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Rhododendrons in Indian Himalayan Region: Diversity and Conservation

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ABSTRACT

The genus Rhododendron of Indian Himalayan Region (IHR) has been enumerated in the present paper. A total of 87 *species,* 12 *subspecies and 8 varieties of Rhododendrons recorded in IHR, among these* 6 *species and one subspecies are reported from Western Himalaya. The maximum concentration of 86% observed in Arunachal Pradesh* (75 *species*). *The species of Rhododendrons exhibit significant diversity in habit and broad range of distribution from the altitude of* 800-6000 *m. and the best range is observed in* 3001-3500 *m altitudes. In analysis revealed* 20 *taxa are endemic,* 30 *are rare,* 24 *are threatened / endangered,* 3 *are vulnerable and* 47 *taxa have to be assessed. The major threats to rhododendrons are deforestation and unsustainable extraction for firewood and incense by local people has been discussed.*

Keywords*: *Rhododendrons, Indian Himalayan Region, Ericaceae, India

1. Introduction

The genus *Rhododendron,* family Ericaceae, was founded by Linnaeus [1]. The word *Rhododendron* is derived from two Greek words *rhodon* (rose) and *dendron* (tree) meaning rose tree. The genus with attractive and beautyful flowers is represented by 850 species in the world [2]. They are mostly distributed at higher elevations in the Sino-Himalayan region with maximum concentration in Western China [3]. In India, the species are mostly confined to the Himalayan region, particularly in Eastern Himalaya. A revision of the genus was carried out by Cullen [4], Chamberlain [5], Philipson and Philipson [6], Chamberlain and Rae [7], Kron [8] and, Judd and Kron [9]. Preliminary enumerations and inventories of the genus were made by Pradhan [3,10], Ghosh and Samaddar [11], Bhattacharyya and Sanjappa [12]. Sastry and Hajra [13] and Mao *et al.* [14] were made the contribution on rare and endemic Rhododendrons of India. The Rhododendrons of Sikkim-Himalaya region were done by Pradhan and Lachungpa [15] and Singh *et al.* [16]. The importance of Rhododendrons in Meghalaya dealt by Yumnam [17].

The Indian Himalayan Region (IHR) occupies a special place in the mountain ecosystems of the world. The IHR is one of the most fragile mountain regions of the world and holds an enormous repository of biological diversity which is increasingly under pressure from human activities. The region comprises a rich variety of flora, fauna, human communities and culture. Of the estimated 8,000 species of vascular plants in the Himalayan region, around 3,160 are endemic and 450 species are endangered [18,19]. The indiscriminate exploitation, destruction of habitats, spread of harmful chemicals and introduction of alien species, a number of plants have been disappeared while others await a smilar fate [20]. As a result, gap between demand and supply is widening. In this regards, global efforts are being made to conserve the phytodiversity especially rare, endangered and threatened species, which are known to be important component of biodiversity.

Due to human interference the natural populations of rhododendrons in the entire Himalaya are gradually diminishing. The major threats to rhododendrons are deforestation and unsustainable extraction for firewood and incense by local people. A set of rhododendrons which are classified as rare/endangered may be wiped out from the biota in the near future if proper conservation measures are not made. So, the present task of diversity and conservation status of Rhododendrons of Indian Himalayan Region has made.

2. Methodology

The present work on Rhododendrons of Indian Himalaya

is based on extensive literature surveys made in different states of Indian Himalayan Region (IHR). For the threat categories, we have consulted different published scientific papers, monographs, red-list documents, IUCN list, etc. All the taxa have been listed alphabetically with altitude, distribution in Indian Himalayan States and other region, and revealed threat categories. For enumeration of species, the IHR is divided into two botanical regions, namely the Western Himlaya and the Eastern Himalaya. The Western Himalaya region is the states of Jammu & Kashmir, Himachal Pradesh and Uttaranchal. Similarly, the Eastern Himalayan region includes the seven sisters states of North-Eastern India (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura), Sikkim and Darjeeling district of West Bengal. The species of Rhododendrons are calculated and enumerated in state wise representation of Western and Eastern Himalaya.

3. Results

A total of 87 species, 12 subspecies and 8 varieties of Rhododendrons recorded in IHR (**Table 1**). The Western Himalaya has 6 species, namely *Rhododendron anthopogon* (Plate 1a), *R. arboreum* (Plate 1b), *R. barbatum*, *R. campanulatum* (Plate 1c), *R. lepidotum* and *R. nivale*; while Eastern Himalaya is represented by all enumerated species. The maximum concentration of species is observed in Arunachal Pradesh (86%). Out of 87 species known from IHR, 75 species occur in the state of Arunachal Pradesh alone. The state wise distribution of species is showed in **Figure 1**. The distribution of species in relation to altitude is shown in **Figure 2**. The maximum numbers of Rhododenrons are present in the 3001-3500 m altitudes, lowest in 500-1000 m and above 5000 m, and absent in less than 500 m (**Figure 2**). A single species namely *R. arboreum* Sm. is only found in less then 1000 m altitude (from 800 m onwards) and found in almost all the states of IHR except Assam and Tripura. *R. nivale* Hook. f. is a single species found in above 5000m altitude and found in the state of Sikkim and Uttarakhand. The taxa endemic to Arunachal Pradesh are *R. arboreum* Sm. subsp. *delavayi* (Franch.) D. F. Chamb., *R. chamaethomsonii* (Tagg) Cowan & Davidian, *R. concin- noides* Hutch. & Kingdon-Ward, *R.. falconeri* Hook. f. subsp. *eximium* (Nattau) D. F. Chamb., *R. imberbe* Hutch., *R. nayarii* G.D. Pal, *R. santapaui* Sastry, Kataki, P. Cox, Patricia Cox & P. Hutch. and *R. subansiriense* D. F. Chamb. & Cox. The taxa namely *R. candelabrum* Hook. f. and *R. sikkimense* U. C. Pradhan & S. T. Lachungpa are endemic to Sikkim. *R. formosum* Kingdon-Ward is endemic to the states of Arunachal Pradesh and Meghalaya. A variety, *R. triflorum* Hook var. *bauhiniiflorum* (Watt *ex* Hutch.) J. Cullen is endemic to Manipur and categorized as Rare in distribution. *R. decipiens* Lacait. is endemic to Sikkim and West Bengal hills. A variety namely, *R. formosum* Wall. var. *inaequale* (Hutch.) J. Cullen is endemic to Meghalaya, Mizoram and Nagaland. The species *R. johnstoneanum* Watt *ex* Hutch. is endemic and endangered in Arunachal Pradesh, Manipur and Mizoram. *R. macabeanum* Watt *ex* Balf. f. is endemic and found in rare in Manipur and Nagaland.

Table 1. Rhododendrons of Indian Himalayan Region.

S. No.	NAME OF THE TAXA	ALTITUDE (IN METRE)	DISTRIBUTION		STATUS
			India	Other region	
1	*R. anthopogon* D. Don	3350-5000	AP, HP, SK, WB	Bhutan, China, Nepal, Tibet	NE
2	*R. anthopogon* D. Don subsp. *hypenanthum* (Balf. f.) J. Cullen	3350-5000	AP, HP, JK, SK, UK	Bhutan, Nepal	NE
3	*R. arboreum* Sm.	800-3000	AP, HP, JK, UK, MN, MG, MZ, NG, SK, WB	Bhutan, Myanmar, Nepal, Sri Lanka, Pakistan, Tibet	NE
4	*R. arboreum* Sm. subsp. *Cinnamomeum* (Wall. *ex* G. Don) Tagg	c. 2500	SK, WB	Nepal	NE
5	*R. arboreum* Sm. var. *roseum* Lindl.	2500-3600	SK, WB	Bhutan, China, Myanmar	NE
6	*R. arboreum* Sm. subsp. *delavayi* (Franch.) D. F. Chamb.	2500-3200	AP, MN, MG	China, Myanmar, Thailand	NE
7	*R. arboreum* var. *peramoenum* (Balf. f. & Forrest) D.F. Chamb.	3000-3200	AP	-	EN[1]
8	*R. assamicum* Kingdon-Ward	c. 3000	AP	-	EN[1]
9	*R. baileyi* Balf. f.	3000-4000	SK	Bhutan, Tibet	RA[1]
10	*R. barbatum* G. Don	2500-3700	AP, SK, UK, WB	Bhutan, China, Nepal	NE
11	*R. beanianum* Cowan	3000-3350	AP	Myanmar	RA[1]
12	*R. boothii* Nutt.	1800-2500	AP	Bhutan, China	TN[1]
13	*R. bulu* Hutch.	3000-3800	AP	China, Tibet	TN[1]
14	*R. calostrotum* Balf. f. & King-don-Ward subsp. *riparium* (King-don-Ward) J. Cullen	3000-4500	AP	China, Myanmar	RA[1]

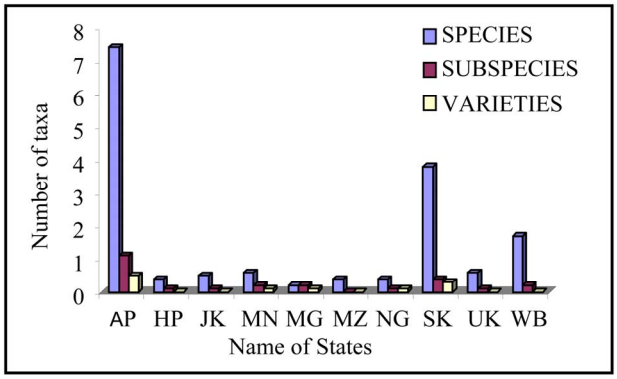
Continued Table 1

15	*R. camelliaeflorum* Hook. f.	2700-4000	AP, SK	China, Nepal, Tibet	NE
16	*R. campanulatum* D. Don	2500-4300	AP, HP, JK, SK, UK, WB	Bhutan, Nepal	NE
17	*R. campanulatum* D. Don subsp. aeruginosum (Hook. f.) D. F. Chamb.	4500-5000	SK	Bhutan, Nepal	NE
18	*R. campanulatum* D. Don var. *wallichii* Hook. f.	4000	AP, SK	Bhutan, Nepal	NE
19	*R. campylocarpum* Hook. f.	3300-4300	AP, SK	Bhutan, Myanmar, Nepal, Tibet	RA[1]
20	*R. campylogynum* Franch.	2700-4300	AP	China, Myanmar	NE
21	*R. candelabrum* Hook. f.	3600-4300	SK	-	EN[1]
22	*R. cephalanthum* Franch.	3000-4500	AP	China, Myanmar	RA[1]
23	*R. cerasinum* Tagg	3000-3200	AP	China, Myanmar, Tibet	NE
24	*R. chamaethomsonii* (Tagg) Cowan & Davidian	3600-5000	AP	-	EN[1]
25	*R. ciliatum* Hook. f.	2700-3400	SK	Bhutan, China, Nepal	NE
26	*R. cinnabarinum* Hook. f.	3000-4000	AP	Bhutan, China, Nepal, Tibet	NE
27	*R. cinnabarinum* Hook. f. subsp. *xanthocodon* (Hutch.) J. Cullen	3000-4000	AP	Bhutan, China	TN[1]
28	*R. concinnoides* Hutch. & Kingdon-Ward	2400-3400	AP	-	EN[1], TN[1]
29	*R. coxianum* Davidian	c. 1800	AP	-	EN[1]
30	*R. crinigerum* Franch.	3100-4000	AP	China, Myanmar	NE
31	*R. dalhousiae* Hook. f.	1800-2300	AP, SK, WB	Bhutan, Nepal	NE
32	*R. dalhousiae* Hook. f. var. *rhabdotum* (Balf. f. & Cooper) J. Cullen	c. 2500	AP	Bhutan, China	RA[1], VU[3]
33	*R. decipiens* Lacait.	2500-3000	SK, WB	-	EN[1]
34	*R. dendricola* Hutch.	1200-1400	AP	China, Myanmar	RA[1]
35	*R. edgeworthii* Hook. f.	2100-3300	AP, SK	Bhutan, China, Myanmar	RA[1]
36	*R. elliottii* Watt	2700-3000	MN, NG	-	EN[1], ED[1]
37	*R. eudoxum* Balf. f. & Forrest	3300-4000	AP	China, Tibet	NE
38	*R. eudoxum* Balf. f. & Forrest subsp. *tamenium* (Balf. f. & Forrest) Tagg	3300-4000	AP	Bhutan, China	NE
39	*R. exasperatum* Tagg	3000-4000	AP	China, Myanmar	RA[1]
40	*R. falconeri* Hook. f.	2100-4000	AP, SK, WB	Bhutan, Nepal	NE
41	*R. falconeri* Hook. f. subsp. *eximium* (Nattau) D. F. Chamb.	3000-3500	AP	-	EN[1], ED[1]
42	*R. formosum* Kingdon-Ward	1500-2000	MG	-	EN[1], TN[1]
43	*R. formosum* Wall. var. *inaequale* (Hutch.) J. Cullen	1500-2000	MG, MZ, NG	-	EN[1], TN[1]
44	*R. fulgens* Hook. f.	3000-4300	AP, SK, WB	Bhutan, China, Nepal, Tibet	RA[2]
45	*R. fulvum* Balf. f. & W. W. Smith	2460-3385	AP	China, Myanmar, Tibet	NE
46	*R. glaucophyllum* Rehder	3080-3700	SK	Bhutan, Nepal, Tibet	NE
47	*R. glaucophyllum* Rehder var. *tubiforme* Cowan & Davidian	3100	AP	Bhutan, China, Myanmar	NE
48	*R. grande* Wight	2160-3385	AP, SK, WB	Bhutan, China, Napel, Tibet	NE
49	*R. griffithianum* Wight	2160-2770	AP, SK, WB	Bhutan, Napal, Tibet	NE
50	*R. hodgsonii* Hook. f.	3080-3690	AP, SK,WB	Bhutan, Napal, Tibet	NE
51	*R. hookeri* Nutt.	2500-3700	AP	Bhutan	RA[1]
52	*R. imberbe* Hutch.	2770	AP	-	EN[1]
53	*R. johnstoneanum* Watt *ex* Hutch.	1160-3000	AP, MN, MZ	-	EN[1], ED[1]
54	*R. kasoense* Hutch. & Kingdon-Ward	2500-2700	AP	China	RA[1]
55	*R. kendrickii* Nutt.	2300-2800	AP	Phutan, China	RA[1]
56	*R. keysii* Nutt.	2440-3650	AP, SK	Bhutan, China, Tibet	RA[1]
57	*R. lanatum* Hook. f.	3080-4000	AP, SK	Bhutan, China, Tibet	NE
58	*R. lanigerum* Tagg	3080-3385	AP	China, Tibet	NE
59	*R. lepidotum* Wall. *ex* D. Don	2160-4620	AP, JK, HP, SK,UK	Bhutan, China, Myanmar, Napal, Pakistan	NE
60	*R. leptocarpum* Nutt.	2300-4310	AP, SK	Bhutan, China, Myanmar, Tybet	ED[2]
61	*R. lindleyi* T. Moore	1850-3080	AP, MN, SK,WB	Bhutan, China, Myanmar, Napal, Tibet	NE
62	*R. macabeanum* Watt *ex* Balf. f.	2500-3000	MN, NG	-	EN[1], RA[1]
63	*R. maddenii* Hook. f. subsp. *crassum* (Franch.) J. Cullen	2250-3000	MN, MG, NG	Bhutan, China, Myanmar, Vietnam	RA[1]

Continued Table 1

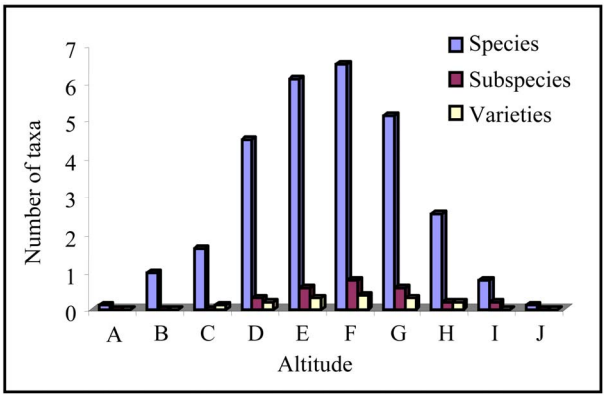
64	*R. maddenii* Hook. f.	2400-3650	AP, SK	Bhutan, China	RA[1], ED[2]
65	*R. megacalyx* Balf. f. & Kingdon-Ward	2160-2770	AP	China, Myanmar	RA[1]
66	*R. megeratum* Balf. f. & Forrest	3050-4150	AP	China, Myanmar, Tibet	RA[1]
67	*R. mekongense* Franch. var. *rubrolineatum* (Balf. f. & Forr.) J. Cullen	3350-4250	AP	China	RA[1]
68	*R. nayarii* G.D. Pal	2500-3000	AP	-	NE
69	*R. neriiflorum* Franch. subsp. *phaedropum* (Balf. f. & Farrer) Tagg	3000	AP	Bhutan, China, Myanmar	TN[1]
70	*R. nivale* Hook. f.	4000-6000	SK, UK	Butan, China, Nepal	NE
71	*R. niveum* Hook. f.	3080-3700	AP, SK	Bhutan	ED[2]
72	*R. nuttallii* Booth *ex* Nutt.	1200-3650	AP	Bhutan, China, Myanmar	RA[1]
73	*R. obtusum* Hort. *ex* Wats	1500	AP	Japan, Myanmar	NE
74	*R. papillatum* Balf. f. & Copper	1800-3300	AP, SK	Bhutan, Nepal	RA[1]
75	*R. pemakoense* Kingdon-Ward	2400-3050	AP	China	RA[1]
76	*R. pendulum* Hook. f.	2270-3650	AP, SK	Bhutan, China, Nepal, Tibet	RA[1]
77	*R. pocophorum* Balf. f. *ex* Tagg	3650-4600	AP	China	RA[1]
78	*R. pruniflorum* Hutch. & Kingdon-Ward	3050-3950	AP	Myanmar	RA[1]
79	*R. pumilum* Hook. f.	3500-4500	AP, SK	Bhutan, China, Myanmar, Nepal, Tibet	ED[2]
80	*R. rex* Levl. subsp. Arizelum (Balf. f. & Forr.) D. F. Chamb.	3000-4000	AP	China, Myanmar	RA[1]
81	*R. santapaui* Sastry, Kataki, P. Cox, Patricia Cox & P. Hutch.	2300	AP	-	EN[1], ED[1]
82	*R. setosum* D. Don	2160-4950	AP, SK, WB	Bhutan, China, Nepal, Tibet	NE
83	*R. sidereum* Balf. f.	2770-3080	AP	China, Myanmar	NE
84	*R. sikkimense* U. C. Pradhan & S. T. Lachungpa	3700	SK	-	EN[1]
85	*R. sinogrande* Balf. f.	3080-4310	AP	China, Myanmar, Tibet	NE
86	*R. smithii* Nutt.	2160-3700	AP, SK	Bhutan, China	NE
87	*R. stenaulum* Balf. f. & W. W. Smith	2770	AP	China	NE
88	*R. stewartianum* Diels	3080-4310	AP	China, Myanmar, Tibet	NE
89	*R. subansiriense* D. F. Chamb. & Cox	2600-2800	AP	-	EN[1], ED[1], VU[3]
90	*R. succothii* Davidian	3400-4200	AP	Bhutan	RA[1]
91	*R. taggianum* Hutch.	2160-3390	AP	China, Myanmar	NE
92	*R. tanastylum* Balf. f. & Kingdon-Ward	1850-3350	AP	China, Myanmar	RA[1]
93	*R. tephropeplum* Balf. f. & Farrer	2450-4300	AP	China, Myanmar	RA[1]
94	*R. thomsonii* Hook. f.	3390-4000	AP, NG, SK WB	Bhutan, Napal, Tibet	NE
95	*R. triflorum* Hook. f.	2160-2930	AP, SK, WB	Bhutan, China, Myanmar, Nepal, Tibet	NE
96	*R. triflorum* Hook var. *bauhiniiflorum* (Watt *ex* Hutch.) J. Cullen	2470-3080	MN	-	EN[1], RA[1]
97	*R. tsariense* Cowan	2000-3000	AP	Bhutan, China	NE
98	*R. uvarifolium* Diels	2160-2470	AP	China	NE
99	*R. vaccinioides* Hook. f.	1850-3700	AP, SK, WB	Bhutan, Myanmar, Napal, Tibet	NE
100	*R. virgatum* Hook. f.	2160-2770	AP, SK	Bhutan,China, Myanmar	NE
101	*R. virgatum* Hook. f. subsp. *oleifolium* (Franchet) J. Cullen	2200-3000	AP	China, Tibet	NE
102	*R. veitchianum* Hook.	1230-1700	MZ	Loas, Myanmar, Thailand	RA[1]
103	*R. wallichii* Hook. f.	4000-4500	SK, WB	Bhutan, China, Nepal	NE
104	*R. walongense* Kingdon-Ward	1500-2150	AP	China	RA[1]
105	*R. wattii* Cowan	2700	AP, MN	-	EN[1], ED[1], VU[3]
106	*R. wightii* Hook. f.	3050-4310	AP, SK	Bhutan, China, Myanmar, Nepal, Tibet	RA[2]
107	*R. xanthostephanum* Merrill	1500-3000	AP, SK	China, Myanmar	RA[1]

1 - Mao *et al*., 2002; 2 – Singh *et al.*, 2003; 3 - Anonymous, 2009; AP – Arunachal Pradesh; ED - Endangered; EN – Endemic; HP – Himachal Pradesh; JK-Jammu & Kashmir; MG – Meghalaya; MN – Manipur; MZ- Mizoram; NE – Not Evaluated; NG – Nagaland; RA – Rare; SK – Sikkim; TN-Threatened; UK – Uttarakhand; VU – Vulnerable; WB – West Bengal



Name of the States: AP – Arunachal Pradesh; HP – Himachal Pradesh; JK-Jammu & Kashmir; MG – Meghalaya; MN – Manipur; MZ- Mizoram; NG – Nagaland; SK – Sikkim; UK – Uttarakhand; WB – West Bengal

Figure 1. Distribution of rhododendrons in different states of IHR.



Altitudes (in m) A: 500-1000; B: 1000-1500; C: 1500-2000; D: 2000-2500; E: 2500-3000; F: 3000-3500; G: 3500-4000; H: 4000-4500; I: 4500-5000; J: >5000

Figure 2. Altitudinal diversity of rhododendrons in IHR.

4. Discussion

The species of Rhododendrons exhibit significant diversity in habit and broad range of distribution from the altitude of 800-6000 m. A total of 87 species, 12 subspecies and 8 varieties of Rhododendrons recorded in IHR. Out of these species, 20 taxa are endemic to IHR. While considering the status, 47 taxa are not yet evaluated, 30 are rare, 24 are threatened / endangered and 3 are vulnerable [14,16,21]. In comparison with neighboring countries, China is having a total of 571 species of Rhododendrons, out of which 409 species are endemic [22] and other countries like Pakistan, Bhutan, Nepal, etc are having very less species diversity in Rhododendrons. A lot of exploration is still lacking to discover the species described in other parts of the country, because, the China and India is having similar habitat in support the growth of Rhododendrons. While considering the importance of altitude the maximum number of Rhododendrons present in the altitudes of 3001-3500 m. These altitudes are considered as best suitable sites for Rhododendrons for conservation and multiplication.

In the recent days, IHR is greatly affected due to various threat posed by the nature as well as by human beings. Since Rhododendrons are the inhabitants of the IHR, they are also greatly affected and their population in the nature is gradually dwindling [14]. The rise in population with demand on land for farming, increased animal husbandry practices, construction of roadways, hydel-power stations and allied works, army personnel garrisoned at alpine locations and lately the tourist influx have collectively resulted in the building up of considerable pressure on the availability of rhododendron species. The major threats to rhododendrons are deforestation and unsustainable extraction for firewood and incense by local people. Due to the presence of polyphenols and flavonoids, rhododendrons make excellent firewood that burns even under wet conditions. *Rhododendron* firewood is also being used in the high-altitude trekking corridor for the purpose of tourism. Some of the species have already become scarce, for example, *R. leptocarpum* is endangered and reported to have only 16 surviving individuals at present in the Sikkim [16].

The conservation of *Rhododendron* species can be effected by two well established means, the *in-situ* and *ex-situ* methods. *In-situ* conservation can be brought about by establishing *Rhododendron* sanctuaries, Parks, etc. Some efforts by Sikkim forest department and Sikkim *Rhododendron* Society have been made by fencing the *Rhododendron* rich sites and declaring them as Rhododendron Sanctuary between Lachung and Yumthang in the State. Similar efforts need to be made by Arunachal Pradesh Government as the state is home for more than 50 percent rare and endemic IHR species. The *ex-situ* conservation can be effected by cultivating *Rhododendron* species in the gardens and parks under suitable climatic conditions or by using tissue culture techniques. There should not be many difficulties in introducing these species in Botanic Gardens and Parks as most of them have successfully been introduced and cultivated in the European and American countries. The species of *Rhododendron arboreum* are propagated through cuttings [23,24]. Tissue culture studies of Indian Rhododendrons are recently initiated; only few species especially *Rhododendron maddeni* has only been propagated through tissue culture methods (Singh and Gurung, 2009) and some others are under progress. But in foreign countries, the Rhododendrons have already been carried out for commercial cultivation [26-32]. The standard culture medium for tissue culture methods is readily available in the market [14]. Successful tissue culture of these species will be a great contribution for rapid multiplication and

towards *in-vitro* conservation. The success of conservation programme depends on the awareness of local people. It is imperative to educate the local inhabitants about the wealth of Rhododendrons and importance towards the conservation of biodiversity in IHR.

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