8
CYPERACEAE	9	31
DIOSCOREACEAE	1	2
HYPOXIDACEAE	2	2
JUNCACEAE	1	1
LILIACEAE	1	16
MUSACEAE	5	5
MELANTHACEAE	1	1
ORCHIDACEAE	1	1
POACEAE	24	32
TRILIACEAE	25	35
IRIDACEAE	1	6
UVALIARACEAE	1	1
ZINGIBERACEAE	2	3
SMILACACEAE	3	4
<b>Total Families : 17</b>	<b>89</b>	<b>163</b>

**Table 7.3:** Family-wise Numerical representation of Gymnosperms of PWS.

FAMILY	GENERA	SPECIES
PINACEAE	1	1
TAXACEAE	2	2
CUPRESSACEAE	3	3
<b>Total Families: 3</b>	<b>6</b>	<b>6</b>

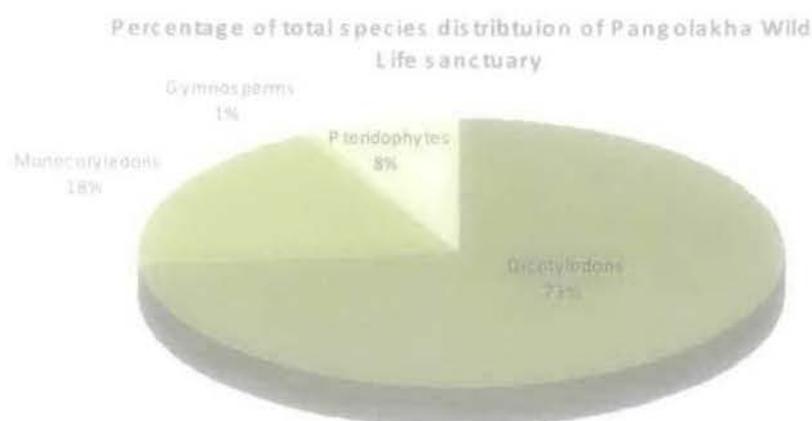
**Table 7.4:** Family-wise numerical representation of Pteridophytes of PWS.

FAMILY	GENUS	SPECIES
ADIANTACEAE	2	2
ASPIDIACEAE	4	14
ASPLENIACEAE	1	3
ATHYRIACEAE	4	5
CYATHEACEAE	1	1
DENNSTAEDTIACEAE	3	3
EQUISETACEAE	1	1
GLEICHENIACEAE	1	3
HAMIONTIDIACEAE	1	1
HYMENOPHYLLACEAE	1	2
HYPOLEPIDACEAE	1	1
LINDSAEACEAE	2	2
LYCOPODIACEAE	1	4
OLEANDRACEAE	4	4
PHROLEPIDACEAE	1	1
POLYPODIACEAE	7	14
PTERIDACEAE	1	4
SELAGINELLACEAE	1	1
THELYPTERIDACEAE	1	1

VITTARIACEAE	1	1
<b>Total Families: 20</b>	<b>39</b>	<b>68</b>

**Table 7.5:** Relative distribution of different group of vascular plants in PWS.

Plant Group	Representation					
	Family		Genus		Species	
	No.	%	No.	%	No.	%
DICOTYLEDONAE	100	71.43	287	68.17	655	73.43
MONOCOTYLEDONAE	17	12.14	89	21.14	163	18.27
GYMNOSPERMS	3	2.14	6	1.43	6	0.67
PTERIDOPHYTES	20	14.29	39	9.26	68	7.62
<b>TOTAL:</b>	<b>140</b>		<b>421</b>		<b>892</b>	



**Fig. 7.1:** Percentage distribution of different major taxa in the flora of PWS

Table 6.5 presents the percentage distribution (Fig. 6.1) of different major groups of vascular plants recorded from PWS. Dicotyledonous angiosperms having the major domination of 73.35 % species as it is true for most of the floras in tropical and subtropical regions of the world. On the other hand, unlike the sub-alpine and alpine parts of the planet, gymnosperms are very poorly represented, only 0.67 % of vascular plants. Comparing with the monocotyledonous flora of nearby regions, it also appears to be little less than the expectation. However, families like Poaceae, Cyperaceae and Orchidaceae are quite well represented and occupying quite higher positions among the ten dominant families of the sanctuary (Fig. 6.2).

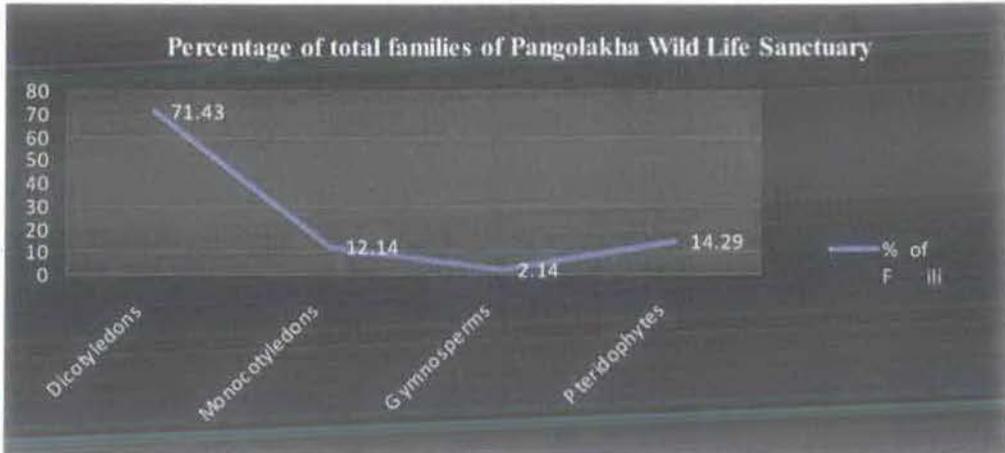


Fig. 7.2: Graphical representation of the percentage distribution of different families under the major taxa recored in the flora

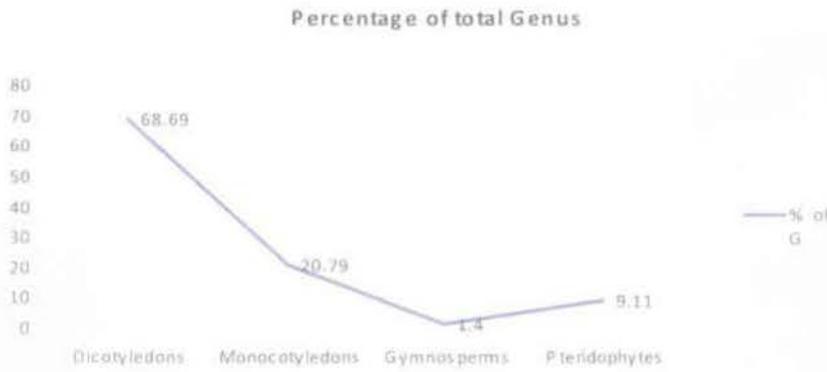


Fig. 7.3: Percentage distribution of genera under different major taxa in the flora

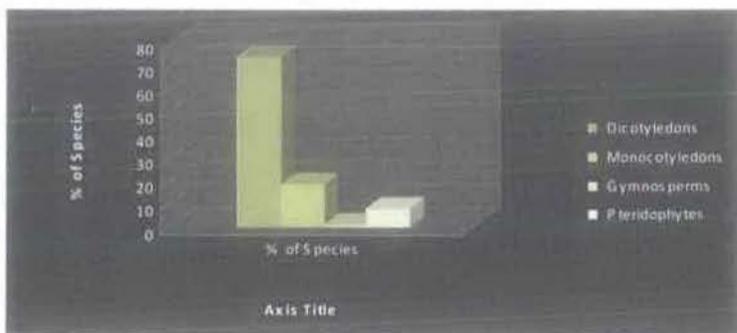


Fig. 7.4: Percentage distribution of species under different major groups of taxa

The comparison of 10 dominant families in *Flora of British India* (Hooker 1872-1897), *Flora of Eastern Himalaya* (Hara 2966, 1971; Ohashi 1975) and of Sikkim Plants (Singh & Chauhan 1998) with that of the present work (Table 6.6) shows the families, such as *Asteraceae*, *Poaceae*, *Rosaceae*, *Cyperaceae*, *Orchidaceae* etc. are the most dominant ones in generalized

term, substantiating the earlier stand (Hooker 1906,1907; Chatterjee 1940; Hara 1966, 1971) of the dominance of these families in the flora of the Eastern Himalayan region.

**Table 7.6:** List of 10 dominant families in Flora of British India, Flora of Eastern Himalaya, Sikkim Plants and Pangolakha Wildlife Sanctuary

SN	FBI	FEH	SP	PWS
1	Orchidaceae	Orchidaceae	Orchidaceae	Asteraceae
2	Compositae	Leguminosae	Asteraceae	Poaceae
3	Gramineae	Gramineae	Poaceae	Rosaceae
4	Rosaceae	Compositae	Fabaceae	Primulaceae
5	Cyperaceae	Cyperaceae	Cyperaceae	Cyperaceae
6	Geraniaceae	Rosaceae	Rosaceae	Orchidaceae
7	Ericaceae	Scrophulariaceae	Scrophulariaceae	Apiaceae
8	Liliaceae	Labiatae	Rubiaceae	Polygonaceae
9	Labiatae	Ranunculaceae	Lamiaceae	Lamiaceae
10	Umbelliferae	Urticaceae	Euphorbiaceae	Urticaceae

It is interesting to note that Orchidaceae is domination in all three other floras taken for comparison. But, Orchidaceae is occupying the 5<sup>th</sup> position along with Cyperaceae with the record of only 31 species. In fact, Sikkim flora represents the largest number of orchidaceous plants. Most of the orchids do not prefer the alpine or subalpine environment and the major part of PWS is prevailing with such extremely chilling climatic condition. Again, numerous herbaceous members of Asteracea prefer cooler region, thereby dominating the PWS flora.

**Table 7.7:** List of ten dominating Genera of PWS.

Sl. No.	Genus	Family	No. of Species
1	<i>Primula</i>	Primulaceae	24
2	<i>Rhododendron</i>	Ericaceae	18
3	<i>Juncus</i>	Juncaceae	16
4	<i>Carex</i>	Cyperaceae	14
5	<i>Rubus</i>	Rosaceae	13
6	<i>Impatiens</i>	Balsaminaceae	12
7	<i>Corydalis</i>	Fumariaceae	10
8	<i>Anaphalis</i>	Asteraceae	08
9	<i>Arisaema</i>	Araceae	08
10	<i>Pedicularis</i>	Scrophulariaceae	08

Rhododendrons are trees and form dense forests, which is prevalent in many areas of Darjeeling and Sikkim. For this, the genus *Rhododendron* appears to be most dominant not only in Sikkim but also in adjacent Bhutan (Pradhan 1999). On the other hand, Lepcha *et al* (1997) has presented

the existence of a large number of species of *Juncus* in the PWS. In addition, the herbaceous genus *Primula* is also highly dominating in this region and PWS is housing 24 such plants and expressing *Primulas* as most dominating genus of flowering plants in the Sanctuary.

### 7.1.2. Comparison of Flora of PWS with other Floras of Adjoining Regions

Apart from the *Flora of Sikkim (Monocotyledons)* by Hajra & Verma (1996), the most comprehensive floras pertaining to Sikkim Himalayas and the adjoining regions include (1) *The Flora of British India* by J.D. Hooker (1872-1897). (2) *The Flora of Eastern Himalaya*, Parts I - III by Hara (1966, 1971) and Ohashi (1975), (3) *Enumeration of Flowering Plants of Nepal*, Vols. I - III by Hara *et al* (1978, 1979 & 1982) and (4) *The Flora of Bhutan*, vols. 1 - 3, by Grierson & Long (1983, 1984, 1987, 1991, 1999, 2000; Noltie 1994, 2000; Pearce & Cribb 2002). The first flora, i.e. *The Flora of British India* covers the plants collected from Indian subcontinent, Eastern Himalaya including Sikkim and extending to Pakistan, Bangladesh, Myanmar, Malaysia, etc. *The Flora of Eastern Himalaya* has engrossed the plant collection from the hilly parts of North Bengal, Sikkim, Eastern Nepal and Bhutan regions in the Eastern Himalaya covering an altitudinal range of 300 m (at Tista Bazar) to 4400 m (at Oma La). The third treatise, i.e. *Enumeration of Flowering Plants of Nepal* is the outcome of compilation of the collections of Nepal plants at the Herbaria of British Museum [Natural History (*BM*)], Kew Herbarium (*K*) and Tokyo University Herbarium (*TI*) covering the altitudinal range between 600 - 4900 m in Nepal. The fourth treatise signed between survey of flora of Darjeeling, Sikkim and Bhutan including Terai & Duars (in West Bengal) at the altitude ranging from 140 m and above.

A numerical comparison of the different angiospermic taxa as enumerated in the three earlier floras on Eastern Himalayas, published in the recent past, and that of the present work has been highlighted in the following Table 6.8.

**Table 7.8:** Comparative numerical representation of different angiospermic taxa in the three recently published flora on Eastern Himalayas and in the present work

[Abbreviations used: FEH - Flora of Eastern Himalaya; EFPN - Enumeration of the Flowering Plants of Nepal; FB - Flora of Bhutan; Gen. - Genus; Sp. - Species]

FAMILIES	REPRESENTATION IN RECENT FLORAS							
	FEH		EFPN		FB		Present Work	
	Gen.	Sp.	Gen.	Sp.	Gen.	Sp.	Gen.	Sp.
<b>DICOTYLEDONS</b>								
<i>Acanthaceae</i>	19	46	31	69	27	83	4	7
<i>Aceraceae</i>	1	11	1	13	1	13	1	7
<i>Actinidiaceae</i>	2	4	1	2	1	8	0	0
<i>Alangiaceae</i>	1	2	1	3	1	2	0	0

<i>Aizoaceae</i>	1	1	2	2	2	3	0	0
<i>Amaranthaceae</i>	9	16	11	19	11	21	2	3
<i>Anacardiaceae</i>	5	8	12	20	9	14	4	5
<i>Annonaceae</i>	3	3	5	8	9	18	0	0
<i>Apiaceae</i>	13	28	32	73	41	94	15	26
<i>Apocynaceae</i>	12	13	16	19	22	35	0	0
<i>Aquifoliaceae</i>	1	7	1	10	1	12	1	3
<i>Araliaceae</i>	10	15	12	24	13	27	7	10
<i>Aristolochiaceae</i>	1	3	2	6	1	6	1	2
<i>Asclepiadaceae</i>	19	32	26	49	25	68	3	6
<i>Asteraceae</i>	70	166	110	382	126	370	30	66
<i>Balanophoraceae</i>	1	4	2	4	2	5	0	0
<i>Balantaceae</i>	0	0	0	0	1	1	0	0
<i>Balsaminaceae</i>	1	29	1	39	1	39	1	12
<i>Basellaceae</i>	1	1	2	2	1	1	0	0
<i>Begoniaceae</i>	1	16	1	18	1	20	1	8
<i>Berberidaceae</i>	2	11	3	34	2	15	1	4
<i>Betulaceae</i>	4	5	4	8	4	7	3	4
<i>Bignoniaceae</i>	2	2	9	15	7	9	0	0
<i>Bischofiaceae</i>	0	0	0	0	1	1	0	0
<i>Bixaceae</i>	0	0	0	0	1	1	0	0
<i>Bombacaceae</i>	1	1	1	1	1	1	0	0
<i>Boraginaceae</i>	11	19	21	50	19	52	2	5
<i>Brassicaceae</i>	10	16	0	0	32	84	4	6
<i>Budlejaceae</i>	1	2	0	0	1	8	1	3
<i>Burseraceae</i>	1	1	1	1	3	4	1	1
<i>Buxaceae</i>	1	3	2	5	2	3	1	1
<i>Cactaceae</i>	0	0	2	2	3	4	0	0
<i>Callitrichaceae</i>	1	1	1	2	1	2	0	0
<i>Campunulaceae</i>	7	17	10	47	11	46	3	10
<i>Cannabaceae</i>	0	0	1	1	1	1	0	0
<i>Capparaceae</i>	0	0	4	9	4	11	0	0
<i>Caprifoliaceae</i>	2	23	4	27	5	36	4	11
<i>Cardiopteraceae</i>	0	0	0	0	1	1	0	0
<i>Caricaceae</i>	1	1	1	1	1	1	0	0
<i>Carlemannaiaceae</i>	0	0	1	1	1	2	0	0
<i>Caryophyllaceae</i>	12	36	16	77	14	56	7	10
<i>Celastraceae</i>	5	16	7	20	8	28	3	8
<i>Chenopodiaceae</i>	1	2	8	16	2	12	1	1
<i>Chloranthaceae</i>	1	1	1	1	0	0	0	0
<i>Chloranthaceae</i>	0	0	0	0	1	1	0	0
<i>Circaesteraceae</i>	0	0	1	1	1	1	0	0
<i>Clethraceae</i>	0	0	0	0	1	1	0	0
<i>Combretaceae</i>	3	7	4	12	4	15	0	0
<i>Convolvulaceae</i>	6	21	11	41	11	39	2	3

<i>Cordiaceae</i>	0	0	2	6	0	0	0	0
<i>Coriariaceae</i>	0	0	1	2	1	2	0	0
<i>Cornaceae</i>	3	3	2	4	6	8	3	3
<i>Corylaceae</i>	0	0	2	2	0	0	0	0
<i>Crassulaceae</i>	1	6	6	40	5	34	2	4
<i>Cucurbitaceae</i>	16	22	21	31	26	39	4	4
<i>Cuscutaceae</i>	0	0	0	0	1	4	1	1
<i>Daphniphyllaceae</i>	1	1	1	1	1	2	1	1
<i>Datisceae</i>	0	0	1	1	1	1	0	0
<i>Diapensiaceae</i>	0	0	1	1	1	3	0	0
<i>Dilleniaceae</i>	1	2	1	4	2	3	0	0
<i>Dipsacaceae</i>	3	7	4	7	3	5	2	3
<i>Dipterocarpaceae</i>	1	1	1	1	2	2	0	0
<i>Droceraceae</i>	1	1	1	2	1	2	1	1
<i>Ebenaceae</i>	0	0	1	5	1	4	0	0
<i>Elaeagnaceae</i>	1	2	2	7	2	7	2	2
<i>Elaeocarpaceae</i>	1	4	2	8	1	8	2	2
<i>Elatinaceae</i>	0	0	2	2	1	1	0	0
<i>Ericaceae</i>	9	54	9	56	9	81	4	28
<i>Euphorbiaceae</i>	27	54	28	83	34	110	1	4
<i>Eupteliaceae</i>	0	0	0	0	1	1	0	0
<i>Fabaceae</i>	71	184	88	281	85	277	5	5
<i>Fagaceae</i>	3	14	3	16	4	23	4	6
<i>Flacourtiaceae</i>	1	1	0	0	4	8	1	1
<i>Fumariaceae</i>	6	17	8	59	4	47	2	12
<i>Gentianaceae</i>	8	28	14	106	15	99	4	13
<i>Geraniaceae</i>	1	9	2	14	2	8	1	3
<i>Gesneriaceae</i>	10	30	11	32	14	54	5	9
<i>Grossulariaceae</i>	0	0	1	10	1	8	1	2
<i>Clusiaceae</i>	0	0	2	2	3	8	0	0
<i>Haloragaceae</i>	0	0	1	1	2	2	0	0
<i>Hamamelidaceae</i>	1	1	1	1	3	3	0	0
<i>Hippocastanaceae</i>	2	2	1	1	1	2	0	0
<i>Hippocrateaceae</i>	0	0	0	0	2	3	0	0
<i>Hippuridaceae</i>	0	0	1	1	1	1	0	0
<i>Hydrangeaceae</i>	1	4	4	10	2	6	2	4
<i>Hydrophyllaceae</i>	0	0	1	1	0	0	0	0
<i>Hypericaceae</i>	1	8	1	15	1	17	1	5
<i>Icacinaceae</i>	1	1	1	1	4	4	0	0
<i>Illiciaceae</i>	0	0	0	0	1	1	0	0
<i>Iteaceae</i>	0	0	0	0	1	1	0	0
<i>Juglandaceae</i>	1	2	2	2	2	2	1	1
<i>Lamiaceae</i>	39	88	48	149	43	117	11	18
<i>Lardizabalaceae</i>	2	2	2	2	2	2	1	1
<i>Lauraceae</i>	10	42	12	52	14	67	7	11

<i>Leaceae</i>	0	0	1	7	1	7	1	1
<i>Lecythidaceae</i>	0	0	1	2	1	2	0	0
<i>Lentibulariaceae</i>	1	4	2	12	1	10	1	1
<i>Linaceae</i>	1	2	3	4	3	6	1	1
<i>Lithraceae</i>	4	11	6	14	6	11	0	0
<i>Lobeliaceae</i>	0	0	0	0	0	0	2	4
<i>Loganiaceae</i>	1	1	4	9	1	2	0	0
<i>Loranthaceae</i>	5	10	7	14	9	21	2	2
<i>Magnoliaceae</i>	4	11	6	15	4	11	2	4
<i>Malpighiaceae</i>	1	1	2	3	2	3	0	0
<i>Malvaceae</i>	8	18	12	31	12	34	1	1
<i>Martiniaceae</i>	1	1	0	0	0	0	0	0
<i>Melastomaceae</i>	6	13	6	16	7	19	4	6
<i>Meliaceae</i>	0	0	9	14	13	24	0	0
<i>Melianthaceae</i>	0	0	0	0	1	1	0	0
<i>Menispermaceae</i>	6	10	0	0	10	14	1	2
<i>Menyanthaceae</i>	0	0	0	0	1	1	0	0
<i>Mimosaceae</i>	0	0	0	0	10	27	2	2
<i>Monotropaceae</i>	0	0	2	3	2	3	0	0
<i>Monotropaceae</i>	1	1	2	3	2	3	1	1
<i>Moraceae</i>	6	15	5	41	7	52	2	4
<i>Morinaceae</i>	0	0	0	0	3	5	2	2
<i>Moringaceae</i>	0	0	1	1	1	1	0	0
<i>Myricaceae</i>	0	0	1	1	1	1	0	0
<i>Myristicaceae</i>	0	0	1	1	2	3	0	0
<i>Myrsinaceae</i>	4	11	4	14	7	23	2	4
<i>Myrtaceae</i>	3	3	6	12	5	18	0	0
<i>Nyctaginaceae</i>	1	1	3	5	3	5	0	0
<i>Nymphaceae</i>	1	1	2	2	0	0	0	0
<i>Nyssaceae</i>	0	0	0	0	1	1	1	1
<i>Ochniaceae</i>	0	0	1	1	0	0	0	0
<i>Oleaceae</i>	0	0	3	3	3	5	0	0
<i>Oleaceae</i>	5	12	7	28	8	26	3	3
<i>Onagraceae</i>	4	14	4	27	4	23	2	9
<i>Opiliaceae</i>	0	0	2	2	1	1	0	0
<i>Orobanchaceae</i>	2	2	3	7	5	8	0	0
<i>Oxalidaceae</i>	2	6	2	6	3	7	1	3
<i>Paeoniaceae</i>	0	0	1	1	0	0	0	0
<i>Papaveraceae</i>	5	10	0	0	3	19	2	3
<i>Parnasiaceae</i>	0	0	1	6	1	7	1	4
<i>Passifloraceae</i>	0	0	1	3	2	4	0	0
<i>Pedaliaceae</i>	0	0	2	2	1	1	0	0
<i>Philadelphaceae</i>	0	0	0	0	2	4	0	0
<i>Phrymaceae</i>	1	1	0	0	1	1	0	0

<i>Phytolaccaceae</i>	1	1	1	3	1	1	1	1
<i>Piperaceae</i>	2	9	2	10	2	15	2	5
<i>Pittosporaceae</i>	1	1	1	1	1	2	0	0
<i>Plantaginaceae</i>	1	2	1	5	1	4	1	2
<i>Plumbaginaceae</i>	1	1	2	2	3	4	0	0
<i>Podophyllaceae</i>	1	1	0	0	1	2	1	1
<i>Polemoniaceae</i>	0	0	1	1	0	0	0	0
<i>Podostemaceae</i>	1	1	1	1	0	0	0	0
<i>Polygalaceae</i>	0	0	3	12	3	14	0	0
<i>Polygonaceae</i>	11	41	11	72	11	63	6	21
<i>Portulacaceae</i>	1	1	2	2	1	2	0	0
<i>Primulaceae</i>	5	58	6	93	6	29	3	33
<i>Proteaceae</i>	1	1	2	2	2	2	0	0
<i>Punicaceae</i>	0	0	1	1	1	1	0	0
<i>Pyrolaceae</i>	1	2	1	1	2	3	0	0
<i>Ranunculaceae</i>	17	72	19	143	22	112	7	25
<i>Rhamnaceae</i>	6	10	0	0	7	19	1	2
<i>Rhizophoraceae</i>	0	0	1	1	1	1	0	0
<i>Rosaceae</i>	26	112	29	72	27	169	10	34
<i>Rubiaceae</i>	31	66	35	100	55	153	9	14
<i>Rutaceae</i>	11	19	12	31	14	38	4	8
<i>Sabiaceae</i>	2	5	2	7	2	9	0	0
<i>Sacospermataceae</i>	0	0	0	0	1	1	0	0
<i>Salicaceae</i>	2	7	2	33	2	29	2	4
<i>Sambucaceae</i>	0	0	2	14	0	0	1	1
<i>Santalaceae</i>	2	2	4	8	4	7	1	1
<i>Sapindaceae</i>	4	4	5	5	7	8	0	0
<i>Sapotaceae</i>	1	1	2	2	3	3	0	0
<i>Saurauiaceae</i>	0	0	1	3	0	0	0	0
<i>Saururaceae</i>	1	1	1	1	1	1	1	1
<i>Saxifragaceae</i>	8	40	6	93	6	89	3	9
<i>Schisandraceae</i>	1	3	1	3	2	3	1	1
<i>Scrophulariaceae</i>	32	95	36	165	38	176	9	18
<i>Simaroubaceae</i>	0	0	2	3	3	4	0	0
<i>Solanaceae</i>	7	25	16	45	22	50	2	2
<i>Sonneratiaceae</i>	0	0	1	1	1	1	1	1
<i>Sphenocleaceae</i>	1	1	1	1	0	0	0	0
<i>Stachyuraceae</i>	1	1	3	4	1	1	1	1
<i>Staphyllaceae</i>	1	1	0	0	1	2	1	1
<i>Sterculiaceae</i>	2	2	9	13	10	18	0	0
<i>Strychnaceae</i>	0	0	0	0	1	1	0	0
<i>Styracaceae</i>	1	2	2	2	1	2	0	0
<i>Symplocaceae</i>	1	8	1	10	1	9	1	5
<i>Tamaricaceae</i>	2	2	2	5	1	2	0	0
<i>Tetracentraceae</i>	1	1	1	1	1	1	0	0

<i>Tetramelaceae</i>	0	0	1	1	0	0	0	0
<i>Theaceae</i>	4	8	0	0	5	9	1	2
<i>Thymeliaceae</i>	3	3	4	8	4	7	2	4
<i>Tiliaceae</i>	3	8	3	18	4	15	0	0
<i>Toricelliaceae</i>	0	0	1	1	0	0	0	0
<i>Trapaceae</i>	0	0	1	1	0	0	0	0
<i>Tropaeolaceae</i>	0	0	0	0	1	1	0	0
<i>Ulmaceae</i>	4	6	4	11	4	6	0	0
<i>Urticaceae</i>	15	54	17	59	17	73	9	20
<i>Vaccinaceae</i>	1	1	0	0	0	0	2	5
<i>Valerianaceae</i>	2	3	3	5	3	5	2	2
<i>Verbanaceae</i>	9	21	16	29	16	45	0	0
<i>Violaceae</i>	1	16	1	14	2	12	1	5
<i>Vitaceae</i>	7	23	7	27	7	27	2	2
<i>Zygophyllaceae</i>	0	0	1	1	1	1	0	0
<b>Total: [198]</b>	<b>776</b>	<b>2081</b>	<b>1077</b>	<b>3610</b>	<b>1233</b>	<b>4025</b>	<b>294</b>	<b>655</b>
<b>MONOCOTYLEDONS</b>								
<i>Araceae</i>	14	37	17	37	17	44	5	12
<i>Alliaceae</i>	0	0	0	0	3	12	0	0
<i>Alismataceae</i>	1	1	3	4	1	2	0	0
<i>Agavataceae</i>	0	0	1	4	1	3	0	0
<i>Amaryllidaceae</i>	0	0	5	14	4	5	0	0
<i>Aponogetonaceae</i>	0	0	0	0	1	1	0	0
<i>Arecceae</i>	0	0	0	0	13	25	0	0
<i>Asparagaceae</i>	0	0	0	0	1	3	0	0
<i>Bromeliaceae</i>	0	0	1	1	1	1	0	0
<i>Bumotaceae</i>	0	0	1	1	1	1	0	0
<i>Burmanniaceae</i>	1	1	1	3	1	2	0	0
<i>Cannaceae</i>	1	1	1	4	1	4	0	0
<i>Colchicaceae</i>	0	0	0	0	1	1	0	0
<i>Commelinaceae</i>	9	16	9	21	11	31	3	3
<i>Convallariaceae</i>	0	0	0	0	6	28	4	8
<i>Costaceae</i>	0	0	0	0	1	2	0	0
<i>Cyperaceae</i>	10	114	19	171	73	181	9	31
<i>Dioscoraceae</i>	1	8	1	13	1	13	1	2
<i>Dracanaceae</i>	0	0	0	0	2	2	0	0
<i>Eriocaulaceae</i>	1	6	0	0	1	6	0	0
<i>Hemerocallidaceae</i>	0	0	0	0	1	3	0	0
<i>Hydrocharitaceae</i>	1	1	5	7	3	3	0	0
<i>Hypoxidaceae</i>	2	3	0	0	3	8	2	2
<i>Iridaceae</i>	2	4	2	7	5	13	1	1
<i>Juncaceae</i>	2	26	2	34	2	41	1	16
<i>Juncaginaceae</i>	1	1	1	2	1	2	0	0
<i>Lemnaceae</i>	1	2	3	4	1	2	0	0
<i>Liliaceae</i>	24	50	35	65	6	16	5	5

<i>Limnorchitaceae</i>	0	0	0	0	1	1	0	0
<i>Marantiaceae</i>	1	1	1	1	2	3	0	0
<i>Melanthaceae</i>	0	0	0	0	3	5	1	1
<i>Musaceae</i>	1	1	2	4	1	4	1	1
<i>Najadaceae</i>	1	1	1	2	0	0	0	0
<i>Orchidaceae</i>	61	188	87	113	132	579	24	32
<i>Pandanaceae</i>	0	0	1	1	1	2	0	0
<i>Poaceae</i>	78	183	112	346	125	381	25	35
<i>Pontederiaceae</i>	1	2	2	3	2	3	0	0
<i>Potamogetonaceae</i>	0	0	1	8	1	6	0	0
<i>Phormiaceae</i>	0	0	0	0	1	1	0	0
<i>Smilacaceae</i>	1	15	1	15	2	14	1	6
<i>Sparganiaceae</i>	0	0	0	0	1	1	0	0
<i>Trilliaceae</i>	0	0	0	0	3	4	1	1
<i>Typhaceae</i>	1	1	1	1	1	1	0	0
<i>Uvulariaceae</i>	0	0	0	0	4	7	2	3
<i>Xyridaceae</i>	0	0	1	2	1	3	0	0
<i>Zannichelliaceae</i>	0	0	1	1	0	0	0	0
<i>Zingiberaceae</i>	8	17	11	35	14	47	3	4
<b>Total: [47]</b>	<b>224</b>	<b>680</b>	<b>329</b>	<b>924</b>	<b>458</b>	<b>1517</b>	<b>89</b>	<b>163</b>

**Table 7.9.** Numerical comparison of different ranks of taxa recorded in three previously published floras covering this region with the flora of PWS

Flora		Family		Genus	Species
		No.	%		
Fl. East. Himalaya	Dicot	134	67.68	776	2081
	Monocot	24	51.06	224	680
	<b>TOTAL</b>	<b>158</b>	<b>64.49</b>	<b>1000</b>	<b>2761</b>
En. Fl. Pl. Nepal	Dicot	165	83.33	1077	3610
	Monocot	30	63.83	329	924
	<b>TOTAL</b>	<b>195</b>	<b>79.59</b>	<b>1406</b>	<b>4534</b>
Fl. Bhutan	Dicot	180	91.84	1233	4025
	Monocot	45	95.74	458	1517
	<b>TOTAL</b>	<b>225</b>	<b>91.84</b>	<b>1691</b>	<b>5547</b>
Fl. PWS	Dicot	100	50.51	294	655
	Monocot	17	36.16	89	163
	<b>TOTAL</b>	<b>117</b>	<b>47.76</b>	<b>383</b>	<b>818</b>

Table 6.9 shows the numerical comparison of the three important floras covering this region with that of the flora of PWS (Figs. 6.5 & 6.6). In comparison to the area covered by first three floras to area of PWS is too little. Even then, PWS is hosting as much as 47.76% of the angiospermic families recorded so far from this entire region. Again, the record of a total of 818 angiospermic species is also quite high for such a small place specially when it is located in subalpine and alpine climatic zones.

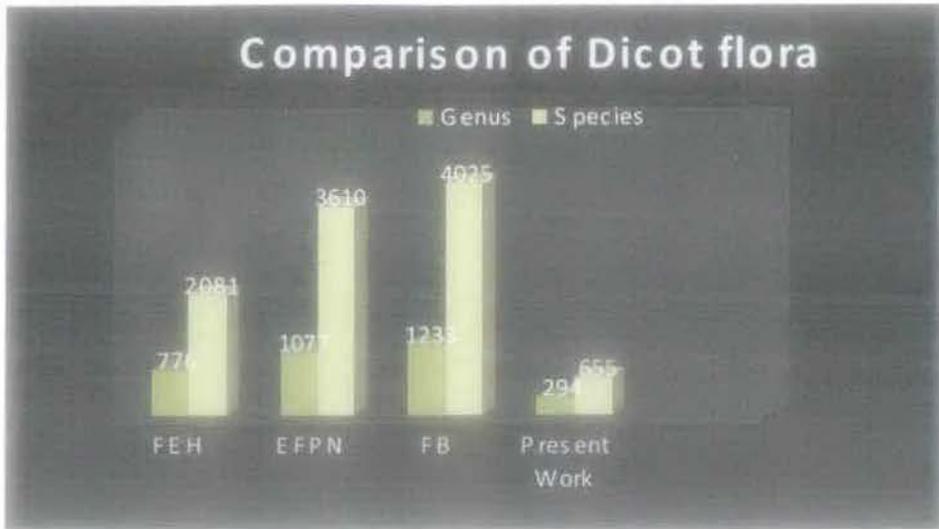


Fig. 7.5: Comparison of recorded dicotyledonous species in the present flora with that of three other floras covering this region.

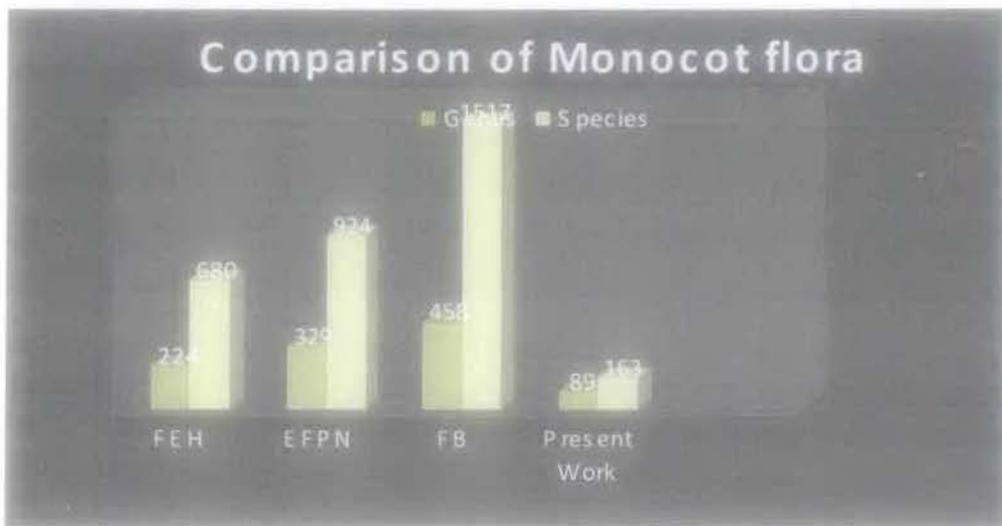


Fig. 7.6: Comparison of recorded monocotyledonous species in the present flora with that of three other floras covering this region.

#### 7.1.2 Comparison and affinities of PWS with Neora Valley National Park.

The PWS also shared a common boundary with the Neora Valley National Park (NVNP) situated in the Darjeeling district of West Bengal. Since, the Neora valley and Pangolakha ridge shares a contiguous and an uninterrupted wide ecozone, the distribution pattern of the vegetation is also partly shares its similarities, at least upto the altitude of 3100 m, which is the highest altitude place of NVNP. However, the majority of the landmass of PWS falls above 3100 m altitude. Das (1995), Rai & Das (2002) studied the flora of Neora Valley National Park revealed the presence

of 812 species and varieties, 468 genera belonging to 138 families of angiosperms, 4 genera and 4 species of gymnosperms under 3 families and a total number of 45 fern species under 26 genera belonging to 18 families. Being situated adjacent to each other, both the part of protected network area holds a diverse variation of the climatic, edaphic, altitudinal and biotic conditions along with their complex inter-relationships and species composition which have enabled the region support and sustain the rich diversity of floristic components.

As per the analysis of the floristic elements, the family *Asteraceae* represents the dominant family with largest numbers of species in both the Protected Areas (PA). Six of the ten dominant families of both of these PAs, namely Asteraceae, Cyperaceae, Poaceae, Polygonaceae, Rosaceae and Urticaceae are common. A comparative account of ten dominant families in these two PAs is proved in Table 6.10. The main reason behind the differences is probably caused by the altitudinal distribution of these two Pas. While NVNP is distributed in tropical – temperate (300 m) region, the PWS is distributed in temperat to alpine (3100 m) region.

**Table 7.10:** Comparative chart of 10 dominating families of the flowering plants of PWS (Sikkim) with Neora Valley National park (W.B.) situated at the adjoining to the Sanctuary.

Sl. No.	Flora of PWS	Flora of NVNP
1	Asteraceae	Asteraceae
2	Poaceae	Rosaceae
3	Rosaceae	Rubiaceae
4	Primulaceae	Cyperaceae
5	Cyperaceae	Poaceae
6	Orchidaceae	Urticaceae
7	Apiaceae	Leguminosae
8	Polygonaceae	Scrophulariaceae
9	Lamiaceae	Ericaceae
10	Urticaceae	Polygonaceae

### 7.1.3. Habit Groups

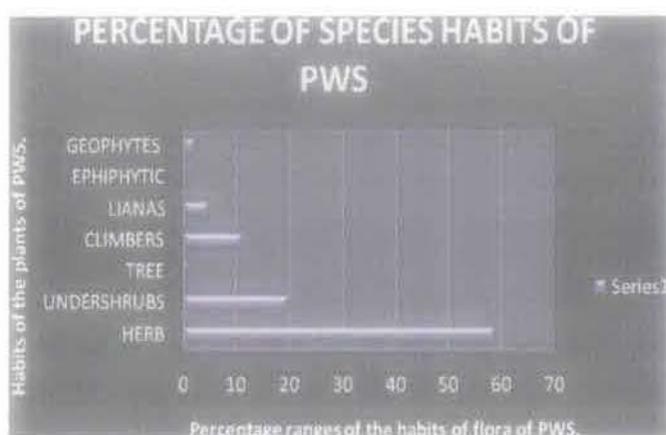
The PWS represents immense richness in all forms of habit groups of plants. Being an inaccessible terrain, the sanctuary area remained unexplored and undisturbed for many centuries, resulting the natural conservation of vegetation and floristic elements of the sanctuary. However, slight mislay in forest degradation is observed at some negligible portion of the sanctuary, especially for the development of camp sites for army. Significantly, the species richness and the occurrence of wide range of favorable habitats suitable for diverse habit groups of the flora

rendered uniqueness to the nature-bestowed pristine beauty to the Pangolakha Wildlife Sanctuary. It is interesting to note that the occurrence of epiphytes within flora is quite high, where as the parasites and hydrophytes represent considerably less. The Table 6.11 and Fig. 6.1 below exhibits the distribution of habit groups in the flora of PWS.

**Table 7.11:** Different habit groups of angiosperms recorded from PWS.

[Abbreviations used: H: Herb; US: Under-shrub; S: Shrub; T: Tree; C: Climber; E: Epiphytes; P: Parasites; Sp: Saprophyte; H: Hydrophyte; G: Geophyte]

Forms of Plant	No. of species		Total species	% of the total species
	DICOT	MONOCOT		
H	370	112	481	58.85
S	153	10	163	19.90
US	06	00	06	00.73
T	86	06	92	11.24
C	34	04	38	04.64
L	02	02	04	00.48
E	04	13	17	02.08
G	00	16	17	02.08
<b>Total</b>	<b>655</b>	<b>163</b>	<b>818</b>	



**Fig. 7.1:** Graphical representation of different habit groups in the flora of PWS

**7.1.3 / I. HERBS:** Flora of PWS clearly reveals that the herbaceous species are comparatively in much higher percentage than any other habit groups of the plants. The number of herbaceous species is high as 481 species of angiosperms which is much higher than total number of shrubs, trees and climbers saprophytes, hydrophytes, geophytes in the flora of the PWS. In addition, except very few all the recorded pteridophytes are herbaceous. The alpine and sub-alpine parts of

the sanctuary also support a huge number of herbaceous species. Significantly, the ground covering vegetation is chiefly constituted of herbaceous plants even in the dense forests.

Majority of the economically important plant species are herbs. Interestingly, the sizes of herbs are gradually reduced to small scrubs in alpine and sub-alpine parts. As such the most predominantly occurring herbs of both temperate and sub-alpine region are *Anaphalis contorta*, *A. triplinervis*, *A. margeritaceae*, *Ageratum conyzoides*, *Ainslea latifolia*, *Begonia gemmipara*, *Berginia ciliata*, *Cacalia chenopodiifolia*, *Carex filicina*, *Clinopodium umbrosum*, *Corydalis* spp., *Didymocarpus* spp., *Elatostema sessile*, *Erigeron* spp., *Festuca cumminsii*, *Gaultheria nummularioides*, *Galium asperifolium*, *Geranium polyanthes*, *Geranium nepalensis*, *Hydrocotyle nepalensis*, *Impatiens* spp., *Juncus allioides*, *J. grisebachii*, *J. wallichianus*, *Oxalis corniculata*, *Potentilla polyphylla*, *Pedicularis siphonantha*, *Persicaria* spp., *Pilea scripta*, *Primula sikkimensis*, *Prunella vulgaris*, *Rubus nubicola*, *Rumex nepalensis*, *Ranunculus diffusus*, *Ranunculus hirtellus*, *Spiranthes sinensis*, *Stellaria patens*, *Viola biflora*, *Viola diffusa* etc.

Besides this, some of the notable and continuously occurring geophytes of PWS are *Arisaema concinnum*, *Arisaema flavum*, *Arisaema griffithii*, *Arisaema propinquum*, *Arisaema tortuosum*, *Colocasia esculenta*, *Remusatia pumila*, etc. As such, *Acorus calamus*, *R. nasturtium-aquaticum*, etc are amongst the most commonly occurring wetland plants of the sanctuary.

**7.1.3 / II. SHRUBS:** Shrubs are the most important constituent of vegetation in open places or in the thick forests. The distribution of shrubs is gradually decreases with the rise of elevation. The shrubs are mostly dominated at the forest fringes, cliff, crest, open forest and in deep forests of PWS. Some of the commonly occurring shrub species of the sanctuary are *Aconogonum molle*, *Aralia fragrans*, *Aralia cachemirica*, *Astilbe rivularis*, *Artemisia vulgaris*, *Berberis aristata*, *Berberis hookeri*, *Boehmeria macrophylla*, *Daphne bholua*, *Dichroa febrifuga*, *Euonymus frigidus*, *Gaultheria fragrantissima*, *Gaultheria griffithiana*, *Girardinia diversifolia*, *Heracleum nepalensis*, *Hydrangea aspera*, *Hypericum choisianum*, *Hypericum uralum*, *Helwingia himalaica*, *Leycesteria glaucophylla*, *Leycesteria formosa*, *Leycesteria stipulata*, *Mahonia napaulensis*, *Maesa chisia*, *Maesa rugosa*, *Neillia rubiflora*, *Ribes glaciule*, *Selinum wallichianum*, *Skimmia laureola*, *Rosa sericea*, *Rubus ellipticus*, *Rubus splendissimus*, *Viburnum erubescens*, *Zanthoxylum acanthopodium* etc.

It is also interesting to note that the majority of the shrubs are bushy and thorny. *Aconogonum molle* and *Viburnum mullaha* are the most dominant shrubs of the upper ridge and *Hydrangea aspera* and *Astilbe rivularis* are the common shrubs of the middle zone.

**7.1.3 / III. CLIMBERS:** Samanta & Das (1995, 1998) has recorded 252 species and varieties of climbers from the hills of Darjeeling & Sikkim. It is being noted that the climbers are also one of the important components of floral resource of PWS. The diversity of the climber species is exceptionally rich and varied in the sanctuary. They are normally inhabits on trees, rocks, bamboo and also on the bushy shrubs. Apart from that, the climbers also uphold the important value for medicine, food, and fodder etc. The climber of PWS also deserves a separate and comprehensive study. The angiospermic climbers of the Pangolakha ridge as a whole, can be classified as herbaceous, shrubby and lianas depending upon their habit forms and mode of climbing. However, for the convenience of classification, climbers are further categorized as root climber, twinner, tendril climber, scandent, epiphytic climbers etc. Some climbers e.g. species of *Dioscorea bulbifera*, *Dioscorea pentaphylla* are having good economical value. However, the *Clematis buchananiana*, *C. acuminata*, *C. smilacifolia*, *Cuscuta reflexa*, *Hedyotis scandens*, *Rubia manjith*, *Rubus ellipticus*, *Zanthoxylum oxyphyllum*, *Stephania glabra*, *Aconogonum molle*, *Bauhinia vahlii*, etc. are some of important climbers that have been used in traditional medicine by the local people residing in the periphery. In contrast, some consumption of some climbers' viz. *Codonopsis affinis*, *Trichosanthes wallichiana* are poisonous to the human being.

Where as, *Clematis montana*, *Codonopsis inflata*, *Dicentra scandens*, *Gentiana speciosa*, *Raphidophora glauca*, *Schisandra grandiflora*, *Thunbergia coccinia*, *Tripteropermum voluble* etc are of potential ornamental value.

- a. **Herbaceous climbers:** The flora of PWS also represents a rich and diverse representation of herbaceous climbers. The majority of the herbaceous climbers are perennial. Though this type of climbers are mostly seen in the temperate to sub-alpine regions. Some of the dominating climbers of the sanctuary are *Codonopsis affinis*, *C. dicentrifolia*, *Dicentra scandens*, *Gentiana speciosa*, *Hedyotis scandens*, *Tripteropermum volubile*, *Stephania elegans*, *Ipomoea nil*, *I. purpurea*, *Porana grandiflora*, *Scizandra grandiflora*, *Parthenosissua semicordata*, *Tetrastigma serrulatum*, *T. obtectum*, *S. neglecta* etc.
- b. **Shrubby climbers:** The shrubby climbers are mostly recorded from the temperate hills of the PWS. The most commonly occurring shrubby climbers includes *Aconogonum molle*,

*Celastrus paniculatus*, *Clematis buchania*, *C. acuminata*, *C. Montana*, *C. connata*, *C. wightiana*, *Elaeagnus pyriformis*, *Hydrangea anomala*, *Rubus acuminatus*, *R. paniculatus*, *Schisandra grandiflora* and *Senecio scandens*, *Piper mulesua*, etc.

- c. **Lianas:** The forest of PWS constitutes the huge population of woody climbers. The lianas are mostly occurring in between lower temperate to lower sub-alpine regions. Some of these woody climbers constitute important species for ethno-botanical point of view. The most common lianas of the sanctuary are *Mucuna macrocarpa*, *Bauhinia vahlii*, *Trichosanthes cordata*, *Thunbergia fragrans* etc.

**4.1.3/IV. TREES:** Trees constitute the major component of the flora of the PWS. The forests of Pangolakha represent an immense diversity of the tree species. The dense vegetation of inaccessible canopy right from the foothills to higher hilly ridges of the Pangolakha is because of thick and extensive growth of trees. The trees of the sanctuary have also been remained as a home of numerous epiphytic and parasitic plants. Having been remained isolated and undisturbed for centuries, the trees of the sanctuary become exceptionally robust and tall. Most importantly, *Rhododendron arboreum* growing into robust trees, which is rare in other part of the state, is a common characteristic of these forests. The occurrence of this rare phenomenon is recorded from Rachela and Pangolakha ridge. The tree vegetation in the sanctuary gradually reduced with the rise in the elevations.

The commonly occurring tree species recorded from Pangolakha Wildlife Sanctuary is given in the Table 6.12.

Most importantly the occurrence of various species of *Rhododendron* are the prominent trees of upper temperate and lower sub-alpine region of the sanctuary. However, in many areas *Rhododendrons* are also growing with *Viburnum erubescens*, *Viburnum mullaha*, *Zanthoxylum alatum* and *Betula utilis*.

**Table 7.12:** Some common tree species of PWS. [Abbreviations used: (L) = Lepcha name; (N) = Nepali name; T= Temperate region, SA= Sub-alpine]

BOTANICAL NAME	LOCAL NAME	CLIMATIC ADOPTION
<i>Acer campbellii</i>	Doam kung (L), Kapasey (N)	T-SA
<i>Acer oblongum</i>	Phirphiri (N)	T
<i>Acer pectinatum</i>	Yatli kung (L), Lekh Kapasey (N)	T-SA
<i>Alangium alpinum</i>	Hlo-palit kung, lasune	T
<i>Alnus nepalensis</i>	Sungdu kung (L), Utis (N)	T
<i>Betula alnoides</i>	Sunglee Kung (L), Saur (N)	T

<i>Betula utilis</i>	Sunglee kung (L)	T
<i>Brassaiopsis mitis</i>	Sungzam kung (L), Phutta	T
<i>Exbucklandia populnea</i>	Sinlyang kung (L), Pipli	T
<i>Buddleja colvillei</i>	Choungkung (L), Bhimsenpatti	T
<i>Castanopsis hystrix</i>	Kusyo kung (L), Katus	T
<i>Castanopsis tribuloides</i>	Sri-kusyo kung (L), Musrey katus	T
<i>Cryptomeria japonica</i>	Dhupi	T
<i>Elaeocarpus lanceaefolius</i>	Batrasey	T
<i>Erythrina arborescens</i>	Jasey kung (L), Phaledo,	ST- T
<i>Eurya acuminata</i>	Sanu jinguni	T
<i>Eurya symplocina</i>	Flotukchonkung (L), Bara jingun	T
<i>Evodia fraxinifolia</i>	Sohom kung (L), Khanakpa	T
<i>Ilex insignis</i>	Tonglong kung (L), Hare /lisey	T
<i>Ilex sikkimensis</i>	Lisey(N)	T- SA
<i>Juniperus recurva</i>	Chukboo (L)	T
<i>Leucosceptum canum</i>	Chyong kung (L), Ghurpis	T
<i>Lindera pulcherrima</i>	Nupsor kung (L), Sissi	T
<i>Litsea citrate</i>	Tanghaercher kung (L), Siltimur	T
<i>Litsea elongata</i>	Thulo Pahenle	T
<i>Lyonia villosa</i>	Hlo Tuksolkung (L), Lekh angeri	T
<i>Maesa chisia</i>	Purmu kung (L), Syano bilowney (N)	T- SA
<i>Mallotus nepalensis</i>	Numbung kung (L), Malata (N)	T
<i>Michelia campbellii</i>	Gok (L), Gogey chanp (N)	T- SA
<i>Michelia excelsa</i>	Sigu rip (L), Seto chanp (N)	T
<i>Michelia lanuginosa</i>	Guay chanp, Phusray chanp	T
<i>Myrsine semiserrecta</i>	Phalamey /Jhingni	T
<i>Nyssa javanica</i>	Lekh chilowney	T
<i>Pentapanax leschenaultia</i>	Chindey	SA
<i>Populus camblei</i>	Pilpiley	T
<i>Prunus napaulensis</i>	Tukporinyok (L), Arupatey	T-SA
<i>Quercus lamellosa</i>	Buuk (L), Bajrant (N)	T
<i>Lithocarpus pachyphylla</i>	Sri-kung (L), Sungurey katus (N)	T
<i>Quercus lineate</i>	Phalat	T
<i>Rhododendron arboreum</i>	Etok (L), Gurans (N)	T
<i>Rhododendron barbatum</i>	Lal Chimal	T
<i>Rhododendron grande</i>	Patley kurlingo	T
<i>Rhododendron hodgsonii</i>	Kurlingo	T-SA
<i>Rhus succedanea</i>	Sukung (L), Rani Bhalayo	T
<i>Sarococca hookeriana</i>	Chile kath	T-SA
<i>Saurauia griffithii</i>	Hlo sipha kung (L), Gogun	T
<i>Saurauia nepaulensis</i>	Kasur kung (L), Gogun	T
<i>Schefflera impressa</i>	Bhalu chindey, Bhalu Phutta	T
<i>Semecarpus anacardium</i>	Sukung (L), Kalo bhalayo	T
<i>Symplocos theifolia</i>	Kharaney	T
<i>Talauma hodgsonii</i>	Hare/ Bhalukhat	T
<i>Taxus baccata</i>	Cheongboo kung (L), Dhengre Salla	T
<i>Turpinia nepalensis</i>	Thali	T-SA
<i>Viburnum mullaha</i>	Ghora khari	AS
<i>Viburnum cordifolium</i>	Tuksol kung (L), Bara Asarey (N)	T
<i>Viburnum erubescens</i>	Naglam kung (L), Asarey	T
<i>Zanthoxylum acanthopodium</i>	Boke timur	T
<i>Zanthoxylum alatum</i>	Sungru kung (L), Baley Timur	T

#### 7.1.4 Distribution of Floristic Elements

Migration of floras, survival of relicts, evolution of new species by an intermixing of different floras and by mutation and acclimatization of species from the lower altitudes must have all their role in determining the present day composition and distribution of the Eastern Himalayan alpine flora. One of the effects may also of glaciations and its resultant climatic changes. The well known plant geographer, Ronald Good has mentioned “by this kind of migration the movement by which independently originating floras becomes mixed so as to, consist of or show elements derived from various directions”.

As such, Pangolakha range represents huge floristic compositions. The distribution of local floral elements of the sanctuary has clear dominance over others along with the rise of the altitude. The majority of the tree species of this region are quite old and huge in their size. This trees species are supported by the overwhelming growth of shrubs, herbs and epiphytes. *Leucocephalum canum*, *Oxyspora paniculata*, *Osbeckia nepalensis*, *Aconogonum molle* etc. are dominating in the partially open vegetation. The composition of the herbaceous flora is also significant in places located above 2000 m altitude.

The distribution of the floristic elements in PWS in between elevation of 1200 m to 4600 m amsl is distinctly marked by the enormous variation of habit groups i.e. herbs, shrubs, climbers, twidders and prostrate elements those are common and distinctly prevalent. The forests in this range is of marked distinction of being compact composition of the some tree species which includes *Alnus nepalensis*, *Acer campbellii*, *Quercus lamellosa*, *Lithocarpus pachyphylla*, *Q.clineata*, *Magnolia campbellii*, *Michelia doltsopa*, *Michelia cathcartii*, *Betula alnoides*, *Prunus nepalensis*, *P. cerasoides*, *Castanopsis hystrix*, *C. tribuloides*, *Symplocos glomerata*, *S. theaeifolia*, *Eurya japonica*, *Evodia fraxinifolia*, *Taxus baccata*, *Rhododendron arboreum*, *Toona ciliata* etc. The vegetation is further enriched by the following shrubs, viz. *Acuba himalaica*, *Maesa chisia*, *Neillia thirsiflorus*, *Gaultheria griffithiana*, *Elsholtzia fruticosa*, *Ilex crenata*, *Rubus lineatus*, *Leycesteria formosa*, *Viburnum erubescens* and of various species of small bamboos. All these species put together to constitute a magnificent thick layer of dense shrubs layer. Apart form this, there is predominant composition of herbaceous species which includes *Potentilla polyphylla*, *P. sundaica*, *Prunella vulgaris*, *Didymocarpus aromaticus*, *Chirita macrophylla*, *Begonia sikkimensis*, *Fragaria nubicola*, *Impatiens bracteata*, *Voila biflora*, *Cynoglossum glochidiatum*, etc.

Temperate cold forests (2400 – 2800 m) comprising of dense growth of tall trees terminate at some distance above and are replaced by grassy slopes on which trees are growing scattered. The vegetation of this type is distinguished further through the commendable

occurrence of herbs, shrubs, and sporadic appearance of numerous strangling climbers. The main components of broad-leaved trees are *Acer campbellii*, *Betula utilis*, *Engelhardtia spicata*, *Exbucklandia populnea*, *Ilex dipyrena*, *Quercus lineata*, *Q. lamellosa*, *Lithocarpus pachyphylla*. The oak forests are the characteristic feature of this zone.

The notable shrubs of the vegetation are *Aconogonum molle*, *Dichroa febrifuga*, *Gaultheria fragrantissima*, *Helwingia himalaica*, *Daphne bholua*, *Holboellia latifolia*, *Rubus lineatus*, *Rubus paniculatus*, *Vaccinium retusum*, *Arundinaria malling*, *Dendrocalamus hamiltonii*, *Smilax glaucophylla*, *Vaccinium retusum*, *Lyonia ovalifolia*, *Piptanthus nepalensis*, *Principia utilis*, *Rhododendron grande*, *R. falconeri*, *Viburnum erubescens*, *Zanthoxylum oxyphyllum*, etc.

The herbaceous species forms the chief component of this vegetation zone in which most dominant species are *Anemone vitifolia*, *Arisaema jacquemontii*, *Ajuga lobata*, *Aster tricephalus*, *Cardamine impatiens*, *Fragaria vesca*, *Hemiphragma heterophyllum*, *Primula sikkimensis*, *Gallium mollugo*, *Valeriana wallichii*, *Gnaphalium affine*, *Fimbristylis dichotoma*, *Potentilla fulgens*, *Elsholtzia strobilifera*, *Fragaria nubicola*, *Voila pilosa*, *Hydrocotyle himalaica*, *Poa annua*, *Streptolirion volubile*, *Carex* spp. It is notable to see *Alnus nepalensis* and *Thysalonema maxima* inhibit to confine at the degraded and land slide-prone areas.

The distribution of major floristic elements of temperate or sub-alpine (2800 – 3400 m) conifer forests is characterized by a mixed forest of different species of *Rhododendron* and conifers. The Initiation of sub-alpine forest from the cold temperate forests are marked by the presence of several species of trees like *Acer caudatum*, *A. campbellii*, *A. sikkimensis*, *Quercus lineata*, *Lithocarpus pachyphylla*, *Magnolia campbellii*, *Tsuga dumosa*, *Abies densa*, *Euonymus frigidus*, *Enkianthus deflexus* etc. However the *Rhododendrons* gradually dominate the forests as the elevation goes up. In between the trees *Abies densa* and *Tsuga dumosa* appeared uniformly inside *Arundinaria* sp., and mixed silver fir trees. Significantly, the forests are now symbolized with the strong under growth of *Berberis wallichiana*, *Enkianthus deflexus*, *Euonymus frigidus*, etc. followed by the species of the *Lonicera*, *Rubus*, *Ribes*, *Gaultheria*, etc. However, the most predominant shrubs are constituted by the majority species of *Rhododendron* e.g. *R. barbatum*, *R. edgeworthii*, *R. grande*, *R. arboreum*, *R. falconeri*, *R. dalhousie*, *R. griffithianum*, *R. glaucophyllum*, *R. thomsonii*, *R. lepidotum* and *R. campanulatum*. Some rare and interesting herbs found here are the *Panax pseudoginseng* var *bipinnatifolia*, *Panax pseudoginseng* var *angustifolia*, *Swertia chirayita*, *Valeriana wallichiana*, *Gallium mollugo*, *Fragaria daltoniana* and *Podophyllum hexandrum*. It is interesting to note that *Rhododendron arboreum* in Rachel

ridge is significantly attained its optimum growth with extremely huge girth *hitherto* not seen in other parts of the state.

The sub-alpine and alpine scrubs (3400 – 4600 m and above) occupies a core part of the PWS, where the shrubby habits dominate at most. The major floristic constituent of this part of the PWS are *Rhododendron anthopogon* and *R. setosum* form the dense tussocks near the sub-alpine mountain tops. The herbaceous species are however common and distributed evenly e.g. *Aconitum ferox*, *Anaphalis contorta*, *Cassiope fastigiata*, *Meconopsis paniculatus*, *Primula capitata*, *P. sikkimensis*, *Sedum multicaule*, and species of *Arenaria*, *Epilobium*, *Potentilla*, *Polygonatum*, *Rodiola*, etc. The vegetation at this zone is further enriched by the presence of plants with of great medicinal value viz. *Aconitum heterophyllum*, *Podophyllum hexandrum*, *Panax pseudoginseng*, *Picrorhiza kurroa* etc.

As the elevation rises up higher and higher, the stunted bushy growth of *Rhododendron anthopogon*, *R. lepidotum*, *Salix caliculata*, *S. lindleyana*, *Cotoneaster microphylla*, *Rosa sericea*, *Lonicera tomentella* are more regular and uninterrupted. The *Rhododendron nivale* is also observed to be distributed at altitude of 4600 m too, which is *hitherto* not seen in other part of the Sikkim. Significantly, the species like *Polygonatum campanulatum*, *Nardostachys jatamanshi*, *Rheum australe* were once common at Kupup, Nathang, Baba Mandir areas are now rarely distributed. In addition to this *Rhododendron anthopogon*, *R. campanulatum*, *R. thomsonii*, *R. setosum* and species of *Ranunculus*, *Primula*, *Aconitum*, *Voila*, *Fragaria*, *Meconopsis*, *Potentilla*, *Arisaema* are also distributed widely.

The majority of the herbs and shrubs represented themselves with more colorful and bright colored flowers which is presumed to be adapted to attract the pollinators. With the exception of *Delphinium*, *Lamiaceae*, *Asteraceae* and primroses all the species are remarkably devoid of odor. The species of alpine scrubs is also signifying with their procumbent habit e.g. *Rhododendron lanatum*, *Rhododendron lepidotum*, *Rhododendron thomsonii* etc. Species of *Carex*, *Kobresia*, *Festuca*, *Stipa*, *Poa* etc occupies among the grasses and sedges and the higher cliffs are the habitats for species of *Lonicera*, *Meconopsis*, *Saussurea*, *Saxifraga*, *Leontopodium* and *Tanacetum* etc.

#### 7.1.5. Phytogeography of PWS

The Himalayan mountains are geologically young (Xu & Ding 2003). The rugged, and largely inaccessible landscape makes biological surveys in the Eastern Himalayan Mountains extremely difficult. Undescribed species, including some from the higher taxonomic groups including plant

species are very likely to occur in the more remote, heavily forested regions. However, despite the scant knowledge, what we know of the biodiversity indicates that the Eastern Himalayan region is amongst the biologically richest areas on the Earth.

The scale and complexity of the mountains in the Eastern Himalayan region contribute to high biological diversity in several ways. One of the important factors to contribute to the exceptional biological diversity of the Eastern Himalayas is its multiple biogeographic origins. Its location at the juncture of two continental plates places it in an ecotone represented by rich flora and as well as fauna. However, the topographic complexity normally isolates islands of habitat. Antecedent rivers and streams separated by mountain massifs may support reproductively isolated populations of low elevation species. And high ridges separated by valleys may isolate high elevation species. This can contribute to genetic differences among populations, a step toward the evolution of endemic species. On a shorter time scale, historical vicariant events isolate populations by affecting local immigration and extinction. Because the Himalayas are relatively young and the levels of endemism is low. However, the stage has been set for speciation.

Hooker (1906) attributed the floristic diversity of the Indian subcontinent " To the immigration of the plants from widely different bordering countries, notably Chinese and Malayan on the east and south, of oriental, European and African on the west and of Tibetan and Siberian on the North".

George A. Gammie in 1893 contended that the flora of Sikkim consists of elements from the tropics to the poles, and probably no other country of equal or large extent on the globe can present so many features of interest or many problems for the solution to the thoughtful materialist."

As such, the Flora of PWS also represents a mixed with numerous plants of common distribution from various biogeographic region of the world. The migration of the plants from other parts of the world has been taken place prior to the advent of Britishers during the nineteenth century. Significantly, many exotic plants have been introduced in India during British-India regime. In addition to this, the wealth of the Himalayan flora including many alpine species was also taken to England in the early part of the twentieth century. The detail analysis of the flora of PWS reveals about the following results.

**A. Neotropical Elements:** Th floristic elements representing Neotropical elements are mainly of tropical American region. The representing species from the study area include *Argemone mexicana*, *Chenopodium ambrosioides*, *Mimosa pudica*, *Physalis minima*, *Tridax procumbens* etc.

**B. Pantropic Elements:** The representing pantropical species of the study area includes *Achyranthes aspera*, *Ageratum conyzoides*, *Cleome gynandra*, *Cyperus compressus*, *Leucas aspera* etc.

**C. Cosmopolitan Elements:** The cosmopolitan floristic elements are widely distributed throughout the world. The representing cosmopolitan elements from the study area are *Chenopodium album*, *Cyperus rotundus*, *Gnaphalium affine*, *Eupatorium adenophorum*, *Sagina saginoides*, *Sagina procumbens*, *Prunella vulgaris*, *Drymaria diandra*, *Oxalis corniculata*, *Cerastium glomeratum*, *Poa annua*, etc.

**D. Central Asiatic Elements:** The floristic elements representing the Central Asiatic and commonly from Iran, Afganistan, Pakistan along with some from distant parts of Western India, Russia, and China are *Anaphalis contorta*, *Buddleja paniculata*, *Primula denticulata*, *Quercus lamellosa* etc.

**E. Afro-Asiatic Elements:** There are also few plants of Africa and Arabian region recorded from the sanctuary. The representing Afro-Asiatic elements are *Achyranthes bidentata*, *Conyza stricta* var. *stricta*, *Nasturtium officinale*, *Sanicula elata*, *Parochetus communis* etc.

**G. American Elements:** Interestingly, six American floral elements are also recorded from the sanctuary. The representing American species are *Cestrum aurantiacum*, *Drymaria villosa*, *Eupatorium adenophorum*, *Oxalis corymbosa*, etc.

**H. Australian Elements:** There are some common species of Australia those are also been recorded from the study area. The representing Australian species from the study area are *Celastrus paniculatus*, *Erigeron karwinskianus*, *Melastoma malabathricum*, *Siegesbeckia orientalis*, *Stellaria uliginosa*, *Toona ciliata*, etc.

#### **I. European and North American elements**

Some of the prominent species of European and American origin are *Andromeda*, *Rhamnus*, *Spiraea*, *Viburnum*, *Cotoneaster*, *Hippophae*, *Convallaria*, *Oxalis*, *Ranunculus*, *Potentilla*, *Chaerophyllum*, *Galium*, *Paris*, *Thlaspe*, *Poa* etc.

**J. Eurasian Elements:** Quite a few numbers of Eurasian's plant species (Europe & USSR) are also recorded from the sanctuary in insignificant proportion. The representing species of Eurasian elements are *Cardamine hirsuta*, *Persicaria hydropiper*, *Urtica dioica*, etc.

**K. Euro-Siberian elements:** The PWS represents wide range of altitudinal variation right from the temperate to alpine and subalpine region. As such, a number of species recorded from here

are of European and Siberian origin. The representing floristic elements of Euro-Siberian recorded from the sanctuary are *Veronica anagalis*, *Viola biflora*, etc.

**L. Indian and Indian Subcontinental Elements:** These are the indigenous plants species of India. The major plants under this category also represent Indo-Gangetic part of India. The representing species of Indian subcontinental origin from the study area are *Murraya koenigii*, *Erythrina stricta* etc.

**M. Himalayan elements:** The floristic elements of PWS also constitute many native species of Himalayan ranges. The representing Himalayan elements from the study area are *Ainslea aptera*, *Euonymus echinatus*, *Mazus* sp. *Populus ciliata*, *Rubus paniculatus*, *Stellaria patens*, *Sabia* spp. etc.

**N. Eastern Himalayan Elements:** The representing species of Eastern Himalayan origin from PWS are *Acer hookeri*, *Daphne sureil*, *Euonymus frigidus*, *Gaultheria fragrantissima*, *Hoya lanceolata*, *Juncus ochraceus*, *Loxostigma griffithii*, *Lonicara glabrata*, *Mucuna macrocarpa*, *Oxalis acetosella*, *Pilea terniifolia*, *Rhododendron dalhousiae*, *Rhododendron grande*, *Smilax ferox*, *Stellaria sikkimensis*, etc.

**O. Sino-Himalayan Elements:** Interestingly there are also few Chinese plants that have been recorded from the PWS. The common Chinese elements collected from the study area are *Aconogonum campanulatum*, *Carpesium trachelifolium*, *Polygonatum cirrhifolium*, *Pteracanthus alatus*, *Schefflera impressa*, *Thunbergia coccinea*, etc.

**P. Floristic elements distributed from E.Himalaya to Japan:** The representing floristic elements of eastern Himalaya extending their distribution to Japan from the study area are *Sonchus arvensis*, *Spiraea micrantha*, *Helwingia japonica*, *Lyonia ovalifolia*, *Viburnum erubences*, etc.

**Q. Floristic elements distributed from Western Himalaya to Japan:** The representing floristic elements of western Himalaya extending their distribution to China from study area are *Cardiocrinum giganteum*, *Houttuynia cordata*, *Rhus javanica*, *Streptolirion volubile*, etc.

**R. Floristic elements distributed from western Himalaya to China:** The representing floristic elements of western Himalayas to China recorded from the study area are *Acer oblongum*, *Alnus nepalensis*, *Anemone rupicola*, *Arisaema tortuosum*, *Astilbe rivularis*, *Cotonester microphylla*, *Elsholtzia fructicosa*, *Fragaria nubicola*, *Gaultheria trichophylla*, *Holboellia* spp. *Juniperus*

*recurva*, *Nardostachys grandiflora*, *Paris polyphylla*, *Piptanthus nepalensis*, *pleione praecox*, *Podophyllum hexandrum*, *Prunus cerasoides*.

**S. Floristic elements distributed throughout the Himalaya and absent from China and Japan:** The representing floristic elements of Himalaya and absent from China and Japan from the study area are *Acer sterculaceum*, *Cortia depressa*, *Gypsophylla cerastioides*, *Lonicera obovata*, *Parnassia nubicola*, *Potentilla lineata*, *Rhododendron anthopogon*, *R. barbatum*, *R. campanulatum*, *Rosa microphylla*, *Rubus nepalensis*, *R. paniculatus*, *Sorbus cuspidata*, *S. microphylla* etc.

**T. S.E. Asian and Indo-Malayan Elements:** These are common plants of S.E. Asian and Indo-Malayan origin. The representing floristic elements of S.E Asian and Indo-Malayan recorded from the PWS are *Aconogonum molle*, *Arisaema concinum*, *Bischofia javanica*, *Callicarpa microphylla*, *Cinnamomum impressinervium*, *Engelhardtia spicata*, *Eria paniculata*, *Gentiana speciosa*, *Hoya linearis*, *Maesa chisia*, *Michelia cathcartii*, *Pratia montana*, *Michelia champaca*, *Rubus lineatus*, *Smilax ovalifolia*, *Toona ciliata* etc.

**U. Floristic elements distributed from the eastern Himalaya to Japan:** Majority of the taxa of this group do not extend to China and western Himalaya and restricted to the Eastern Himalaya to Japan area. The representing floristic genera of above category recorded from the study area are *Enkianthus*, *Helwingia*, *Rodgertia*, *stachyrus* etc.

**V. Floristic elements distributed from the Eastern Himalaya to China:** The representing floristic elements distributed from Eastern Himalaya to China recorded from the study area are *Betula alnoides*, *Campylandra aurantiaca*, *Coelogyne corymbosa*, *Ilex fragilis*, *Leycesteria gracilis*, *Litsea cubea*, *Meconopsis napaulensis* etc.

**W. Tibetan elements:** The Tibetan element is mainly xerophytic and greatly differs from that of Himalayan mainly because of low rainfall and high altitude. Some of these Tibetan elements extended into PWS are *Cortiella hookeri*, *Kobresia schoenoides*, *Phlomis spp.*, *Saussurea ovalata*, etc.

**X. Arctic-alpine Elements:** The species of this category are widespread in arctic regions and belong to the high mountain ranges of Europe and Asia. Most importantly, some of the representing arctic-alpine species recorded from the study area are *Juncus triglumis*, *Oxyria digyna*, *Sagina saginoides*, etc.

**Y. Transition elements:** The flora of PWS is characteristically unique. Being situated at adjacent to the TAR (Tibet Autonomous Region) and Bhutan, the migration of many species has

also been taken place on the course of time. Some fascinating species under this category are *Anemone vitifolia*, *Eupatorium adenophorum*, *Leptocodon gracilis* etc. (Gammie 1893).

Flora of PWS is significantly diverse and peculiar in its floristic composition. The floristic elements of the sanctuary are reasonably interesting and exceptionally rich floristic composition.

#### 7.1.6. Floristic Elements of the Wetlands

Wetlands are important self sustained ecosystems, which also forms an important life support system for numerous plants and animals. Sikkim Himalaya is bestowed with 42 identified wetlands with an area of 1101 ha comprising 150 small and big lakes situated between 300 m to 8500 m altitudes (Shukla *et al.* 2002). Wetlands in alpine and sub-alpine region of East Sikkim occupy a significant geo-morphological proportion in landscape and play a crucial ecological and socio-economic role. Apart from that they are the centre attraction for tourists in turns, generate employment for the local people. The alpine region of east Sikkim offers a large numbers of wetlands, yet no proper documentation is available regarding their ecological status except a few scattered (Roy *et al.* 1998). Therefore, diversity of floristic composition of wetlands of Pangolakha deserves a separate study, infavour of conservation aspect. Some of the prominent lakes of those constitute the wetland system in the Alpine region of East Sikkim including Pangolakha wildlife sanctuary are Bidang tsho (Kupup lake), Memenchu lake, Lampokhri, Sherathang lake which are situated between 1670 m to 4379 m. Besides, there are several other lakes, which have no prominent individual names as such. It is noteworthy; some wetlands including lakes are now gradually becoming degraded. The area of these lakes remain frozen for about five months from November to march and become important Pasteur land, especially for domestic animals *viz.* Yak, sheep, horses etc. Haridasan *et al.* 2002, has recorded 74 species of angiospermic plants under 21 families from the wetlands of east Sikkim. As such, 32 species of plants that grows on the marshy places, along the streams, edges of lakes of PWS and other adjoining regions of alpine and sub - alpine region of east Sikkim has been collected. Some of the dominant families recorded under this category from the sanctuary are *Juncaceae*, *Polygonaceae*, *Scrophulariaceae*, *Cyperaceae*, *Primulaceae*, *Fumariaceae*, *Asteraceae*, *Poaceae*,

*Ranunculaceae*, *Droceraceae*, *Lamiaceae*, *Saxifragaceae*, appears to be the 10 largest dominating families of flowering plants. Some of the common floristic elements of the wetland of Pangolakha range *Bistorta amplexicaulis*, *B. microphylla*, *Caltha scaposa*, *C. palustris*, *Corydalis filicina*, *Drosera peltata*, *Epilobium tibetanum*, *E. sikkimensis*, *Juncus allioides*, *J. amplifolius*, *J. benghalensis*, *J. bufonius*, *J. duthie*, *J. effuses*, *J. inflexus*, *J. sikkimensis*, *J. thomsonii*, *J. trychophyllus*, *J. triglumis*, *J. uinflora*, *Agrostis nervosa*, *Lagotis kunawurensis*, *Parnasia cooperi*, *P. tanella*, *Primula capitata*, *P. sapphirina*, *P. sikkimensis*, *Pedicularis siphonantha*, *Ranunculus hirtellus*, *Ranunculus ficariifolius* etc. grows around lake margins and marshy places. However, it is also very interesting to record that, there are absent of any wind of floating hydrophytes.

#### 7.1.7. Peculiar adaptation mechanism in alpine plants of Pangolkha Wildlife Sancruary:

W.W. Smith (1913) reported that the plants species of alpine and subalpine region of East Sikkim are endowed with fascinating protective mechanism, which saves them from continuous exposure to the moisture of unpredictable climate. Similar type of adaptation on plants is also observed during the present floristic survey. The majority of the shrubs and herbs of this region are of flowers with bright colors that attract enormous bees and other pollinating agent for their effective pollination leading to the seed formation. During the flowering season the *Rhododendron anthopogon* along with some other species are highly aromatic and attracts many pollinators, though occasional visitors of the region often tend to develop headache.

However, the *Asteraceae* and *Primulaceae* being the largest families of flowering plants of the region, the majority of their species are devoid of any odor. Many other species that exist in the area are mostly being transformed within themselves for adaptation. For instance, the inflorescence of the *Rheum nobile* is often hidden under densely overlapping bracts. Smith also reported that the leaf of *Eriophyton* also serves to protect its flowers from various external interferences. Similarly, it was noted that the flower head in *Saussurea obvallata* is compactly enclosed with numerous inflated papery bracts, while the *Saussurea gossypiphora* is completely enveloped in a woolly covering, therefore, it is being assumed that this natural modification in itself is a for self protection from any external injuries.

Apart from this, while studying the general aspect of flora of alpine and subalpine region it was also being noted that some species are often seen in procumbent habit that grows in dense, hard, tufts for e.g. *Rhododendron anthopogon*, *R. lepidotum* etc, which was also noted in *R. nivale* by Smith in 1913. Therefore, it is apparent that spreading in ground stature seems to save them from being broken by the continuous strong blowing of wind and such modification in habit and the composition of small spiny, harsh leaves tend to defend them from being browsed by other living organisms.

Interestingly, the pollens and seeds of Conifers being light and winged are easily carried away for long distances by wind that enables the seeds germination in the far distance from its mother plant. The trees of the subalpine region also attained extensively gregarious, that could save them from cattle and other herbivorous animals. Although these naturally protected plants are seemingly more adapted to their environment, yet they certainly do not show by numerical superiority, that they have gained any advantage for the struggle of life.

## **7.2. ENDEMIC FLORA OF PANGOLKHA WILDLIFE SANCTUARY**

The number of endemic elements in the Himalayan region is 3165 out of 6850 in India. As such, the Himalayas has a very high percentage of Indian endemics (46 %) of the total endemic elements of the country (Chatterjee 1940, 1960). Sir J.D. Hooker in 1849 claimed that majority of the Indian floristic species are migrated from other part of the world. However, many recent workers support the contention of D. Chatterjee for his estimation of about 60 % of the Indian flora are of Indian origin, and out of which 14 % being exclusively endemic to India. According to Singh & Chauhan (1998) over 3% of the plant species are endemic to Sikkim. Bhujel & Das (2002) recorded a total of 397 dicotyledonous species are endemic to Eastern Himalaya including those extending to NE India. Some of these plants are also with extremely restricted distribution like 'Endemic to Darjeeling' of West Bengal. Hence, the PWS being situated adjoining to the Neora Valley National Park under Darjeeling district of West Bengal, shares a common representation in endemic species. Significantly, PWS being one of the important natural conservatories of the Sikkim, acts as a repository of endemic flora of Sikkim and for the country. Despite the fact that the several efforts may be essential to identify and to protect these vanishing endemic species in the state, an adequate and well designed strategy to carry out this task needs to be framed and implemented (Lama, 2001).

The floristic analysis of the PWS holds about 26.53.% of the recorded species as endemic flora. Having being PWS is not distinctly represents a distinct physico-climatic zone, assessment of the endemic taxa is categorized broadly into following three phytogeographical divisions:

- I. Endemic to Sikkim
- II. Endemic to Eastern Himalaya [240]
- III. Endemic to Himalayas [112]
- IV. Endemic to Eastern Himalaya extending to NE India
- V. Endemic to the Himalayas extending to NE India.

### I. Endemic to Sikkim

Flora of PWS represents some endemic taxa which are strictly endemic to Sikkim hills. A list of such taxa presented below in Table 7.13:

**Table 7.13.** Plants endemic to Sikkim Himalaya recorded from PWS

Names of Plants	Family
<i>Lactuca cooperi</i>	Asteraceae
<i>Ligularia kingiana</i>	Asteraceae
<i>Rhododendron aeruginosum</i>	Ericaceae
<i>Corydalis changuensis</i>	Fumariaceae
<i>Androsace croftii</i>	Primulaceae

### II. Endemic to Eastern Himalaya

Quite a large number of plants with their distribution restricted within the Eastern Himalayan region have been recorded from the PWS. This, in fact, expresses the originality of the flora of this sanctuary and deserves special attention for its proper maintenance. Recorded plants endemic to the Eastern Himalayan region are presented below in Table 7.14.

**Table 7.14.** Taxa recorded from PWS, endemic to Eastern Himalaya

Name of Plant	Family
<i>Actinodaphne longipes</i>	Lauraceae
<i>Agapetes hookeriana</i>	Ericaceae
<i>Agapetes serpens</i>	Ericaceae
<i>Ainsliea aptera</i>	Asteraceae
<i>Anaphalis griffithii</i>	Asteraceae
<i>Anisadenia saxatilis</i>	Lineaceae
<i>Arenaria melandrioides</i>	Caryophyllaceae
<i>Arisaema griffithii</i>	Araceae
<i>Begonia gemmipara</i>	Begoniaceae
<i>Begonia josephii</i>	Begoniaceae
<i>Begonia ovatifolia</i>	Begoniaceae
<i>Begonia satrapis</i>	Begoniaceae

<i>Begonia sikkimensis</i>	Begoniaceae
<i>Berberis angulosa</i>	Berberidaceae
<i>Berberis hookeri</i>	Berberidaceae
<i>Berberis insignis</i>	Berberidaceae
<i>Brassaiopsis hispida</i>	Araliaceae
<i>Brassaiopsis mitis</i>	Araliaceae
<i>Carex insignis</i>	Cyperaceae
<i>Cathcartia villosa</i>	Papaveraceae
<i>Circaea alpina</i> ssp. <i>angustifolia</i>	Onagraceae
<i>Codonopsis dicentrifolia</i>	Campanulaceae
<i>Codonopsis foetens</i>	Campanulaceae
<i>Codonopsis inflata</i>	Campanulaceae
<i>Codonopsis peduncularis</i>	Campanulaceae
<i>Cremanthodium cremanthoides</i>	Asteraceae
<i>Delphinium caldelabrum</i>	Ranunculaceae
<i>Didymocarpus albicalyx</i>	Gesneriaceae
<i>Didymocarpus podocarpus</i>	Gesneriaceae
<i>Dubyaea hispida</i>	Asteraceae
<i>Epilobium clarkeanum</i>	Onagraceae
<i>Euonymus echinatus</i>	Celastraceae
<i>Euphorbia himalayensis</i>	Euphorbiaceae
<i>Euphorbia luteo-viridis</i>	Euphorbiaceae
<i>Euphorbia sikkimensis</i>	Euphorbiaceae
<i>Fimbristylis stolonifera</i>	Cyperaceae
<i>Gentiana elwesii</i>	Gentianaceae
<i>Gentiana prolata</i>	Gentianaceae
<i>Heracleum nepalense</i>	Apiaceae
<i>Hoya serpens</i>	Asclepiadaceae
<i>Ilex sikkimensis</i>	Aquifoliaceae
<i>Impatiens bracteata</i>	Balsaminaceae
<i>Impatiens juripia</i>	Balsaminaceae
<i>Impatiens longipes</i>	Balsaminaceae
<i>Impatiens porrecta</i>	Balsaminaceae
<i>Impatiens pradhanii</i>	Balsaminaceae
<i>Isodon repens</i>	Lamiaceae
<i>Kobresia fragilis</i>	Cyperaceae
<i>Kobresia stiebritziana</i>	Cyperaceae
<i>Lasianthus sikkimensis</i>	Rubiaceae
<i>Ligularia hookeri</i>	Asteraceae
<i>Mahonia napaulensis</i>	Berberidaceae
<i>Mussaenda roxburghii</i>	Rubiaceae
<i>Mussaenda treautleri</i>	Rubiaceae
<i>Neanotis gracilis</i>	Rubiaceae
<i>Pedicularis flexuosus</i>	Scrophulariaceae
<i>Pedicularis furfuracence</i>	Scrophulariaceae
<i>Persea clarkeanum</i>	Lauraceae
<i>Persea gammiceana</i>	Lauraceae
<i>Pilea ternifolia</i>	Urticaceae
<i>Porana grandiflora</i>	Convolvulaceae
<i>Primula capitata</i> var. <i>capitata</i>	Primulaceae
<i>Primula geranifolia</i>	Primulaceae
<i>Primula sapphirina</i>	Primulaceae
<i>Primula soldanelloides</i>	Primulaceae

<i>Primula tibetica</i>	Primulaceae
<i>Primula walshii</i>	Primulaceae
<i>Psychotria erratica</i>	Rubiaceae
<i>Pycneus sanguinolentus</i>	Cyperaceae
<i>Rheum acuminatum</i>	Polygonaceae
<i>Rhododendron anthopogon</i>	Ericaceae
<i>Rhododendron baileyi</i>	Ericaceae
<i>Rhododendron dalhousiana</i>	Ericaceae
<i>Rhododendron falconeri</i>	Ericaceae
<i>Rhododendron glaucophyllum</i>	Ericaceae
<i>Rhododendron grande</i>	Ericaceae
<i>Rhododendron griffithiana</i>	Ericaceae
<i>Rhododendron lanatum</i>	Ericaceae
<i>Rhododendron thomsonii</i>	Ericaceae
<i>Rubia wallichina</i>	Rubiaceae
<i>Rubus hyperigymus</i>	Rosaceae
<i>Rubus treautleri</i>	Rosaceae
<i>Salix caliculata</i>	Salicaceae
<i>Salvia campanulata</i>	Lamiaceae
<i>Sarcococca hookeriana</i>	Euphorbiaceae
<i>Saxifraga latifolia</i>	Saxifragaceae
<i>Scrophularia elatior</i>	Scrophulariaceae
<i>Silene gonosperma</i>	Caryophyllaceae
<i>Sloanea desycarpa</i>	Elaeocarpaceae
<i>Sorbus foliolosa</i>	Rosaceae
<i>Sorozeris hookeriana</i>	Asteraceae
<i>Spiraea canacense</i>	Rosaceae
<i>Strobilanthes echinata</i>	Acanthaceae
<i>Symplocos dryophylla</i>	Symplocaceae
<i>Symplocos glomerata</i>	Symplocaceae
<i>Tanacetum atkinsonii</i>	Asteraceae
<i>Teautlera insignis</i>	Asclepiadaceae
<i>Thunbergia lutea</i>	Acanthaceae

### III. Endemic to the Himalayas

The distribution of some species of plants is extending outside the Eastern Himalayan region but remain restricted within the Himalayas. A list of some such plants has been presented below in Table 7.15.

**Table 7.15.** Floristic elements of PWS endemic to the Himalayan region

Plant Name	Family
<i>Acer sterculiaceum</i>	Aceraceae
<i>Aconitum bisma</i>	Ranunculaceae
<i>Agapetes saligna</i>	Ericaceae
<i>Anaphalis royleana</i>	Asteraceae
<i>Anaphalis triplinervis var. intermedia</i>	Asteraceae
<i>Anaphalis triplinervis var. monocephala</i>	Asteraceae
<i>Androsace geraniifolia</i>	Primulaceae
<i>Androsace globifera</i>	Primulaceae
<i>Androsace hookeriana</i>	Primulaceae

<i>Arisaema propinquum</i>	Araceae
<i>Arisaema utile</i>	Araceae
<i>Aristolochia griffithii</i>	Aristolochiaceae
<i>Artemisia thellungiana</i>	Asteraceae
<i>Aster stracheyi</i>	Asteraceae
<i>Asystasia macrocarpa</i>	Acanthaceae
<i>Bistorta emodi</i>	Polygonaceae
<i>Bistorta macrophylla</i>	Polygonaceae
<i>Bistorta vacciniifolia</i>	Polygonaceae
<i>Boehmeria hamiltoniana</i>	Urticaceae
<i>Boehmeria macrophylla</i>	Urticaceae
<i>Carex setosa</i>	Cyperaceae
<i>Carex daltonii</i>	Cyperaceae
<i>Carex inanis</i>	Cyperaceae
<i>Carex obscura</i>	Cyperaceae
<i>Carex pulchra</i>	Cyperaceae
<i>Codonopsis subsimplex</i>	Campanulaceae
<i>Cortiella cortioides</i>	Apiaceae
<i>Cortiella hookeri</i>	Apiaceae
<i>Cryptothladia polyphylla</i>	Dipsacaceae
<i>Cyananthus incanus</i>	Campanulaceae
<i>Cyananthus lobetus</i>	Campanulaceae
<i>Cyananthus spathulifolia</i>	Campanulaceae
<i>Cynoglossum wallichii</i>	Boraginaceae
<i>Daphne bholuta</i>	Thymelaeaceae
<i>Daphne papyracea</i>	Thymelaeaceae
<i>Daphne sureil</i>	Thymelaeaceae
<i>Delphinium viscosum</i>	Ranunculaceae
<i>Didymocarpus pulchra</i>	Gesneriaceae
<i>Dipsacus atratus</i>	Dipsacaceae
<i>Edgaria darjeelingensis</i>	Cucurbitaceae
<i>Epilobium royleanum</i>	Onagraceae
<i>Epilobium sikkimensis</i>	Onagraceae
<i>Epilobium wallichianum</i>	Onagraceae
<i>Euonymus echinatus</i>	Celastraceae
<i>Euonymus vagans</i>	Celastraceae
<i>Euonymus viburnoides</i>	Celastraceae
<i>Euphorbia longifolia</i>	Euphorbiaceae
<i>Fraxinus floribunda</i>	Oleaceae
<i>Galium acutum</i>	Rubiaceae
<i>Geranium donianum</i>	Geraniaceae
<i>Geranium polyanthes</i>	Geraniaceae
<i>Hackelia bhutanica</i>	Boraginaceae
<i>Mazus dentatus</i>	Scrophulariaceae
<i>Melissa axillaris</i>	Lamiaceae
<i>Nardostachys grandiflora</i>	Valerianaceae
<i>Neillia rubiflora</i>	Rosaceae
<i>Neolitsea cuipala</i>	Lauraceae
<i>Parnassia chinensis</i>	Saxifragaceae
<i>Parnassia tenella</i>	Saxifragaceae
<i>Pedicularis siphonanthus</i>	Scrophulariaceae
<i>Peperomia heyniiana</i>	Piperaceae
<i>Phlomis macrophylla</i>	Lamiaceae

<i>Physospermopsis kingdom-wardii</i>	Apiaceae
<i>Pleurospermum pilosum</i>	Apiaceae
<i>Populus ciliata</i>	Salicaceae
<i>Potentilla coriandrifolia</i>	Rosaceae
<i>Primula drummondiana</i>	Primulaceae
<i>Rhodiola fastigiata</i>	Crassulaceae
<i>Rhodiola himalayensis</i>	Crassulaceae
<i>Rhododendron barbatum</i>	Ericaceae
<i>Rubus pectinarioides</i>	Rosaceae
<i>Rubus thomsonii</i>	Rosaceae
<i>Saussurea auriculata</i>	Asteraceae
<i>Saussurea candolleana</i>	Asteraceae
<i>Saussurea eriostemon</i>	Asteraceae
<i>Saxifraga montana</i>	Saxifragaceae
<i>Scrophularia urticifolia</i>	Scrophulariaceae
<i>Sedum triactina</i>	Crassulaceae
<i>Sorbus cuspidata</i>	Rosaceae
<i>Sorbus micrphylla</i>	Rosaceae
<i>Swertia hookeri</i>	Gentianaceae
<i>Swertia speciosa</i>	Gentianaceae
<i>Synotis alata</i>	Asteraceae
<i>Synotis wallichii</i>	Asteraceae
<i>Taraxacum eriopodum</i>	Asteraceae
<i>Thalictrum elegans</i>	Ranunculaceae
<i>Tupistra nutans</i>	Convallariaceae
<i>Viburnum mullaha</i>	Caprifoliaceae

#### IV. Plants Endemic to Eastern Himalaya but extending to NE India

There are some plants recorded from this sanctuary those are basically endemic to the Eastern Himalayan region but their distribution is also extending in the NE Indian states. Those plants have been presented in Table 7.16 below:

**Table 7.16.** Plants of PWS endemic to Eastern Himalaya but extending to the NE Indian states

Name of Plant	Family
<i>Ilex crenata</i>	Aquifoliaceae
<i>Primula calderiana</i>	Primulaceae
<i>Primula bracteosa</i>	Primulaceae
<i>Tupistra aurantiaca</i>	Convallariaceae
<i>Raphidophora glauca</i>	Araceae
<i>Berberis umbellata</i>	Berberidaceae
<i>Oenanthe hookeri</i>	Apiaceae
<i>Spiraea micrantha</i>	Rosaceae
<i>Impatiens racemosa</i>	Balsaminaceae
<i>Impatiens radiata</i>	Balsaminaceae
<i>Maytenus rufa</i>	Celastraceae
<i>Rhododendron cinnabarinum</i>	Ericaceae
<i>Hypericum hookerianum</i>	Hypericaceae
<i>Aconitum lacinatedum</i>	Ranunculaceae
<i>Aconitum spicatum</i>	Ranunculaceae
<i>Parthenocissus semicordata</i>	Vitaceae
<i>Ajuga macrosperma</i> var. <i>breviflora</i>	Lamiaceae

<i>Aucuba himalaica</i>	Cornaceae
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#### V. Plants Endemic to Eastern Himalaya but extending to NE India

There is another group of plants in the flora of PWS those are basically endemic for the Himalayan region but their distribution is also extending in the NE Indian states. The names of these plants are presented below in Table 7.17.

**Table 7.17.** Plants of PWS endemic to the Himalaya but extending to the NE Indian states

Name of Plant	Family
<i>Corydalis chaerophylla</i>	Fumariaceae
<i>Swertia chirayita</i>	Gentianaceae
<i>Hypericum uralum</i>	Hypericaceae
<i>Ophiorrhiza fasciculata</i>	Rubiaceae
<i>Elatostema hookerianum</i>	Urticaceae
<i>Piper mullesua</i>	Piperaceae
<i>Stephania elegans</i>	Menispermaceae
<i>Persea duthei</i>	Lauraceae

This analysis of the endemic status for the floristic elements of the Pangolakha Wildlife Sanctuary exposed the originality and importance of its flora once again.

**Table 7.18.** Numerical sum-up of the the endemic flora of PWS

Endemic category	Total Angiospermic flora of PWS	No. of endemic species	% of endemic species	% of type of endemism
Sikkim	818	5	0.61	2.3
Eastern Himalaya		98	11.98	45.16
Himalayas		88	10.76	40.55
E. Himalaya & NE India		18	2.2	8.29
Himalayas & NE India		8	0.98	3.69
<b>TOTAL:</b>	<b>818</b>	<b>217</b>	<b>26.53</b>	

Table 7.18 shows that a total of 217 (out of 818) species is endemic for different geographical regions. This is the 26.53 % of the total angiospermic flora of PWS. Out of the different categories of endemics Eastern Himalayan elements are maximum and representing 11.98 % of recorded angiosperms and 45.16 % of the total number of endemics in PWS. This is followed by Himalayan elements (10.76 %) which is 40.55 % of the recorded endemics.

### 7.3 EXOTICS

Numerous exotic species of plants has been introduced in consideration of their economical importance to meet the human need and desire. On the other hand, another group of foreign plants gradually reached a place though the process of natural migration. So, these exotic plants can be classified as (i) migratory and (ii) introduced exotic species, which formed one of the major components of the flora and vegetation of Eastern Himalaya. A series of studies has been undertaken by Biswas (1940), Hara (1966, 1971), Ohashi (1975), Mathew (1981), Das (2002) and Das & Chanda (1986) on exotic plant species of Eastern Himalayan region. Plants arrived here even from distant places like South East Asia, North East India and from Europe through chains of mountain ranges system and from Deccan and Peninsular India. Plants carried by human agencies are probably the most important method of arrival of exotics to this region. However, in the present context, the global extent and rapid increase in invasive species is homogenising the world's flora and fauna (Mooney & Hobbs 2000) and is recognized as a primary cause of global biodiversity loss. Bio-invasion may be considered as a form of biological pollution and significant component on global change and one of the major causes of species extinction (Mooney & Drake 1987).

The flora of PWS is also reporting a considerable number of exotic species, primarily originated from America, Australian, Chinese, European and Siberia etc. The exotic species recorded from the PWS includes *Cestrum aurantiacum* (North and central American species); *Erigeron karwinskianus* (Mexican species); *Cardamine hirsuta*, *Cardamine flexuosa* (European and temperate Eurasian species); *Hydrocotyle sibthorpioides*, West Indies), etc. The lists of some exotic species recorded from the PWS is mentioned at Table No 7.19.

Beside being the dominating and extensive growth of exotic weeds viz, *Cestrum aurantiacum*, *Eupatorium adenophorum* etc. has an adverse impact on the local ecological system. *Pinus longifolia* is also assumed to be introduced in the recent time.

**Table 7.19.** Lists of exotic species of PWS

[Abbreviation used: Habit; AH = Annual herb, PH= Perennial herb, S= Shrub, AC = Annual climber.]

EXOTIC SPECIES	FAMILIES	HABIT	AREA OF ORIGIN
<i>Cestrum auratiacum</i>	Solanaceae	S	N & C America
<i>Chenopodium ambrosoides</i>	Chenopodiaceae	AH	C. America
<i>Drymaria villosa</i>	Caryophyllaceae	AH	S. America
<i>Erigeron karwinskianus</i>	Asteraceae	PH	Australia
<i>Hydrocotyle sibthorpioides</i>	Apiaceae	AH	West Indies
<i>Eupatorium adenophorum</i>	Asteraceae	S	C. America
<i>Galinsoga parviflora</i>	Asteraceae	AH	C. America

<i>Hydrangea macrophylla</i>	Hydrangeaceae	S	Sino- Japanese
<i>Ipomoea purpurea</i>	Cucurbitaceae	AC	S. America
<i>Oxalis corymbosa</i>	Oxalidaceae	AH	S. America
<i>Pilea microphylla</i>	Urticaceae	PH	S. America
<i>Rorippa nasturtium aquiticum</i>	Brassicaceae	PH	Eurasia
<i>Cardamine hirsuta</i>	Brassicaceae	AH	Europe

#### 7.4. RARE AND THREATENED PLANTS OF PANGOLAKHA WILDLIFE SANCTUARY

The PWS is one of the important conservatories for rare and threatened species of plants. During the study, some of the threatened species of India, under Red Data Books of Indian Plants (Nayar & Shastri 1987, 1988, 1990) is also being recorded. This species seems to be widely distributed inside the sanctuary in different altitudinal zones. The rarity of or threat to a majority of them could be of several reasons, but it could also be due to several frequent anthropogenic factors like habitat destruction due to grazing, transborder species trafficking etc. Unskilled and unscientific collection of species by local plant-traders for several identical purposes, are attributing directly or indirectly in the loss of species population.

The knowledge of plants being used in medicine is maximum in the Indian Himalayan region (Samant & Dhar 1997). There are major gaps in the knowledge of biological resources and the means by which biological diversity is maintained (Heywood & Baste 1995). The very survival of these resources is now under threat from rapidly expanding human population and concomitant environmental degradation occurring at a fast pace. During the study, 10 species of plants, which falls under the category of rare and threatened species according to the Red Data Book of Indian plants (Nayar & Shastri 1987, 1988, 1990) has also been recorded for the first time from east Sikkim. The lists of rare and threatened species of India, from PWS are presented in Table 7.20.

The orchids are the important component of the Flora of PWS. They are widely distributed as geophytes to epiphytes. The PWS hold not less than 55 wild orchids, which is rare in its distribution across the east Himalayan region (Luckson, 2007).

**Table 7.20.** The lists of the threatened species of India recorded from PWS.

FAMILY	SPECIES	STATUS
Aceraceae	<i>Acer hookeri</i>	Endangered
Ranunculaceae	<i>Aconitum ferox</i>	Vulnerable
Begoniaceae	<i>Begonia satrapis</i>	Rare
Campanulaceae	<i>Codonopsis affinis</i>	Rare
Juncaceae	<i>Juncus sikkimensis</i>	Rare
Asteraceae	<i>Lactuca cooperi</i>	Endangered

Valerianaceae	<i>Nardostachys grandiflora</i>	Vulnerable
Scrophulariaceae	<i>Picrorhiza kurroa</i>	Vulnerable
Podophyllaceae	<i>Podophyllum hexandrum</i>	Threatened
Apiaceae	<i>Pimpinella tongloensis</i>	Endangered

Source: Red Data book of Indian Plants (Nayer & Shastri, 1987-88)

## 7.5. ECONOMIC ASSESSMENT

The PWS is housing a large number of floristic elements, which are economically significant. Many of those are holding precious medicinal, ornamental and aromatic values. However, a large numbers of species are having incredible ethnobotanical importance. The tribal people living in the proximity of the sanctuary have been using many species for various purposes in sustainable manner. Many species of plant belongs to the sanctuary are also alternative for wild edibles. The PWS is also a rich depository of the plants used by the local folk healers, faith healers viz, *Vaidyas*, *Bongthing*, *Phedangba* and others.

The sanctuary also inhabited by a good number of high quality timber yielding trees, which has been used for various construction works, furniture, agricultural implements etc. Some of the species of this category are *Alnus nepalensis*, *Alcimandra cathcartii*, *Tsuga dumosa*, *Mangnolia campbellii* etc.

Significantly, the forest of PWS has also been identified as a repository of trees, shrubs, herbs and climbers of immense ornamental value. The sanctuary is also known for being a plethora of economically important species including wild edible and medicinal species, which may also have enormous importance of economical value.

### 7.5.1. Medicinal Plants Resources

PWS is an immensely rich repository of medicinal plants, which can be used in various upcoming pharmaceutical industries of state and its adjoining region for the preparation of several life saving drugs. The plants are either illegally transported to the various medicinal plant base industries. Some of the important potential medicinal plants of the PWS are *Achyranthes bidentata*, *Aconitum ferox*, *Astilbe rivularis*, *Berginia ciliata*, *Clematis acuminata*, *Dioscorea deltoidea*, *Elaeocarpus lancaefolius*, *Heracleum wallichii*, *Hemiphragma heterophyllum*, *Lycopodium clavatum*, *Mahonia napaulensis*, *Neopicrorhiza scrophulariiflora*, *Panax pseudo-ginseng*, *Podophyllum hexandrum*, *Polygala arillata*, *Rubia manjith*, *Swertia chirayita*, *Taxus baccata*, *Zanthoxylum oxyphyllum* etc.

Interestingly, many such other species are traditionally used by the local folk healers for the treatment of various common diseases in both human and cattle. The allopathic system medicines are practically unavailable in the vicinity of sanctuary, the herbal healers treats the

minor ailment using some selected herbs during the accident or in emergency. The details of this category of plants are also discussed in detail below under sub- heading ethno-medicinal plants of PWS.

### 7.5.2. Ornamental Plants of the Sanctuary

Das & Chanda (1990) has analyzed the ornamental potentiality of the flora of adjacent Darjiling Hills. The PWS is also identified as a home for a large numbers of plant species of an immense ornamental significance. Interestingly, some species of wild flowers are now domesticated by the people living in the vicinity for the beautification of their houses and gardens. One of the important components of flora of sanctuary is its wild Orchids, which is immensely rich and widely distributed. These orchids of great ornamental values includes the species of *Calanthe*, *Dendrobium*, *Vanda*, *Cymbidium*, *Paphiopedilum* etc and having huge potential for export market if propagated artificially in large scale. The beautiful flowers of numerous species of *Primula*, *Pedicularis*, *Potentilla*, and *Rhododendrons* are also noteworthy potential ornamentals for the future. However, the flowers of many of these plants are very short lived. Some selected species of *Acer* can also be introduced in parks and garden. The flora of PWS is also having eight small and beautiful bamboos; those can be utilized as ornamental in near future. However, more comprehensive studies are essential in near future to identify other major species with potential ornamental value. The lists of some plants recorded potential ornamental plants from the sanctuary are listed below in Table 7.21.

**Table 7.21.** Some plants of ornamental potential growing in PWS and their climatic suitability. [Abbreviations used: USE: AT = Avenue Tree; EFH = Epiphytic Flowering Herb; EFS = Epiphytic Flowering Shrub; FC = Flowering Climber; FH = Flowering Herb; FIC = Foliage Climber; FIS = Foliage Shrub; FS = Flowering Shrub; FT = Flowering Tree; AVAILIBILTY; C; = Common; LC; Less Common. CLIMATIC ZONE: Alp = Alpine; Salp = Subalpine; Strp = Subtropical; Tem = Temperate; Trp = Tropical]

Name of Species	Use	Avaibility	Climatic suitability
<i>Aconogonum campanulatum</i>	FS	C	Tem – Salp
<i>Aeschynanthus hookeri</i>	EFS	C	Tem
<i>Agapetes serpens</i>	EFS	C	Tem
<i>Ajuga lobata</i>	FH	C	Tem – Salp
<i>Anaphalis triplinervis</i>	FH	C	Tem – Salp
<i>Androsace geraniifolia</i>	FH	C	Salp – Alp
<i>Androsace globifera</i>	FH	C	Salp – Alp
<i>Arisaema griffithii</i>	FH	C	Tem
<i>Arisaema speciosum</i>	FH	LC	Tem
<i>Asystasia macrocarpa</i>	FS	C	Strp – Tem
<i>Begonia flaviflora</i>	FH	LC	Tem

<i>Begonia ovatifolia</i>	FH	C	Tem
<i>Begonia picta</i>	FH	C	Strp - Tem
<i>Berberis insignis</i>	FS	C	Tem - Salp
<i>Berginia purpuracens</i>	FH	LC	Tem - Salp
<i>Brassaiopsis mitis</i>	FS	C	Tem
<i>Caltha palustris</i>	FH	C	Tem - Salp
<i>Cardamine macrophylla</i>	FH	C	Salp
<i>Cardiocrinum giganteum</i>	FH	LC	Tem - Salp
<i>Caulleya spicata</i>	FH	LC	Strp - Tem
<i>Chirita macrophylla</i>	FH	C	Tem
<i>Clematis montana</i>	FC	C	Tem - Salp
<i>Corydalis geraniifolia</i>	FH	C	Salp - Alp
<i>Dendrocalamus sikkimensis</i>	FIS	LC	Strp - Tem
<i>Dichroa febrifuga</i>	FS	C	Tem
<i>Diadymocarpus albicalyx</i>	FH	C	Tem - Salp
<i>Diadymocarpus pulcher</i>	FH	LC	Tem - Salp
<i>Dipsacus atratus</i>	FH	C	Salp - Alp
<i>Disporum calcaratum</i>	FH	LC	Tem - Salp
<i>Disporum cantoniense</i>	FH	LC	Tem - Salp
<i>Dobinea vulgaris</i>	FS	C	Strp - Tem
<i>Euonymus frigidus</i>	FIS	C	Strp - Tem
<i>Euonymus vagans</i>	FIS	C	Strp - Tem
<i>Fragaria rubicola</i>	FH	C	Tem - Salp
<i>Gaultheria griffithiana</i>	FS	C	Salp - Alp
<i>Gentiana speciosa</i>	FC	C	Tem - Salp
<i>Geranium nepalense</i>	FH	C	Tem - Salp
<i>Globba racemosa</i>	FH	C	Trp - Tem
<i>Gynura cusimbua</i>	FH	C	Strp - Salp
<i>Helwingia himalaica</i>	FS	C	Tem
<i>Hippophaea rhamnoides</i>	FT	Rare	Salp - Alp
<i>Holboellia latifolia</i>	FC	C	Tem
<i>Hoya linearis</i>	EFH	C	Tem
<i>Hydrangea macrophylla</i>	FS	C	Strp - Tem
<i>Hypericum hookerianum</i>	FS	C	Tem - Salp
<i>Impatiens. cathcartii</i>	FH	C	Tem - Salp
<i>I. pulchra</i>	FH	C	Tem
<i>I. stenantha</i>	FS	C	Tem
<i>I. porrecta</i>	FH	C	Tem
<i>Ipomoea purpurea</i>	FC	C	Strp - Tem
<i>Jasminum dispernum</i>	FS	C	Strp - Tem
<i>Leycesteria formosa</i>	FS	LC	Tem - Salp
<i>Ligustrum lucidum</i>	FS	LC	Tem
<i>Lobelia pyramidalis</i>	FH	C	Strp - Salp
<i>Lonicera macrantha</i>	FC	C	Tem - Salp
<i>Loxostigma griffithii</i>	FH	C	Tem
<i>Meconopsis paniculata</i>	FH	C	Tem - Salp
<i>Melastoma malabathricum</i>	FS	C	Trp - Tem
<i>Merrillioanax alpinus</i>	FS	C	Tem - Salp
<i>Michelia doltsopa</i>	AT	C	Strp - Tem
<i>Neillia thyrsoiflora</i>	FS	C	Tem - Salp
<i>Osbeckia nepalensis</i>	FS	C	Trp - strp
<i>Osbeckia stellata</i>	FS	C	Tem
<i>Oxyspora paniculata</i>	FS	C	Strp - Tem

<i>Paris polyphylla</i>	FH	LC	Tem – Salp
<i>Pedicularis microcalyx</i>	FH	C	Salp – Alp
<i>Pimpinella diversifolia</i>	FH	LC	Strp – Tem
<i>Pleione praecox</i>	EFH	C	Strp – Tem
<i>Polygonatum cirrhifolium</i>	FH	C	Tem – Salp
<i>Polygonatum oppositifolium</i>	FH	C	Tem – Salp
<i>Porana grandiflora</i>	FC	LC	Tem
<i>Potentilla fulgens</i>	FH	C	Strp- Salp
<i>Pratia montana</i>	FH	C	Tem
<i>Pratia nummularia</i>	FH	C	Strp – Tem
<i>Primula denticulata</i>	FH	C	Salp – Alp
<i>Primula kingii</i>	FH	C	Salp – Alp
<i>Primula sikkimensis</i>	FH	C	Salp – Alp
<i>Prunella vulgaris</i>	FH	C	Strp – Tem
<i>Raphidophora glauca</i>	FIC	C	Strp – Tem
<i>Rheum nobile</i>	FH	Rare	Salp – Alp
<i>Rhododendron dalhousiae</i>	FS	LC	Tem – Salp
<i>Rhododendron anthopogon</i>	FS	LC	Salp – Alp
<i>Rhododendron arboreum</i>	FT	C	Tem – Salp
<i>Rhododendron glaucophyllum</i>	FS	C	Tem – Salp
<i>Rhynchoglossum obliquum</i>	FH	LC	Strp – Tem
<i>Ribes glaciale</i>	FS	C	Tem – Salp
<i>Rosa sericea</i>	FS	C	Salp
<i>Rubus calycianus</i>	FH	C	Tem
<i>Satyrium nepalense</i>	FH	C	Strp – Salp
<i>Schefflera venulosa</i>	FIC	C	Tem
<i>Schisandra grandiflora</i>	FC	C	Tem
<i>Senecio scandens</i>	FC	C	Tem – Salp
<i>Smilax rigida</i>	FIS	C	Salp
<i>Swertia bimuculata</i>	FH	C	Strp – Salp
<i>Treutlera insignis</i>	FC	LC	Salp
<i>Vaccinium vacciniaceum</i>	EFH	C	Tem
<i>Viola canescence</i>	FH	C	Tem

### 7.5.3. Wild Edible Species of PWS

The rich and diverse plant wealth of PWS is a rich source of food for the local people. The edibles resource of PWS can be classified into five categories, wild edibles plants, leafy vegetables, edibles fruits, edibles seeds and seeds as source of edible oil. Interestingly, some edible species has now found prominent place in the local market. As from the time immemorial, some species are the alternative food for tribal living in the vicinity of the PWS, during food crisis. The people living in Jocal areas like Prem lakha, Padamchen, Rigu and Hathicherey are more or less depended on the Pangolakha forests for their day-to-day vegetables requirement. The prominent edible parts of these wild vegetables are young buds, young shoots, climbing shoot and young leaves. The most widely collected edible plants and readily available in local market are *Urtica dioca*, *Aconogonum molle*, *Laportea terminalis* and young shoot bamboos and ferns. However, some of the important animals of the sanctuary including bears, deer, squirrels etc. are

mostly depended on these wild edible plants. Some of the common edible plants recorded from the PWS are given below in Table 7.22.

**Table 7.22.** Some wild-edible plants from PWS along with their local names and edible parts.

Species	Local name (Lepcha)	Edible parts	Marketing Prospect
<i>Aconogonum molle</i>	<i>Kundyam dung</i>	Young shoot	√
<i>Actinidia strigosa</i>	<i>Tusking rik</i>	Ripe fruit	×
<i>Allium wallichii</i>	<i>Lho sungo</i>	Flower	×
<i>Bauhinia vahlii</i>	<i>Ra kung</i>	Stem & leaves	×
<i>Cardamine macrophylla</i>	-	Fruits	×
<i>Castanea sativa</i>	-	Fruits	×
<i>Cinnamomum bejolghota</i>	<i>Sumsor</i>	Bark	√
<i>Corylus ferox</i>	-	Fruits	×
<i>Dendrocalamus hamiltonii</i>	<i>Ruveet</i>	Young shoot	√
<i>Dioscorea bulbifera</i>	<i>Kusok</i>	Tuberous root	√
<i>Dioscorea pentaphylla</i>	<i>Kaching</i>	Tuberous root	√
<i>Elaeocarpus lanceifolius</i>	-	Fruits	
<i>Evodia fraxinifolia</i>	<i>Kunda</i>	Fruits	√
<i>Fagopyrum debotrys</i>	<i>Palop bee</i>	Young shoot	√
<i>Fragaria vesca</i>	<i>Hublong muuk</i>	Fruits	√
<i>Hemiphragma heterophyllum</i>	-	Ripe Fruits	
<i>Heracleum wallichii</i>	<i>Syamben</i>	Seeds	
<i>Holboellia latifolia</i>	<i>Kaol rik</i>	Fruits	×
<i>Juglans regia</i>	<i>Koelkung</i>	Kernel	√
<i>Laportea terminalis</i>	<i>Kuju sorong</i>	Leaves and Flower	√
<i>Machilus edulis</i>	<i>Fam kung</i>	Fruits	√
<i>Morus australis</i>	<i>Sano Kimbu</i>	Fruits	×
<i>Mussaenda roxburghii</i>	<i>Tungbub</i>	Young leave	×
<i>Nasturtium officinale</i>	<i>Sim bee</i>	Young shoot	√
<i>Pentapanax fragrans</i>	-	Fruits , leaves	
<i>Phytolacca acinosa</i>	<i>Zaringo</i>	Leaves.	
<i>Piper mullesua</i>	<i>Kunten</i>	Ripe Fruits	×
<i>Rhododendron arboretum</i>	<i>EE-tok kung</i>	Flowers	×
<i>Rosa sericea</i>	<i>Chung-chung sisi</i>	Ripe Fruits	×
<i>Rubus acuminatus</i>	<i>Biralay lahara</i>	Ripe Fruits	×
<i>Rubus calycinus</i>	-	Fruits	
<i>Rubus ellipticus</i>	<i>Ka'syim</i>	Ripe Fruits	×
<i>Rubus niveus</i>	<i>Kalo aisaylo</i>	Ripe Fruits	×
<i>Rubus paniculatus</i>	<i>Domaytsalu</i>	Ripe fruits	√
<i>Schizandra grandiflora</i>	<i>Singhghatta lahara</i>	Ripe fruits	×
<i>Schizandra neglecta</i>	<i>Singhghatta lahara</i>	Ripe fruits	×
<i>Sloanea dasycarpa</i>	-	Fruits	
<i>Smilacina oleraceae</i>	<i>Choklee bee.</i>	shoot/ flower buds	×
<i>Smilax aspericaulis</i> Wall.	-	Fruits	
<i>Tetradium fraxinifolium</i>	<i>Bokey timber</i>	Fruits	
<i>Tupistra natans</i>	<i>Purfek-dung</i>	Flowers	√
<i>Urtica dioca</i>	<i>Surong nok bee</i>	Leaves and flower	√
<i>Viburnum erubescens</i>	<i>Purmu kung</i>	Ripe Fruits	√

#### 7.5.4. Important Timber Yielding Plants of PWS.

One of the important assets of the PWS is its timber yielding plants. Some wooden plank that derived from various trees species is of great demand in the market. Some of the trees of this category are as old as 150 years or more. The total girth recorded is upto 200 cm. The making of furniture through the wood of *Michelia doltsopa* is considered as most durable and expensive. However, in the present context and prices the values of the timber which is being produce by other trees are also gradually rising up in local markets. Therefore, the sanctuary is now one important Genepool of timber yielding plants for the future. Though Department of Forests in their part also has banned the felling of some of rare trees for future conservation, the illegal trafficking of woods is occasionally being done by the trans-border businessman. During the survey, 22 species that has been being used for the timber yielding has been collected from PWS, including *Taxus baccata*, *Michelia doltsopa*, *Michelia cathcartii*, *Magnolia globosa*, *Magnolia campbellii* etc. the cutting down of this species is already being banned in state. Some of the notable timber species of the PWS is mentioned in the Table 7.23.

**Table 7.23.** Important timber yielding plants of PWS.

<b>Timber yielding species</b>	<b>Lepcha name</b>
<i>Albizia lebbeck</i>	<i>Sundyong kung</i>
<i>Alnus nepalensis</i>	<i>Sungru kung</i>
<i>Betula alnoides</i>	<i>Sunglee kung</i>
<i>Betula utilis</i>	<i>Bhojpatra</i>
<i>Castanopsis indica</i>	<i>Serol kung</i>
<i>Castanopsis tribuloides</i>	<i>Kusyo kung</i>
<i>Castanopsis indica</i>	<i>Aulay Katus</i>
<i>Cryptomeria japonica</i>	<i>Chunden kung</i>
<i>Duabanga grandiflora</i>	<i>Nyomhren kung</i>
<i>Lithocarpus pachyphylla</i>	<i>Sunguray Katus</i>
<i>Magnolia campbellii</i>	<i>Pandey or Gok</i>
<i>Magnolia globosa</i>	<i>Kok pandey</i>
<i>Michelia cathcartii</i>	<i>Gokdum</i>
<i>Michelia doltsopa</i>	<i>Pandey kung</i>
<i>Pinus roxburghii</i>	<i>Chunden kung</i>
<i>Prunus napaulensis</i>	<i>Kongki</i>
<i>Quercus lamellosa</i>	<i>Buk kung</i>
<i>Quercus lineata</i>	<i>Sri- kung</i>
<i>Rhododendron arboreum</i>	<i>Etok kung</i>
<i>Taxus baccata</i>	<i>Cheongbu kung</i>
<i>Terminalia myriocarpa</i>	<i>Sunglyok kung</i>
<i>Tsuga dumosa</i>	<i>Tungsyng kung</i>

#### 7.5.5. Important Dye Yielding Plants

The PWS houses numerous plant species of potential natural dye. Plants mentioned in the Table 7.24 are the most prominent ones and are used by the local people for obtaining various dyes

since long. These dyes are usually a color substance for local artifacts especially, bamboo art, wood craft etc. *Rubia manjith* is the most widely used dye yielding plants. Therefore the sustainable use of locally derived natural dyes may partly ease the demand of the natural dye in the local markets. Some of the plants mentioned below are also being used by the Government Institute of Cottage Industry or Directorate of Handicraft and Handloom, Govt of Sikkim especially in Lepcha traditional hat, cane and bamboo arti-crafts.

**Table 7.24.** Some important dye yielding plants of PWS. [N = Nepali; L = Lepcha]

Dye yielding species	Local name	Part used	Colour
<i>Bischofia javanica</i>	Kainjal (N)	Leaves	Yellow
<i>Jasminum dispernum</i>		Fruits	Black
<i>Juglan regia</i>	Kolkung (L)	Bark	Yellow
<i>Mahonia napaulensis</i>	Chutro/Kesari(N)	Stem bark	Yellow
<i>Rheum acuminatum</i>	Khokim (N)	Roots	Yellow
<i>Rubia manjith</i>	Vyem (L), Majito (N)	Fruits, roots	Red, blue, purple, yellow
<i>Rubia wallichiana</i>	Vyem (L)	Fruits	Purple
<i>Symplocos paniculata</i>	Kagatey (L)	Fruits	Violet

#### 7.5.6. Fodder plants of PWS

One of the important aspects of flora of PWS is of its rich composition of fodder plants. Large number of trees, shrubs, climbers, herbs, epiphytes has been recorded for their fodder value from the sanctuary and some alpine species are also been identified as potential fodder plants for the future. Due to the abundant availability of fodder, the practice of cattle rearing and grazing was quite common before the declaration of area as sanctuary. Therefore, the complete removal of the cattle from the sanctuary area was a Herculean task to the forest department. It has taken over 10 years for the Forest Department people to remove all the cattle herds from the sanctuary area. Though some "Goth" are still present in nearby places of the sanctuary. The lists of some potential fodder plants recorded from the PWS has been given below (Table 7.25 and Table 7.26)

**Table 7.25.** List of some fodder plants recorded from the grasslands of alpine and sub-alpine region of PWS. [C = Common; LC = Less Common].

PLANT NAME	FAMILY	AVAILABILITY
<i>Arundinaria hookeriana</i>	POACEAE	C
<i>Anaphalis triplinervis</i>	ASTERACEAE	C
<i>Anaphalis contorta</i>	ASTERACEAE	C
<i>Anaphalis royleana</i>	ASTERACEAE	C
<i>Anaphalis subumbellata</i>	ASTERACEAE	LC
<i>Acer campbellii</i>	ACERACEAE	C
<i>Carex cruciata</i>	CYPERACEAE	LC
<i>Commenila paludosa</i>	COMMENILACEAE	C
<i>Dipsacus inermis</i>	DIPSACEAE	C
<i>Elsholtzia strobilifera</i>	LAMIACEAE	C
<i>Epilobium roseum</i>	ONAGRACEAE	C
<i>Fagopyrum esculentum</i>	POLYGONACEAE	C
<i>Fragaria vesca</i>	ROSACEAE	C
<i>Gallium asperifolium</i>	RUBIACEAE	C

<i>Geranium donianum</i>	GERANIACEAE	C
<i>Hemiphragma heterophyllum</i>	SCROPHULARIACEAE	C
<i>Impatiens falcifer</i>	BALSAMINACEAE	C
<i>Iris clarkia</i>	IRIDACEAE	C
<i>Juncus effuses</i>	JUNCACEAE	C
<i>Juncus membranaceous</i>	JUNCACEAE	C
<i>Juncus allioides</i>	JUNCACEAE	C
<i>Juncus amplifolius</i>	JUNCACEAE	C
<i>Juncus bufonius</i>	JUNCACEAE	C
<i>Juncus clarkei</i>	JUNCACEAE	C
<i>Juncus grisebachii</i>	JUNCACEAE	C
<i>Juncus himalensis</i>	JUNCACEAE	LC
<i>Juncus khasiensis</i>	JUNCACEAE	LC
<i>Juncus ochraceus</i>	JUNCACEAE	C
<i>Kyllinga brevifolia</i>	CYPERACEAE	C
<i>Myriactis nepalensis</i>	ASTERACEAE	C
<i>Persicaria alata</i>	POLYGONACEAE	C
<i>Persicaria capitata</i>	POLYGONACEAE	C
<i>Persicaria runcinata</i>	POLYGONACEAE	C
<i>Potentilla fulgens</i>	ROSACEAE	C
<i>Potentilla peduncularis</i>	ROSACEAE	C
<i>Potentilla polyphylla</i>	ROSACEAE	C
<i>Primula capitata</i>	PRIMULACEAE	C
<i>Selinum tenuifolium</i>	APIACEAE	C
<i>Senecio graciliflorus</i>	ASTERACEAE	C
<i>Setaria palmifolia</i>	POACEAE	C
<i>Thysanolaena maxima</i>	POACEAE	C

**Table 7.26.** Lists of some common fodder plants recorded from the upper and lower temperate region of PWS. [C = Common; LC = Less Common]

Fodder plant	Local name		Availability
	Lepcha name	Nepali name	
<i>Acer lavigatum</i>	Yarli kung	Kapasi	LC
<i>Acer hookeri</i>	-	Kapasi	Rare
<i>Ageratum conyzoides</i>	Numyu muuk	Elame	C
<i>Albizia lebbek</i>	Sree kung	Sirish	C
<i>Axonopus compressus</i>	-	Ghans	C
<i>Amoora wallichii</i>	Leet kung	Lali / Ball	C
<i>Artemisia vulgaris</i>	Tuknyil	Tithepathi	C
<i>Boehmeria hamiltoniana</i>	Ka'yan	Chiplay	C
<i>Boehmeria macrophylla</i>	Ka-yaun	Kamle	C
<i>Brassaiopsis mitis</i>	Sungjam Kung	Chuletro	C
<i>Castanopsis tribuloides</i>	Kusyo kung	Katush	C
<i>Cynodon dactylon</i>	Pong muuk	Dhubo	C
<i>Dendrocalamus sikkimensis</i>	Po-dyang	Bhalu bans	LC
<i>Dendrocalamus hamiltonii</i>	Po	Choya bans	LC
<i>Drymaria cordata</i>	-	Abhijalo	C
<i>Eupatorium aderophorum</i>	Vongnokbu	Banmara	C
<i>Eurya japonica</i>	Tukzyel kung	Jhingani	C
<i>Exbucklandia populnea</i>	Sunklyang kung	Pipli	C
<i>Ficus auriculata</i>	Kundong kung	Nebhara	C
<i>Ficus benjamina</i>	Lungzyi kung	Kabra	C

<i>Ficus neriifolia</i>	Syit kung	Dudhilo	C
<i>Garuga pinnata</i>	Mul-dit kung	Dabdaba	C
<i>Girardinia diversifolia</i>	Kuju	Bhangrey	C
<i>Glochidion acuminatum</i>	-	Lalikaath	C
<i>Hedyotis scandens</i>	-	Kane	C
<i>Litsea polyantha</i>	Sumpat kung	Kutmiro	C
<i>Macaranga nepalensis</i>	Numbung kung	Malato	C
<i>Morus alba</i>	Numbyong	Kimbu	C
<i>Persicaria nepalensis</i>	Rungyi muk	Ratnawlu	C
<i>Parthenocissus semicordata</i>	Tundonok rik	Charchare	LC
<i>Prunus cerasoides</i>	Kangki kung	Cherry	C
<i>Saurauja napaulensis</i>	Kasur kung	Gogun	C
<i>Sonchus wightianus</i>	-	-	LC
<i>Setaria palmifolia</i>	Ka'rhem	Dhutesaro	C
<i>Tetrastigma serrulatum</i>	Tundo rik	Charcharey	C
<i>Tetrastigma obtectum</i>	-	-	LC
<i>Rhaphidophora grandis</i>	Tungking	Thulo kanchirna	C
<i>Thysanolaena maxima</i>	Pusyor	Amliso	C
<i>Turpinia nepalensis</i>	Margok kung	Thali	LC
<i>Urtica dioica</i>	Surong	Sismu	C

#### 7.5.7 . NTFP Resource of PWS:

PWS holds enormous resource of Non-Timber Forests Produces (NTFP). The people living in the vicinity of the sanctuary are directly or indirectly depended on it. The NTFP means food, shelter and other necessity essential life supporting system for them. While surveying, 46 species including 15 species of bamboos that falls under this category has been collected. The lists of some important NTFP are given at Table 7.27. Apart from that the bamboos are one of the important components of PWS, which are being used in multipurpose manner by the people residing nearby. The lists of bamboos that grow in PWS and their usages are mentioned at Table 7.28.

**Table 7.27.** Lists of NTFP plants of PWS other than bamboos.

NTFP Plants	Local Name	Uses
<i>Aconogonum molle</i>	Kundyamdung	The young shoots are used for making pickles.
<i>Albizia lebbeck</i>	Sungdyong	Used for fuel-wood and planted for shades.
<i>Allium wallichii</i>	Ree- sungu	Young shoots are used for making pickles.
<i>Arisaema griffithii</i>	Sungtuk	Bread can be prepared from its tuber paste after processing in running water.
<i>Arisaema utile</i>	Sungtuk	Tubers of this species are locally eaten.
<i>Artemisia indica</i>	Tuknil	It acts as a mosquito and insect repellent.
<i>Betula utilis</i>	Sunli kung	Used in making papers
<i>Colocasia esculenta</i>	Sungtee	Young petioles and rhizomes are eaten as vegetable. The plant is also an ideal fodder for pig.
<i>Cortiella hookeri</i>	-	Matured seeds are eaten as spices.
<i>Dichroa febrifuga</i>	Geybu khanong	Shoot and Bark of the roots are used in preparing febrifuge.
<i>Didymocarpus aromaticus</i>		Used traditionally as incense in religious offerings.

<i>Elaeagnus conferta</i>		Use in making pickle.
<i>Elaeagnus conferta</i>		Use in making pickle.
<i>Engelhardtia spicata</i>		Used as a fish intoxicant and also a good firewood.
<i>Erythrina arborescens</i>	Jasey	Planted near field for fencing.
<i>Eupatorium adenophorum</i>		Dried leaves used extensively as potent manure in the cultivation of ginger
<i>Eurya acuminata</i>	Purmu	Used as firewood.
<i>Girardinia diversifolia</i>	Kuzu sorong	Young shoots are eaten as vegetable and the fiber derived from the matured plants are being used in making traditional dresses, bow strings and ropes by the Lepchas.
<i>Glochidion acuminatum</i>		Table plates and cups are made by pinning up the leaves and used in festive occasions especially during puja offerings
<i>Prunus cerasoides</i>	Kongki	The twigs and branches are used for making many household tools.
<i>Rhododendron anthopogon</i>	Balu-salo	The dried leaves are used as incense in Buddhists monasteries in Sikkim, Tibet and Bhutan
<i>Rhododendron arboretum</i>	Etok kung	The wood is used for making handle of Banphok or Khukri's (traditional knife of Sikkim) The wine prepared by the fermentation of the flower by Sherpa tribe is the remedies for antidote and altitude sickne
<i>Rhododendron dalhousiae</i>	Re-etok	Sometime grown in the garden for its asthetic value.
<i>Rhododendron lanatum</i>	Re-etok	The wooly fawn of underside of the leaves is used in oil lamp.
<i>Sarcococca hookeriana</i>		Wood used to make walking sticks.
<i>Spondias pinnata</i>		Shoot yields a gum called "Chop"
<i>Tetradium fraxinifolium</i>		Fruit is used for making pickle
<i>Turpinia nepalensis</i>		A good fire wood.
<i>Turpinia nepalensis</i>		A good firewood.
<i>Urena lobata</i> L		Yield natural fibre

**Table 7.28.** The lists of some common bamboos of PWS and its usages

BAMBOO SPECIES	LOCAL NAME	USAGES
<i>Arundinaria falconeri</i>	<i>Phusray Nigalo(N)</i>	For Fencing, walking sticks
<i>Bambusa nutans</i>	<i>Matlu (L) Mala bans(N)</i>	Fencing, house construction, Local bridges, fodder, alternative nails, prayer flags
<i>Cephalostachyum capitatum</i>	<i>Po-young(L) Gopay bans(N)</i>	Flute & other folk musical instruments, walking stick, Bows and arrows. Lepcha hat, fodder, local straw for drinking brewed-millet.
<i>Dendrocalamus hamiltonii</i>	<i>Ruveet (L) Choya bans(N)</i>	Knitting, mats, roofs, containers, water vessels, house construction, pickles, vegetables.
<i>Dendrocalamus hookeri</i>	<i>Patu (L), Dungray bans (N),</i>	Fencing, houseposts,
<i>Dendrocalamus patellaris</i>	<i>Niba(N)</i>	Fencing, house construction,
<i>Dendrocalamus sikkimensis</i>	<i>Po-dyang(L) Bhalu bans(N)</i>	construction of house, bridges, fences, water vessels, bamboo vessel (Dungro)
<i>Himalaya calamus falconeri</i>		Food & fodder
<i>H. hookerianus</i>		Basket, roofmaking & vegetables.
<i>Neohouzeana dullooa</i>	<i>Tokri bans(N)</i>	Vessel making, fodder
<i>Himalayacalamus</i>	<i>Prong (L) Paryang (N)</i>	Roof making, fodder, fencing, basket making

<i>hookerianus</i>		etc.
<i>Drepanostachyum intermedium</i>	<i>Singhaney bans(N)</i>	Roof making, walking stick, fodder, vegetables,
<i>Yushania maling</i>	<i>Fyung (L)Malingo (N)</i>	Roofing, mats, floors mats, other household articles, fodders
<i>Yushania pantlingii</i>	<i>Rani Malingo(N)</i>	Fencing, fodder etc.
<i>Thamnocalamus aristatus</i>	<i>Pumom (L) Rato Nigalo (N).</i>	Fencing, fodder etc.

## 7. 6 ETHNOBOTANICAL OBSERVATION

Ethnobotany is a total natural and traditional relationship and the interrelations between man and his surrounding plants wealth (Jain 1987). Sikkim is inhabited by three major ethnic communities viz. Lepcha (*indigenous tribe*), Bhutia and Nepali. Among them the Lepcha indigenous primitive tribe of Sikkim is bestowed with very rich culture and having an incredible knowledge on traditional use of the plants (Jana & Das 2000, Maity *et al.* 2003a,b, 2004).

Wild plants are the significantly used as a food, medicine, daily domestic activities, religious-rituals, marriage ceremonies; ethnic cultures etc. form the basis of ethnobotany. The vicinity of the Pangolakha Wildlife Sanctuary is inhabited by the different ethnic communities, viz. Lepcha, Bhutia, Sherpa, Rai, Limboo, Manger, Gurung and others. They have been strongly associated with the plants and significantly, inherited enormous knowledge of traditional uses of plants. However, this knowledge is chiefly confined with the folk healers e.g. *Bongthing, Vaidyas, Phedangba, Amji* etc. and also with the older generations of these communities. In the process of modernization, there are absolute chances of loosing this epitome of knowledge from them. Hence, the essential attempt has been made to record this knowledge for conservation so that in future such knowledge can be scientifically evaluated and used for the betterment of mankind. The ethnic uses of plants by the tribal people living in the far-flung areas of the sanctuary deserves a separates study on extensive documentation and the codification of potential ethnomedicines and wild edible plants for their future sustainable use.

However, the information generated during the field visits through interactions with the folk healers, elderly people and observation of their house-holds and life-style, following ethnobotanical information has been recorded.

### 7.6.1. Ethnomedicinal Plants

The plethora of knowledge of plant species used in medicine is maximum in the Indian Himalayan region (Samant & Dhar 1997). Interestingly, the minor ailments like cough, cold, fever or minor wounds are treated locally by some locally reputed folk healers. It is agreeable that despite the vast scientific progress and achievements in the field of medicines, these therapeutic plants, still now, are to be recognized as valuable source of health care which are providing

PLATE XVI

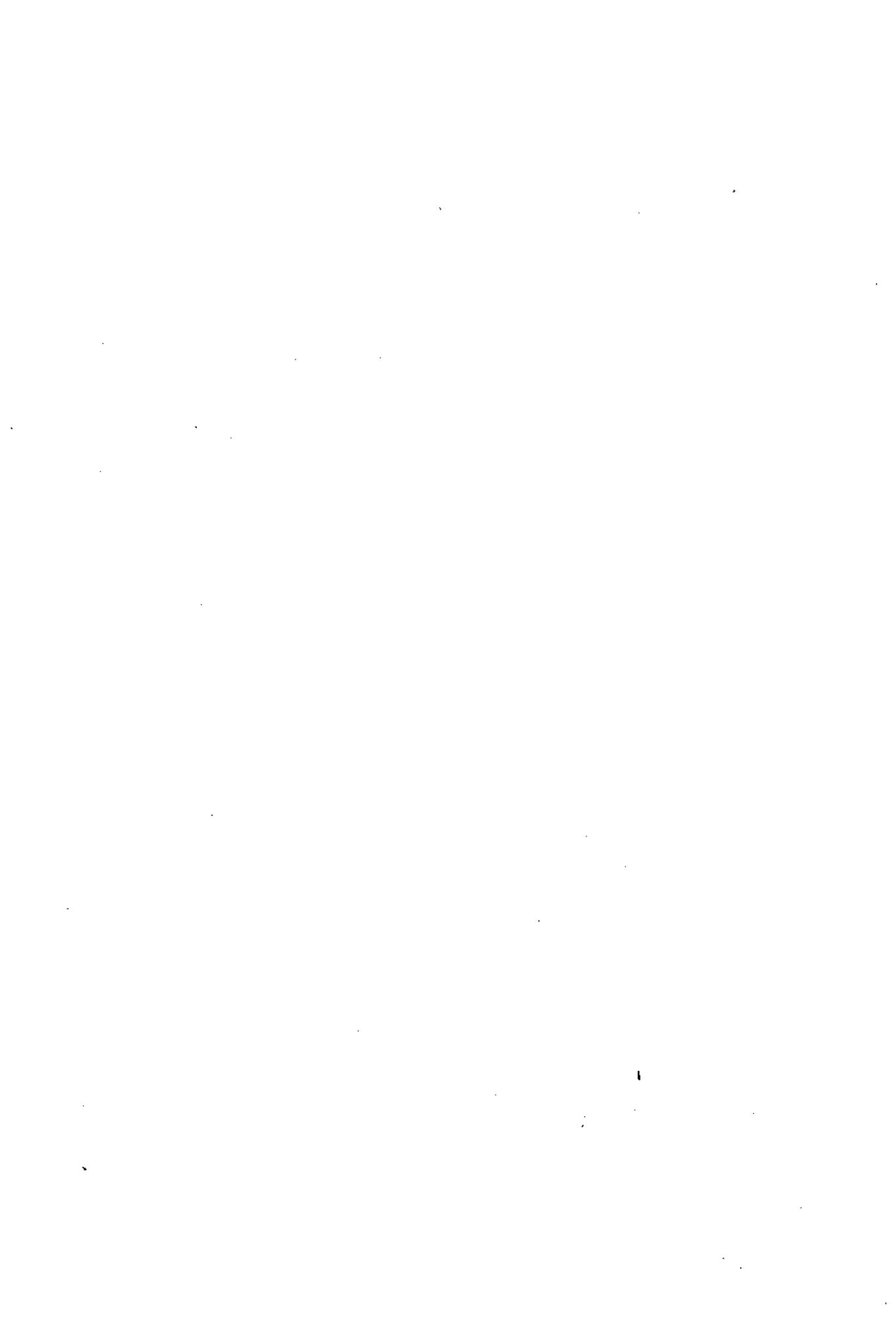


## LEGEND OF PHOTOS

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### Plate XVI

93. The boiled bamboo shoots ready for sale
94. The basket full of *Ficus auriculata*'s fruits collected for pig fodder
95. The local folks carrying firewood way back to home.
96. The bamboo vessel being traditionally used for serving brewed millet (Chee/C hang ).
97. Remains of *Yushania*'s culm sheath after being young shoot eaten by Beer
98. A bamboo's lamp
99. A folk healer while offering to the guardian deity.
100. The people still depended on forest for fodder.



incredible health services to the rural people in the remotest and far-flung areas around the sanctuary. The folk healers are recognized equivalent to the doctor in their settlement. They have proved in a several instances for their successful treatment of patients through the use of one or more plants. However, doses and the mode of administration may vary from place to place and community wise. Some species being medicinal can also equally poisonous or even fatal if not administered properly and in appropriate dose. The plants used in such practice include small herbs of 10 cm to the tall trees of 20 m. Table 7.29 is presenting a list of plants used by ethnic folk-healers of the region. Leaves, roots, stems, flowers or fruits are the major parts of plants used during the formulation of these local medicines. The plants those are being used by the healers are also sometimes sold in the local market at Aritar, Rhenock, and Padamchen during *Haat* (market day). However, many of these are also found on sale in Gangtok and Singtam bazaar. Therefore, a separate and extensive study or documentation of the potential ethno-medicinal plants must be taken up in near future.

**Table 7.29.** List of some important ethnomedicinal plants and their uses of PWS

Ethno-medicinal plants	Lepcha (L)/ Nepali (N) names	Ailments	Parts in use
<i>Achyranthes bidentata</i>	<i>Ankhlai Jhar(N)</i>	Diuretic Rheumatism,	Roots & stems
<i>Aconitum bisma</i>	<i>Lungzee nyin(L)</i> <i>Bikhuma(N)</i>	Fever, Rheumatism	Tubers
<i>Aconitum spicatum</i>	<i>Nying (L) Bikh.</i>	Rheumatism	Tuber s
<i>Acorus calamus</i>	<i>Ruklop (L) Bojo(N)</i>	Expel intestinal worms	Root , rhizome
<i>Albizia lebbeck</i>	<i>Harasisirs(N)</i>	Boils, piles, diarrhea,	Flower, Leaves
<i>Allium wallichii</i>	<i>Ban lasun(N)</i>	Gastric disorder	Flower , roots
<i>Artemisia indica</i>	<i>Tuknil (L) Titepati(N)</i>	Injury, bleeding	Leaf & flower
<i>Astilbe rivularis</i>	<i>Buro-okhati(N)</i>	Tonic for post-natal women	Roots
<i>Bauhinia vahlii</i>	<i>Makrik (L), Varla(N)</i>	Dysentery, laxative	Seeds & leaves
<i>Berberis aristata</i>	<i>Kyarbu kung(L)</i>	Rabbies	Fruits
<i>Bergenia ciliata</i>	<i>Pakhan-bet(N)</i>	Diarrhoea, fever,	Roots
<i>Berginia purpurascens</i>	<i>Pakhanbed</i>	Fever, diarrhoea	Roots
<i>Betula alnoides</i>	<i>Saur (N)</i>	Snake-bite	Bark paste
<i>Boenninghausenia albiflora</i>		Lice problems	Young shoot
<i>Buddleja asiatica</i>	<i>Pondam (L),</i> <i>Bhimsenpati(N)</i>	Skin, abortificant	Leaves , flower,
<i>Cardamine hirsuta</i>	<i>Simrayo(N)</i>	Low BP & cardiac problem	Shoot extract
<i>Centella asiatica</i>	<i>Goltaprey (N)</i>	Penumonia, fever	Shoot
<i>Chenopodium ambrosoides</i>	<i>Bethu saag (N)</i>	Aphrodisiacs, anthelmintic	Whole plant
<i>Clematis acuminata</i>	<i>Pinasay lahara(N)</i>	Sinus pain	Roots
<i>Clematis buchanania</i>	<i>Pinasey lahara(N)</i>	Sinocytis, antiviral,	Roots, shoots
<i>Clematis smilacifolia</i>	<i>Pinasay (N)</i>	Sinosytis	Roots, shoots
<i>Corydalis chaerophylla</i>	-	Stomach-ache	Fruits
<i>Cotoneaster microphyllus</i>	-	Used as stringent	Stolons
<i>Cuscuta reflexa</i>	<i>Akashvel i(N)</i>	Jaundice, cough	Shots, seeds
<i>Dioscorea pentaphylla</i>	<i>Kassok(L) bantarul(N)</i>	Tonic, swelling	Tuber, shoots

<i>Dioscorea bulbifera</i>	<i>Kaching(L), Gittha(N)</i>	Tonic, aphrodisiac, ulcer	Tuber
<i>Drymaria villosa</i>	<i>Abijalo(N)</i>	Pneumonia, sinusitis	Shoots
<i>Dufrenoya platyphylla</i>	<i>Aijenro(N)</i>	-	Fruits
<i>Elsholtzia blanda</i>	<i>Lhasilam(N), Banshilam(N)</i>	Gastritis	Shoot
<i>Erithrina arborescens</i>	<i>Gyesev kung(L), Phaledo (N)</i>	Skin diseases	Leaves, barks
<i>Euodia fraxinifolium</i>	<i>Tungrhul kung (L), Khanak-pa</i>	Typhoid, indigestion	Fruits
<i>Eupatorium adeno-phorum</i>	<i>Vongnokbu (L) Kalijhar</i>	External injuries	Leaf extract
<i>Evodia fraxinifolia</i>	<i>Ka'nu(L), Khanakpa(N)</i>	Antipyretic, diuretic	Fruits & Plants
<i>Fraxinus floribunda</i>	<i>Payjew(L), Lankuri(N)</i>	Bone fracture	Bark
<i>Fritellaria cirrhosa</i>	<i>Kakoli (N)</i>	Tuberculosis, Asthma	Bulbs
<i>Gaultheria fragmatissima</i>	<i>Kalomba (L), Machino(N)</i>	Antiseptic, rheumatism	Leaves
<i>Geranium nepalensis</i>	<i>Bhanda (N)</i>	Astringent	Whole plant
<i>Girardinia diversifolia</i>	<i>Kuju (L) Bangrey (N)</i>	Blood pressure	Flowers
<i>Gynocardia odorata</i>	<i>Gantay(N)</i>	Skin disease & Leprosy	Seeds oil
<i>Hedyotis scandens</i>	<i>Kalhya (L), Bokre lahaha(N)</i>	Eye diseases, sprain, boils	Roots & plant.
<i>Hedychium spicatum</i>	<i>Pankha phool, Sara(N)</i>	Diarrhea, vomiting, asthma	Roots & rhizome
<i>Heracleum nepalensis</i>	<i>Samben (L) Chimphi-ng</i>	Influenza, bodyache	Flower & fruits
<i>Hydrocotyle himalaica</i>	<i>Golpata(N)</i>	Pneumonia, throat infection	Whole plant
<i>Hydrocotyle nepalensis</i>	<i>Golpatta (N)</i>	Throat problems	Whole plant
<i>Hypericum uralum</i>	<i>Urillo (N)</i>	Wounds & bruises	Bark-juice
<i>Laportea terminalis</i>	<i>Sorong (L), Sishmu(N)</i>	Blood pressure	Flower & leaves
<i>Leucocephalum canum</i>	<i>Cheong kung (L).</i>	Epilepsy, wounds	Roots, leaves
<i>Listea cubeba</i>	<i>Siltimur (N)</i>	Stomach disorders	Flowers
<i>Lobelia pyramidalis</i>	<i>Eklebir (N)</i>	antispasmodic	Leaves, flowers
<i>Lycopodium clavatum</i>	<i>Dermusungfon (L), aagbeli (N)</i>	Rheumatism, pulmonary	Plants & spores
<i>M. ussaenda treutleri</i>	<i>Tungbub (L)</i>	Jaundice	Root stock
<i>Maesa chisia</i>	<i>Purmu kung (L), Billaune (N)</i>	Insecticide, anthelmintic	Roots, leaves
<i>Mussaenda macrophylla</i>	<i>Tungbub (L)</i>	Jaundice	Root extracts
<i>Nardostachys jatamanshi</i>	<i>Jatamanshi(L)</i>	Tonic, leprosy, skin disease	plant & root stock
<i>Panax pseudogin-seng var. angustifolius</i>	<i>Paanch pattay(N)</i>	Potent vitaliser	Rhizomes
<i>Panax pseudogin-seng var bipinnatifidus</i>	<i>Panch pattey (N)</i>	Potent vitaliser	Rhizomes
<i>Paris polyphylla</i>	<i>Satuwa (N)</i>	Antidots, fever	Rhizome
<i>Phytolacca acinosa</i>	<i>Jaringo(N)</i>	High blood pressure	Leaves
<i>Picrorhiza kurrooa</i>	<i>Kutki</i>	Jaundice, epilepsy liver	Roots
<i>Plantago erosa</i>	<i>Isagbul (N)</i>	Tooth-ache	Leaves
<i>Podophyllum hexandrum</i>	<i>Ban kakhri(N)</i>	Fever, diarrhoea, anticancer	Roots, fruits
<i>Potentilla fructicosa</i>	<i>Chiniya phal(N)</i>	Astringent	Leaves
<i>Potentilla fulgens</i>	<i>Bajra danti (N)</i>	Diarrhea, toothach	Roots
<i>Prunus ceresoides</i>	<i>Arupatay (N)</i>	Bone-fracture & tooth-ache	Bark, stem
<i>Rhamnus napalensis</i>	<i>Phatnok kung (L), Archal(N)</i>	Used as purgative	Roots
<i>Rheum nobile</i>	<i>Kenjo (N)</i>	Ulcers, bronchitis, fever	Roots
<i>Rhododendron arboreum</i>	<i>Ee-tok reep (L) Lali Gurans(N)</i>	Blood □ Dysentery	Flower

<i>Rhus succedanea</i>	<i>Su-kung(L), Rani balayo (N)</i>	thisis	Fruit, leaves
<i>Rubia manjith</i>	<i>Vyem (L), Majito</i>	Menstrual disorder, skin	Roots & fruits
<i>Rubia wallichiana</i>	<i>Vyem (L),</i>	Jaundice, paralysis	Shoots
<i>Rubus ellipticus</i>	<i>Kusyim (L) Ainselu(N)</i>	Fever	Roots
<i>Rubus lineatus</i>	<i>Suvuk (L)</i>	Food poisoning	Roots
<i>Rumex nepalensis</i>	<i>Halhalay(N)</i>	Skin diseases	Shoots
<i>Scoparia dulcis</i>	-	Diabetes	Young leaves
<i>Sonchus wightianus</i>	-	Jaundice	Roots
<i>Skimmia laureola</i>	<i>Timburyok (L), chumalani (N)</i>	Aromatic	Leaves
<i>Stephania glandulifera</i>	<i>Tamarkay (N)</i>	Liver, Jaundice, Poultry	Root tuber
<i>Swertia chirayita</i>	<i>Rungken (L) Chireto (N)</i>	Dyspepsia, fever, headache	Shoots
<i>Symplocos lucida</i>	<i>Kharane y(N)</i>	Seeds powder	Spider sting
<i>Thalictrum foliolosum</i>	<i>Dampatey (N)</i>	Used as tonic and purgative	Roots
<i>Thalictrum javanicum</i>	<i>Dampatey (N)</i>	Tonic, Purgative	Roots
<i>Valeriana hardwickii</i>	<i>Nakali jatamanshi (N)</i>	Epilepsy neurosis, colic	Roots
<i>Viola biflora</i>	<i>Ghattey gans (N)</i>	Used as emetic, antiseptic	Roots & Flowers
<i>Viola diffusa</i>	<i>Ghattey gans (N)</i>	Chest pain	Flowers
<i>Viscum nepalense</i>	<i>Dag sumthet, Harchur (N)</i>	Body-pain, fracture, fever	Stem

### 7.6.2. Poisonous Plants of PWS.

The PWS also do possess a very good numbers of poisonous plants. The poisonous plants are mostly in the form of roots, leaves, stems etc. The *Aconitum laciniatum* is poisonous to the human being. The local people (Lepchas) use its extract on the arrowhead as poison. Therefore, a separate intensive study is also required for better understanding of this category of plants. Some of the important poisonous plants recorded from the PWS in Table 7.30.

**Table 7.30.** List of common Poisonous Plants of PWS.

Name of the Plant	Family	Poisoinous Parts	Poisonous for
<i>Acontum laciniatum</i>	Ranunculaceae	Roots	Human being
<i>Berberis insignis</i>	Berberidaceae	Stem juice	Fishes
<i>Caltha palustris</i>	Ranunculaceae	Stem juice	Animals
<i>Cestrum aurantiacum</i>	Solanaceae	Shoots	Goat & cattle
<i>Clematis gouriana</i>	Ranunculaceae	Stem& leaves juice	Human beig & Cattles
<i>Codonopsis affinis</i>	Campamulaceae	Shoots	Human being
<i>Dendrocnide sinuata</i>	Urticaceae	Leaves	Human being
<i>Girardinia diversifolia</i>	Urticaceae	Stinging hairs	Animals
<i>Gnaphalium affine</i>	Compositae	Shoots	Cattle
<i>Laportea terminalis</i>	Urticaceae	Stinging hairs	Human being
<i>Lyonia ovalifolia</i>	Ericaceae	Leaves	cattle
<i>Meconopsis napaulensis</i>	Papaveraceae	Roots	Human being
<i>Ranunculus diffusus</i>	Ranunculaceae	Leaf juice	Human being
<i>Rhododendron barbatum</i>	Ericaceae	Stem bark, leaves	Fish

<i>Rhododendron cinnabarinum</i>	Ericaceae	Leaves	Human being
<i>Rhododendron falconeri</i>	Ericaceae	Bark & leaves	Cattles
<i>Rhus succedanea</i>	Anacardiaceae	Stem & leaf juice	Human being
<i>Rumex nepaulesis</i>	Polygonaceae	Root, leaves	
<i>Schima wallichii</i>	Theaceae	Bark	Human being
<i>Semecarpus anacardium</i>	Anacardiaceae	Bark & leaf juice	Human being
<i>Trichosanthes lepiniana</i>	Cucurbitaceae	Seeds	Human being
<i>Urtica ardens</i>	Urticaceae	Stinging hairs	Human being
<i>Semecarpus anacardium</i>	Anacardiaceae	Bark & leaf juice	Human being
<i>Lobelia pyramidatis</i>	Lobeliaceae	Seeds	Human being & Cattles
<i>Maesa chisia</i>	Myrsinaceae	Leaves	Fish

### 6.6.3. Plants of Other Assorted Use

PWS holds a huge number of plant species (Table 7.31) those have been incredibly used for the assorted ethnic importance. Most of the species belongs to this category are either domesticated or conserved or grown somewhere nearby their home. These species are used in making several useful commodities. During the religious rituals, marriage ceremony, festivals, worshipping etc. these are extensively used as a part of culture and tradition in the region. Several significant commodities like traditional wooden containers, milk-curd pots, flower-vase etc, wooden plates, base of the gun, cover of knife (*Banpok*), curry spoon, bows and arrows, bamboo vase (*Chee puthyut /Dungro*) for brewed millet are prepared through various plant species by Lepcha Bhutia, Limboo and Sherpa tribes' community. Some of the plants are also been used in preparation of natural dye, however, some other species are deployed for making traditional drinks "*Chee/Jhaar/ Chang*" (brewed millet). The knowledge related to the plants in traditional assorted uses is presently mostly confined to the older generation rather than with the youth. Hence, the continuity of this knowledge seems to be the only means to save the tribe from vanishing. Therefore, PWS represents an enormous resource of plant species having significant values for the tribal people living in the vicinity of the sanctuary.

**Table 7.31. Plants of other assorted traditional /ethnic use**

PLANTS	LOCAL NAME	ETHNIC USES
<i>Dioscorea hamiltonii</i>	<i>Pumbuk</i> (L) <i>Ban Tarul</i> (N)	Tuberous root traditionally used during Namsung Tendong Lho roomfaat or Maghay sankranti festival
<i>Arundinaria spp.</i>	<i>Prong</i> (L)	The matured stem is good for walking stick.
<i>Mahonia napaulensis</i>	<i>Keshari</i> (N)	Handle of Banpok, Sickles & khukuri are made from it.
<i>Polygala arillata</i>	<i>Guliyo jara</i> (N)	Mungmik, Pho, or Marcha a starter culture is being prepared from it for the fermentation of local brewed millet.

<i>Rubia manjith</i>	<i>Vyem</i> (L), <i>Majito</i> (N)	Yellowish red dye can be extracted from the matured fruits, which is being, used as traditional dyes.
<i>Stephania glandulifera</i>	<i>Tamarkay</i> (N)	The Root-bulb is used as a drinking pot for poultry to prevent from various diseases.
<i>Plagiogyra euphleba</i>	<i>Tungtok</i> (L)	The leaves & the spores are eaten by blood pheasant
<i>Amomum subulatum</i>	<i>Alaichi</i>	Natural dye
<i>Rheum nobile</i>	<i>Chutchu</i>	Natural dye
<i>Rumex nepalensis</i>	<i>Halhaley</i>	Natural dye
<i>Calamas erectus</i>	<i>Bet</i>	Stem used in walking stick, young shoot eaten, string derived making cane and bamboo artifacts.

## 7.7. IMPORTANCE OF THE FLORA

The flora of PWS is huge diverse and includes large proportion of economically significant plants. Those may be either timber-yielding trees or plants of medicinal or ornamental or food or fodder or of ethnic values. However, the people residing in the vicinity of the PWS have been sustainably using those plants prior to the declaration of the sanctuary.

The rich vegetation and its immensely rich taxa of diverse plant groups also has enormous scope of scientific research around the world. The flora of PWS holds many of the plant species of endangered, threatened, highly rare or nearing extinction status (e.g. *Podophyllum hexandrum*, *Rheum nobile*, *Aristolochia griffithii*, *Panax pseudoginseng* etc.) Where as, it thrive well in part of the nation and that deserves for conservation, the importance of Flora of PWS is also because of its significant representation of many endemic orchids (Lucksom 2007). However, the diverse vegetation and natural beauty of the sanctuary has attracted a huge or innumerable tourists from across the nation/world.

A large number of economically important plants of both the indigenous and exotic origin exist in the sanctuary reveals about the significance of the flora of PWS. The checklist of the angiospermic flora of the sanctuary prepared through present floristic work will be useful for policy makers, administrators, and planners to frame proper strategies for their future exploitation and/or conservation related actions of Pangolakha Wildlife Sanctuary. The enumeration of various economically important plant species will further simplify the process for sanctuary management. There are also the possibilities of existence of various indispensable plants those could be exploited for formulation of useful medicines, against various diseases, etc.

Significantly, the PWS comprises of uninterrupted vegetation, presence of distinct climatic bands for migration, suitable climatic conditions and diversity in habitat condition might have supported for evolution.

## 7.8 NEW RECORDS OF DISTRIBUTION

Analysis of the recorded flora of Pangolakha Wildlife Sanctuary revealed the record of the occurrence of some plants first time from Sikkim as follows:

***Anaphalis wightiana* (DC.) DC.**

The species is earlier recorded by J.D. Hooker from Nilgiri hills South India, and the present collection is the new distribution record for Sikkim and North East India.

***Senecio wightianus* DC.**

The species is earlier known to be distributed in Himachal Pradesh, Meghalaya, Tamil Nadu, Nepal, Bhutan, Myanmar, China, Thailand, Japan and Phillipines. The present collection is the new distribution record for Sikkim.

***Vicatia conifolia* DC.**

The species is earlier recorded from Afghanistan, Balistan, and Himalaya India (Kashmir)-Nepal and Bhutan. The present collection is the new distribution record for Sikkim.

***Pimpenilla tonglensis* P.K. Mukherjee**

The species is one of the rare plant species of INDIA, and only recorded from (Labha, Rissisum, Tanglu) Darjeeling, West Bengal, INDIA and the present collection is the new distribution record from Sikkim.

***Sinocarum minusum* M.F. Watson**

The species is earlier only known from Eastern Nepal and Eastern Bhutan. The present collection is the new distribution record for Sikkim

***Impatiens bracteata* Colebrook ex Roxburgh**

The species is earlier recorded from Khasia Mts (Assam, INDIA) and believes to be later introduced and naturalized at Mongpo, Darjeeling and the present collection is the new distribution record for Sikkim.

***Dicentra lichiangensis* (D. Don) Walpers**

The species is earlier recorded from Bhutan. The present collection is the new distribution record for Sikkim.

## **7.9. REDISCOVERY OF PLANTS [AFTER 100 YEARS]**

Quite a few species of plants have been reported in the flora those were known to us from their very old collections are recollected during the present survey in Pangolakha Wildlife Sanctuary. These include the following plant species.

***Lactuca cooperi* Anthony**

The species is an endemic taxon which is collected after the lapse of 100 years, which is equivalent to its rediscovery.

***Primula kingii* Watt**

Earlier, the species was collected by from Nathang by J.D. Hooker in the year 1882. As such, the present collection of this species is more than 100 years after its previous collection from the same region, which is equivalent to its rediscovery.

***Sausurea biligulatus* W.W. Smith**

The species was reported from alpine – subalpine region of east Sikkim by W.W. Smith in the year 1913 and the present collection is collected after laps of 100 years from the same region.

Though recorded recently, but the population of none of these plants is satisfactory. In other words, these are mostly chance collection and never seen again. It appears that all these three species are on the verge of extinction.

## **7.10. THREATS TO THE FLORA AND CONSERVATION MEASURES**

Pangolakha Wildlife Sanctuary holds a significant status for floristic diversity of Eastern Himalaya. However, there is a partial indication of the depletion of vegetation through various means, which deserves immediate attention for ensuring the conservation status of the sanctuary. The following are some of the key factors those control the depletion of forests vegetation.

### **1. Grazing by domestic livestock**

The grazing of cattle is a customary practice for the people residing in the periphery of the sanctuary. However, sometime it does exceed the carrying capacity of the alpine and sub-alpine meadows and forests. At present, the forests department is quite successful to control this practice. The summer and winter are two main seasons for migratory grazing in this

area. In summer the cattle move gradually in high elevation zones camp by camp spending 20 - 45 days in till they reach the alpine pastures in case of yak and sheep. But cows remain fairly below yak and sheep camps within the altitudinal range of 227 m – 3500 m. The summer migration starts from the month of April and reaches alpine pastureland in the middle of June and remains there upto the first week of October.

The movements of cattle normally depend on the extent of availability of grasses. However, availability of fodders is usually influenced by various abiotic factors, such as snow, frost, hailstorm and rain. Occasionally, the summer migrations are delayed due to prolonged snowfall in the upper reaches of the rangeland. The downward migration is also depending on early snowfall or hailstorm. Therefore, the shifting of livestock camps is normally controlled by the prevailing weather conditions in the area. The population of livestock in the sanctuary area is mainly consisting of yak, sheep, goat, pony and cows. The cattle comprised of 55 %, yak 30 % and rest 15 % of the total population of domestic livestock (Anonymous 2000)

However, some local herders believe that the pellet of sheep and goat content high degree of nutrients which enriches the productivity of the rangeland. The majority of local villagers residing in vicinity of the sanctuary own the livestock, and the awareness generation amongst the local herders is essential for the better management of the sanctuary. After eight years of official declaration of the sanctuary, the concerned officials of Forest department, Government of Sikkim also now realized for much improvement that has been taken place in the sanctuary.

## **2. Defense Activities**

The part of the PWS falls under international border area to TAR and Bhutan, therefore, numerous prolong defense activities including establishment and shifting of camps, extension of bunkers, maintenance of line of control and other allied activities are taking place time to time inside the sanctuary area. The northern part of the sanctuary falls under the alpine zone, bordering to TAR region, it is manned by the National Army who occupy the area in short shifts of about six months to a year. Any biodiversity sensitization program is hence short-lived. Most camps are around or near water bodies with resultant pollution, especially of non-biodegradable garbage and spread of stray dogs around these settlements. In addition to preying on wildlife such as *Brahminy Shelduck Tadorna ferruginea*, there have been reports of human casualties due to these dogs (Lachungpa *et al.* 2003). Such scientifically unorganized activities have been resulted recognizable negative impact on the

vegetation and flora of the sanctuary in the long run. Slaughtering of trees, rhododendron scrubs, and absolute clearance of forests for aforementioned reasons must be having some negative impact on the climate change and global warming.

### **3. Bamboo Breaks**

The vegetation composition of the lower belt of the PWS is remarkably rich in species diversity; however, the rapid and dominating expansion of bamboo breaks inside the sanctuary has become a menace to other species. The *Yushania maling* is the most dominating and its population is quickly proliferating in the recent years. The other bamboos steadily emerging for the expansion are *Himalayacalamus falconeri*, *H. hookeriana*, etc. The expansion of population these bamboos not only inhibits the growth of all types of smaller plants but also became threat to the taller plants including trees.

### **4. Hunters:**

The poaching and the hunting is a quite common activities in the vicinity of the PWS. The tribal people residing nearby the sanctuary have been practicing it since time immemorial. Due to inaccessibility, many pockets of the PWS remain out of reach of the forest security personnel or forest officials and such areas are prone to such activities. This illegal poaching and hunting activities forced several species of animals driven out of the sanctuary. Many animal species are assumed to become extinct, due to such undesirable activities.

### **5. Impact of Tourism and Related Activities**

The adjoining part of the PWS viz. Nathula, Nathang, Jalepla, Kupup, Rachela including Changu Lake are now among the places for established tourist hub. As such, the increase in movement of tourists towards this pocket could certainly have negative impact on the ecology of its surroundings in the long run. The impact on vegetation are equally being felt through the camping by hunters, travelers, authorized or unauthorized tourists, which ultimately enforce the inevitable threats to the biodiversity of the sanctuary.

### **6. Illegal Collection of NTFP**

The practice of illegal collection of Non-Timber Forest Produces (NTFP) including medicinal plants, orchids, and uprooting of valuable tree sapling from the forest are often being done in the area prior to the declaration of the area as protected. Some of the high altitude medicinal plants of Sikkim including *Aconitum ferox* (Bikh) and *Picrorhiza scrophulariiflora* (Kurki) were in high demand and were collected during 1970s to 1990s in truckloads with dried tubers of these species fetching USD 0.330 per kg and dried stems of *Kurki* fetching USD 0.44 per kg (Tambey & Rawat 2007). The state government banned the commercial collection of medicinal plants for ten years since 2001 onwards. Aromatic

plants like *Juniperus recurva* (Sikpa) and were in high demand for incense making and large scale commercial collection was done by the yak and dzo herders between 1970s and 1990s. The collection of cane and bamboo shoots, Rhododendrons, ferns etc. and selling those in local markets are common. Such activities is still prevailing in the vicinity of the sanctuary, which may ultimately lead to the gradual depletion of valuable plant resources of the PWS.

### **7. Climate Change & its Impact on Flora**

Himalayan glaciers have been in a state of general retreat since 1850 and the rate of retreat is accelerating. Jangpang & Vohra (1962), Kurien & Munshi (1972), Srikanta & Pandit (1972), Vohra (1981), and many others have made significant studies on the glacier snout fluctuations of the Himalayan glaciers.

Such retreats among glaciers are directly or indirectly responsible for climate change. The impact of change in the climate is also being observed in the distribution of many plants. According to the recent reports the plants are the most affected living being in the planet (Anonymous 2001).

The present study though confined with the exploration of floristic elements, but, this has been observed that many species once reported to be commonly occurring in the sub-alpine to alpine region are now sparsely distributed. W.W. Smith in 1913, reported 26 species of *Primula* occurring in the region. However, now it is after 100 years, only 10 species has been recorded from nearby the area. The reason for such, scattered distribution and becoming rare among species population is not known. Therefore, a separate extensive survey and study on such indispensable issue must be carried out very carefully for the conservation of such species.

### **7.11. CONSERVATION STATUS**

Pangolakha Wildlife Sanctuary holds a significant status for floristic diversity and its conservation in this part of the world. It is one Protected Area (PA) and its importance will increase manifold when one think of the matter along with its strategic location within the IUCN recognized '*Himalaya Conservation Hotspot*' (IUCN 2010). We know, this is one of the worst affected Hotspots and the area of natural habitat is rapidly decreasing there. PWS is one PA which is extending over wide temperature gradient and housing subtropical as well as alpine elements. Its location is well inside the Himalayan ranges and the degradation is still under control. However, there is a partial indication of the depletion of vegetation through various means, which deserves immediate attention for ensuring the conservation status of the sanctuary. The following are some of the key factors that control the depletion of forests vegetation.

### 7.11.1. Unsustainable NTFP extraction

Open borders encourage unregulated commercial trade for medicinal plants, plants of horticultural value; demand from large and increasing population; a form of livelihood for poor.

A. PWS is a home of numerous potential medicinal herbs and NTFPs. The collection of the medicinal plants and their illegal transborder trafficking through networking was once very common. However, such activities were not apparent visible during the survey. The common people residing nearby the sanctuary reveals that the practice is now much reduced after the declaration of the Sanctuary. Some notable medicinal plants extensively collected for such purposes are *Aconitum heterophyllum*, *Aconitum spicatum*, *Berginia ciliata*, *Rheum acuminatum*, *Lycopodium clavatum*, *Swertia chirayita*, *Rubia manjith*, *Heracleum nepalenses*, *Dioscorea spp*s etc. It is therefore, those potential species deserves utmost preservation.

B. Often being aromatic, the twigs and leaves of *Rhododendron anthopogon* and *Juniperus* sp. are traditionally burn as incense in Sikkim, Bhutan and parts of West Bengal. The mixed dried twigs of these species are sold in Rs 10- 20/ Pkt. at local market of Gangtok, Mangan, Gyalzing, Namchi etc. Many tourists from places like Gangtok, Kolkata, Siliguri, Gangtok frequently visits sanctuary for trekking and as pleasure tourists. As such, uprooting of small plants including orchids and taking those to their native places without the information of sanctuary's authority is often observed. Such, undesirable activities will certainly have negative impact on the sanctuary in long run, which needs to be tackle very carefully.

### 7.11.2. Tree-felling:

One of the important threats identified for the forests of PWS is illegal tree-felling activities for timber and planks. Prior to the declaration of the sanctuary, the practice of illegal felling of rare trees for timber in the area such as *Alcimendra cathartii*, *Tsuga dumosa*, *Magnolia campbellii*, is quite usual. However, such activities are much reduced at present. It is also being observed that the population of many other trees is also noted for potential in timber yielding, such as *Castanopsis tribuloides*, *Betula alnoides*, *Prunus dumosa*, etc are now very scattered in their distribution.

### 7.11.3. Fishing practices:

The practice of illegal and legal fishing is taking place as a regular phenomenon of the people living near the PWS. Several methods of fishing practices are being adopted by them. Hence, it is being reported that various fish poisoning items including gelatin candles (*Blasten*) has been

used for killing fishes. The other common method such as closing of Duwali (diversion of water flows), Bamboo made net (*Knu Tuksyor*) are also being adopted during fishing practice inside the PWS. Hence, such uncontrolled fishing activities may also tend to have an adverse impact on vegetation.

#### **7.11.4. Poaching:**

Poaching is one of most common leisure of the people residing nearby the PWS. The local people residing nearby the sanctuary's boarder at Premlakha, Subaney Dara, and Talkharkha are actually associated for such practice since long. Occasionally some hunters from the adjoining areas such as Bhutan, West Bengal (Terai and Duars region) also visit the area. These hunters are entering through numerous illegal passes those exist in the North Eastern and South Eastern borders of PWS. However, such activities are now seemingly reduced to large extent.

#### **7.11.5. Collection of ornamental Plants**

The PWS being bestowed with beautiful orchids, other flowering plants of ornamental values, the local people from Renock, Rongli, Aritaar and also from other adjoining areas are sometime engross in collections of these plants for their domestic or local use. However, there are some

#### **7.11.6. Fuel-wood collection**

Lack of alternative energy sources for cooking and heating forcing the local people to fell trees illegally that imposes tremendous pressure on plant population in the forests. Despites of imposing ban on fire-wood collection by the Government Forest Department, numerous trees are cut down and transported to the nearby areas, and exported through the open borders with Bhutan

#### **7.11.7. Overgrazing by domestic livestock**

The grazing of cattle is customary with the people residing in the periphery of PWS. However, sometimes it does exceed the carrying capacity of the alpine and subalpine meadows and forests. However, in the present juncture, the forests department is successful enough to control such practices.

#### **7.11.8. Customs, tradition, and subsistence**

The tribal people residing near the PWS are dependant on food and medicine for local consumption. These tribal communities consume the leaves, young twigs, buds etc. of trees as vegetable. As such, some of the rare plants are also being collected and sold in the market. Being unaware of the global status of populations, sometime such activities imposed threats to the population structure of some rare species of PWS.

#### **7.11.9. Forest and Grassland Fires**

Quite often, specially during the dry season, fires set by herders and hunters to facilitate grazing and hunting cause great loss to the vegetation and biodiversity of the sanctuary. This is mainly due to the lack of awareness of consequences of the concerned people. Poor forest and fire management facilities available in the area are causing damages far beyond the expectation.

#### **7.11.10. Lack of Information and Awareness**

People do not know about the endangered species as the scientific knowledge and the conservation have remained exclusively with the scientist and forest officials (Anonymous 2007). The comprehensive and intensive scientific exploration in regards to the species diversity of the sanctuary also is *hitherto* not been taken up officially by the government of Sikkim in the past. Due to which, the actual and detailed information about this sanctuary is unavailable. As such, the data management and sharing, in regards to the sanctuary is not been possible up till now. Field workers have been less exposed to modern techniques and technologies in term of forest related activities (Lama 2001). In addition, the capacity building of the concerned departmental personal is essential for the adoption of suitable conservation methodology.

#### **7.11.11. Military operations**

Beside this, the frequent flow of tourists, military exercise in the TAR and Bhutan border, extension of infrastructures for international trade route, monoculture plantation practiced by the Forest Department, massive invasion of bamboo against other species, undesirable and unecofriendly human activities inside the sanctuary, needs to be looked after closely and seriously and given priority for the development of proper strategies of conservation and management of PWS.

### **7.12 PROPOSED METHODS OF CONSERVATION**

By many measures of biodiversity, the Eastern Himalayan region stands out as being globally important. It has been included in the 13 biodiversity hotspots on Earth (Myers *et al.* 2000) when the first set of Hotspots were declared and is also categorized as several Global 200 ecoregions (Olson & Dinerstein 1998), two Endemic Bird Areas (Stattersfield *et al.* 1998), and several centers for plant diversity (IUCN 1995). An understanding of why the Eastern Himalaya is so exceptionally rich in biodiversity requires a brief overview and analysis of its geological history and ensuing biogeographic patterns.

Protected areas are, and have been, the cornerstones of biodiversity conservation. South Asia has a long history of biodiversity conservation in protected areas, dating back to several centuries. For instance, sanctuaries for wildlife conservation were established in India over two thousand years ago by Royal Decree (Singh 1986). In the northeastern region of India, many

tribal groups have traditionally recognized and protected sacred groves, which have been effective refuges for biodiversity for millennia (Gadgil 1985).

A notable feature of the protected areas systems of Bhutan, Nepal, and northeastern India is that those are located adjacent to each other across the national borders, and provide opportunities for transboundary conservation. Adjacent to the Pangolakha Wildlife Sanctuary, the Kanchandzonga National Park in Sikkim and Kangchenjunga Conservation Area in eastern Nepal, and Manas National Park in Bhutan and Manas Tiger Reserve in Assam are two such complexes.

However, the world's highest mountain range has not been spared from the threats to biodiversity loss that pervade this planet. Historically, the human population densities in the region were relatively low, suppressed by disease, low productivity of the land, and inaccessibility. Since development and access is still variable across the region, the severity of threats and consequent rates of biodiversity loss is variable, which has to be considered when assessing conservation opportunities and actions.

Significantly, the Govt. of India has recently taken up some serious measures for the conservation of biodiversity by declaring many biodiversity rich areas as Protected or Reserve Areas for the *in situ* conservation. As such, the proper management of these Reserve Areas with effective monitoring and strong enforcement of laws should be made in order to achieve the target. Considering this fact, Govt of Sikkim has declared some (1) National Parks, (1) Biosphere Reserve and (6) Wildlife Sanctuaries. Apart from that, many small pockets of forests nearby monasteries, herbal garden of Bongthing in a village have been a part of traditional conservation of forest in Sikkim.

However, the People do not know about the endangered species as the scientific knowledge and the conservation have remained exclusively with the scientists and forest officials (Anonymous 2007).

Considering the above facts, few proposals, or recommendations in regard to the management and conservation strategies of the PWS is mentioned below:

1. The PWS authority should enforce the existing wildlife regulation and conservation laws very strictly
2. The visitors, researcher, trekkers should be properly guided by the sanctuary management committee. Rule and regulation in regards to sanctuary must be clearly conveyed to them prior to entering the sanctuary
3. The a part of Prem-lakha and few other villages are falling under the sanctuary's jurisdiction, therefore the encroachment and settlement of people in this village and its

periphery and fringe areas of the Sanctuary must be discouraged and the existing settlements are to be shifted to other feasible areas.

4. A part of PWS being falls under international border areas. Therefore, frequent military operations or training programs are taking place inside the sanctuary area.
5. Unauthorized persons should be strictly prohibited from entering into the sanctuary.
6. Felling of trees for any purpose must be discouraged and the logs of dead and/damaged trees should not be removed from the sanctuary area
7. Deployment of more manpower shall have advantages to check over the activities of hunters, poachers and plant collectors within the sanctuary
8. The concerned sanctuary authority should be very strict in regulation of laws in regards to collection of rare ornamental plants like orchids, medicinal plants, and wild edibles.
9. Nathang, Kupup, Padamchen, Rachela, Pangolakha etc. are some of the popular hubs for tourists. Therefore infrastructure extensions for tourism development in these areas have to be carefully planned. The Tours & Travel Association of Sikkim (TAAS) may be involved in such initiatives and also for efficient management of tourism in this ecologically vulnerable corner of the state. Trekking and mountaineering /scientific expedition activities should have to be made completely in eco-friendly manner
10. The invasion of Bamboos (*Sinarundinaria maling*) has been presently become menace to the PWS. The rapid proliferation of this species has inhibited the growth of all other species and may have negative impact on biodiversity in long run. Therefore, the intensive study on the impact on such massive invasion of this species must be taken up for future sustenance
11. There are some rituals being conducted at Rachela and Pangolakha on Magey Sangrati. However, massive gathering inside the sanctuary and spending 1-2 days should either be well manage or should be minimized. As a result, the visitors' often leave behind a pile of litters including plastics, bottles and other wastes which is unpleasant and derogative for the surrounding environment
12. **Creation of Interpretation Centre:** The defense personnel stationed at the border area of PWS need to be properly imparted the awareness on environment, and biodiversity of the area. As such, a Wildlife Interpretation Center can be established at the entry point of the area with proper facilities for dissemination of information on generation of awareness to the jawans entering the border. Further, the development of eco-friendly infrastructure to provide regular program to the jawans as well as other categories of

defense personnel, concern sanctuary authority and local inhabitants of Phandamchem, Nathag, Kupup and Rigu south, Rigu North, Rongli etc.

13. The detail survey of for mapping of quantitative analysis of bioresource of the sanctuary will also have to be taken up for faunal species and for lower groups of plants e.g. bryophytes, fungi, microbes etc, in regard to their distribution patterns, population size, physiological tolerance, breeding system, reproduction, food-web, ecological needs, pollination and/or dispersal systems, germination, phenology, competition, etc. Further, a comprehensive and extensive study of lower groups of plants to have complete knowledge and understanding of these groups shall have to be done for the improvement of better conservation strategies of the PWS.
14. Buffer zone of Indian boarder to the TAR region and Bhutan including the PWS can be jointly propose for the declaration of transboundary international park for further conservation of bioresources, considering this fact, a high level committee for conservation of genepool of the buffer zone of border area a joint approach can be taken up among three nations. This step will ensure long term sustainability of natural resources not only in parts of Indian Territory (Sikkim) but also build a chain of protected areas for biological resources in the adjoining countries.
15. The inventory cum pilot study of carrying capacity of the grassland of alpine east Sikkim is rationally essential. The alpine and sub-alpine grasslands including alpine east Sikkim covers about 14 % of the total land area of Sikkim. There are unspecified numbers of upland cattle and goats about 11000 sheep and over 5300 yaks are directly or indirectly depended on this vegetation. Having being the poor quality of land, the alpine and sub-alpine grassland of alpine east Sikkim sustains the low grazing and low deterioration intensity as compared to the *Goucharan land* (rangeland). The majority of tree covers are now found stripped. The most important measures for improving the deteriorating grassland are to prepare an inventory of grasses for the entire alpine and sub-alpine.

Further, PWS is a home of many rare and endemic orchids of Sikkim. It is also a centre of diversity of many potential plants in regards to food, medicine, house constructions etc. However, the present study also reveal that some of the species once very common in the hills of Sikkim as noted by famous botanists like D. Don (1825), Sir George King (1898), Gammie (1894), Smith & Cave (1911), W.W. Smith (1913), Mizushima (1967), H. Ohashi (1975), including Sir J.D. Hooker (1906) are now gradually becoming rare and endangered. Therefore, the Pangolakha wildlife sanctuary authourity and PWS management committee should consider the aforementioned facts with proper priority for sustainable conservation of Biodiversity.