PROCEEDINGS

International Conference

RHODODENDRONS: CONSERVATION AND SUSTAINABLE USE

Saramsa, Gangtok-Sikkim, India
(29th April 2010)

Forest Environment & Wildlife Management Department,
Government of Sikkim

June 2010

PROCEEDINGS
International Conference
RHODODENDRONS: CONSERVATION AND SUSTAINABLE USE

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Contents

From the desk of the Convener...

Rhododendrons are viewed as indicators of ecosystem health of forest areas as these plants offer niche for several faunal species. Interestingly buds of rhododendrons being highly sensitive to climate variations can be taken as easy to handle tools for monitoring global warming. Sikkim, having 38 species of rhododendrons out of 80 found in India, is organizing International Rhododendron Festival 2010 and as a part of this year's long celebration, an international conference on "Rhododendrons: conservation and sustainable use" was organized at Saramsa Garden, Gangtok, Sikkim on 29th April 2010, where over 130 forest managers, experts and scientists shared a common platform to deliberate on strategies required for conservation and sustainable use of rhododendrons and prepared an action plan required in Indian scenario with emphasis on Sikkim rhododendrons.

This document is an edited version of the conference proceedings, which includes technical papers and an action plan. I hope that this document would prove useful for the conservation and sustainable use of rhododendrons in Himalaya and elsewhere in the world.

Dr. Anil Mainra
Addl. PCCF

OBJECTIVES OF THE WORKSHOP

Rhododendrons have fascinated people for centuries and represent about 960 species growing worldwide. Majority of the genetic variations of rhododendrons is confined to southeastern Asia, extending from northwest Himalayas (Nepal, Sikkim, eastern Tibet, Bhutan, Arunachal Pradesh, north Myanmar and west and central China), and subsequently southward. Of around 80 species of rhododendrons in India, 38 species are reported from Sikkim.

Rhododendrons have a great role in ecological stability of ecosystems, as indicators of forest health, and for their phenological sensitivity to climatic change. However over past few decades, natural populations have declined worldwide due to natural and anthropogenic pressures. Any sustainable use, including aesthetic value of rhododendrons for tourism would be possible by scientific conservation and management of natural populations. Sikkim is one of the perfect examples of practicing biodiversity conservation programmes with over 31% geographical area coverage under protected area network including one Biosphere Reserve and eight wildlife sanctuaries, of which two are exclusively designated for the conservation of rhododendrons, viz. Shingba Rhododendron Sanctuary (43 sq. km) and Barsey Rhododendron Sanctuary (104 sq. km)

Realizing the enormous conservation potential of rhododendrons, need has emerged for experts, scientists, practitioners, policy makers and forest managers to sit together in a common forum to interact and share their expert ideas on various issues, concerns and policies on rhododendrons of the world, with particular reference to Sikkim Himalaya. In the International Year of Biodiversity 2010 and Sikkim Tourism Year 2010, the Government of Sikkim has organized the International Rhododendron Festival in April 2010, of which International Conference on 'Rhododendrons: Conservation and Sustainable Use' was a major event.

Objectives

Owing to individual habitat niches, the dynamics of ecological behaviour of different species of rhododendrons offer major challenges for their conservation, management, scientific study, and strengthening potential gene resource base for posterity, both in-situ and ex-situ. The conference intended to seek inputs and share views on the following broad areas, specifically restricted to rhododendron conservation:

- Diversity and distribution
- Habitat diversity and ecological adaptation
- Phenological behaviour and climatic relationships
- Sustainable use and future potential
- Field oriented ex-situ conservation
- Eco-tourism potential
- Education, awareness and peoples' participation
- Role of policies and acts

Inaugural session


rvati nd Sustainable Use
East Sikkim


International Conference on
Rhododendrons


International Conference on
Rhododendrons


2010, Saramsa Garden, East Sikkim, India.

INAUGURAL ADDRESS BY THE CHIEF GUEST

Honourable Chief Minister of Sikkim
Shri Pawan Chamling

Esteemed delegates from different countries attending this rare conference, experts and resources persons working in the area of biodiversity conservation, Hon'ble speaker, Deputy Speaker and the other members of Sikkim Legislative Assembly, Officials, distinguished guests, esteemed member of media fraternity and friends

It gives me immense pleasure to attend the inaugural functions of the International Rhododendron Conference, one of the rare occasions to determine the richness of the rhododendron species in Sikkim Himalayas and also reinforce its aesthetic values that blend into the overall living experience of the beautiful people of Sikkim.

I am very glad to see experts, scientists, policy maker and forest managers from different part of the country and the world sitting together in a common forum with a common theme to interact and share their expert findings on various issues, concerns and policies on rhododendron of the world with

particular reference to North Eastern Himalayas and Sikkim. It is only in conference of kind that new ideas are created, discussed and the distilled wisdom is recorded in the form of action plan which form the foundation stones for deciding the future course of action with a view to conserve this important natural resources.

Over past few decades, anthropogenic and natural calamity has threatened the natural population of rhododendrons widely. The Himalayan State is not exception to this. Here I am happy to share that the State of Sikkim has been able to conserve the rhododendron species. The government's role and approaches used for conservation of biological diversity in Sikkim have been eco-friendly and has proved immensely beneficial over many decades. I fully agree with the idea that sustainable use of biodiversity including rhododendrons is possible by scientific conservation and management in nature. I can say that Sikkim is one of the most ideal cases of practicing biodiversity conservation program with over 30 percent geographical area coverage under protected network.

I feel that the conservation of rhododendron within natural habitat is the best approach and the state government has been successful in maintaining the natural habitation of the floral species. In Sikkim, we have one Khangchendzonga Biosphere Reserve and seven wildlife sanctuaries with each of them having rhododendron in their pristine state. Two of them namely Singba Rhododendron sanctuary and Barsey Rhododendron sanctuary are fully devoted to conservation of one of the most beautiful wild genetic resource the rhododendrons. The Khangchendzonga Biosphere Reserve, which is soon expected to be the part of 'Man and Biosphere Reserve' network of UNESCO, supports immensely rich depositories of rhododendrons.

In fact, the, level of environmental awareness among our people is very high because of their proximity to nature and their age old belief in nature as their local deity. The people of Sikkim revere the third highest mountain peak Khangchendzonga as their local deity and worship the various natural features like natural lake, tree and mountain peaks, rivers and hot springs. This has intimately linked our way of life with the existing nature making significant impact upon our lifestyle and also our livelihood pattern.

And in the midst of scientific community and nature lovers, I would like to inform that we formulated many new and innovative conservation measures since the early 1990s. Many of them were hard decisions, politically unpleasant decision tantamount to unsettling the business-as-usual mindset of some section of people. Facing upfront all the perceived risks, the state government has successfully adopted many conservation measures including blanket bans, mass afforestation drive, Smriti Bans concept, Green Mission as long- term strategy for the conservation of biological diversity.

As part of the policy and green initiatives undertaken by the State Government, I seek your permission to recount some of them hereunder:

- In 1995 banned green felling in forests

- Legislation banned the use of non-biodegradable materials like plastic, poly-bags, Bio- medical/chemical waste in 1997.
- In 1998 imposed ban on Grazing in reserved forest areas, plantation areas and water sources areas.
- In the year 1998 the state award "Rajya Van Samrakshan Evam Paryavaryan Puraskar" was constituted.
- On 5th june1999 launched "Smriti Van "program " A people's programme" in all four district at Panchayat/block/village level to bring people close to nature and this programme has been taken up in all the Gram Panchayat units.
- Introduced Compulsory Environment Education for school in 2000
- Ban smoking in public places, sale consumption of pan parag and gutka in 2001.
- Abandoned and closed the Rathang Chhu Hydro Electric Project in West and Firing Range "G" in North Sikkim.
- To preserve the Heritage and fragile ecology, notified in 2001 sacred peaks, caves, rocks, lakes, chhorten, and hot spring and banned scaling of important peaks including Mt. Khangchendzonga (8586 m) for mountaineering expeditions, etc.
- Conservation of unique terrestrial & aquatic eco-system of wetlands/ lakes by prohibiting commercial activities.
- A state Biodiversity Park at Tendong first of its kind was created in 2001.
- To reduce dependence of village on firewood and forest resource, Free LPG connection for people below poverty line and economically weaker section of society are being provided since 15th 2002.
- Sikkim ranked highest on India's Green Protection Index (0.903) by the protection its natural resources as per Green indicators 2004.
- Sikkim Green Mission 2006 launched to integrate people with Nature & invoke Mass support for the causes.
- Eco-club, Green funds created in the numbers of schools & colleges.
- The state Government has decided that every family shall have four dustbins for disposal of different kinds of waste materials.
- We have imposed ban on the use of Diclofenac, the chemical responsible for death and show extinction of vultures from our landscape. By effectively banning this anti-inflammatory drug, we are contributing towards arresting death cases of the bird family and that of vultures.
- Ban of killing of wildlife and aquatic animals has been imposed by the government.
- Foundations stone of Sidkeong Tulku Bird Park at Rabdentse laid during the inauguration of Forest Centenary Celebration.
- A unique programme named 'Ten Minutes to Earth' was launched in 2009. More than 625000 seedlings were planted in 10 minutes.

As early as 1998, the Centre for Science and Environment, New Delhi voted Sikkim's Chief Minister as the Greenest Chief Minister of India. And as early as 1995, we declared the year 95-96 as "Harit Kranti" year and period 2000-2010 as "Harit Kranti Dashak" for green Sikkim forestry, with free distribution of seedling and related green incentives in the state. Respected participants, all this at a time, when urgency on issue of nature conservation and issue like global warming was not adequately reflected and addressed in world forums. That means, on our own, we played the catalyst in terms of generating mass environmental awareness among our people duly recording over two percent increases in forest cover on ground from 43.95% in 1993-94 to 46.28 at present.

In our bid to augment per acre yield, we have exploited our land through use of chemical fertilizers and pesticides. Therefore, to revert the whole process and regain soil fertility, we have call upon our people to use organic manure in their fields that will also fetch competitive price for their local produce. In fact, we have set a long-term mission to make Sikkim chemical free and pesticide free and make it into a total organic State by 2015.

My endeavor has been to promote a balanced growth in Sikkim by duly preserving everything original in Nature and bringing in the best practices of modern development instrument available in the world. This also means bringing in paradigm shift in people's mindset and the way of life to harness the natural resources on sustainable manner and diversity people's profession into service sector

In these connections, all our guests have see how we seek to promote and harness our Nature as sustainable sources of livelihood for our people. Evidently, we are promoting eco-friendly tourism duly linking it with our culture, tradition, faith and belief. As one of the eighteen Biodiversity Hotspots, Sikkim offers wide range o opportunity to promote eco-tourism, culture tourism, nature tourism, home stay and as far as concept like Ekanth-bas deep into the forest!

I am confident that the deliberation of today addressing the conservation and sustainable use will be a great success. I am sure that the conference will go a long way in shaping new directions to this important subject area and hope that the action plan that will emerge will act as the guiding light for conservation and protection of Rhododendrons

Flowers hold special place both in the oriental philosophy and western mythology. Many different species of flowers, according to their properties, have been associated with a wide range of human emotions, conditions, events and ideas. Flowers have always been our treasured wealth a part of our living experience which grows in the wild, blooms in the tree tops and adorns our landscape in careless abundance. Above all, Rhododendrons is our State Flower and this makes the whole feeling all the more intimate .Flower, since time immemorial, has inspired philosophers, poets, lovers, politicians and general admirers both for its physical beauty and aesthetic imagination. The poet john Keats has famously sang and I quote:

"A thing of beauty is a joy forever;

Its loveliness increases;
it will never,

Pass into nothingness."

While we take resources in the immortal lines, I feel privileged to provide Natural ambience in Sikkim to all our distinguished guests for their personal growth- and nature that joy forever as sublime though that increase every passing day.

I extend my best of wishes to all the guests from the state, country and abroad for the success of this conference to enrich the working experience in nature conservation and forge a collective commitment to save the mother earth from whenever we are, whatever we do and whichever way we can.

Welcoming the distinguished guests to our place once again and wishing the conference a grand success.

Thank you all and Jai Hind.

ADDRESS BY SHRI BHIM DHUNGEL

Hon'ble Minister,
Forest, Environment and Wildlife Management, Tourism, Mines and Geology and Science and Technology, Government of Sikkim

Honourable speaker, Sikkim State Legislative Assembly, Hon'ble Ministers, Hon'ble Members of Sikkim Legislative Assembly, respected Shri KC Pradhan, Hon'ble Zilla Adhyaksha, distinguished delegates from various countries all over the world, JFMC and EDC Presidents and members, esteemed members of public, Chief Secretary and other government officials, members of media fraternity, distinguished guests, ladies and gentlemen.

The celebration has begun. This unique Rhododendron festival has already commenced getting inaugurated by His Excellency the Governor of Sikkim in Singba, Lachung on 25th

April. The International Rhododendron Conference is an integral part of the Festival factoring in the latest scientific studies on different aspects of this important genus of the plant kingdom. His Excellency Shri M.K. Narayanan during the inaugural function at Phuni, Lachung mentioned divine reasons for hosting the function and for his inaugurating the festival. His Excellency further stated that the HCM, Sikkim has international thinking and he has capacity to lead the other states in the domain of Biodiversity conservation, protection and conservation of forest areas, ecotourism development.

Holding this international conference in the beatific environs of Sikkim, which is truly the Kindergarten of rhododendrons, has its own importance and flavour. I am glad to see here representatives from the gene centers of various countries working in the domain of Rhododendron propagation and research. The conference will deal with systematics and biology of the genus *Rhododendron*. The sub topics of the conference are very pertinent and they broadly cover the relevant aspects of this genus of the plant kingdom. I am sure during the group exercises very useful inferences will emerge as a result of intensive cerebral activities.

As a Minister of Forests, Environment, Wildlife Management & Tourism, I know very well about the importance of supplying new plants to the market, to offer something special. That's what makes the economy strong. That's what arouses the interest of plant lovers and *Rhododendron* enthusiasts. Concurrent with this the laws concerning protection of wildlife and plants must be respected. I want to take this opportunity to request your cooperation to the august audience present here to protect the wide spectrum of species, in this case of rhododendrons.

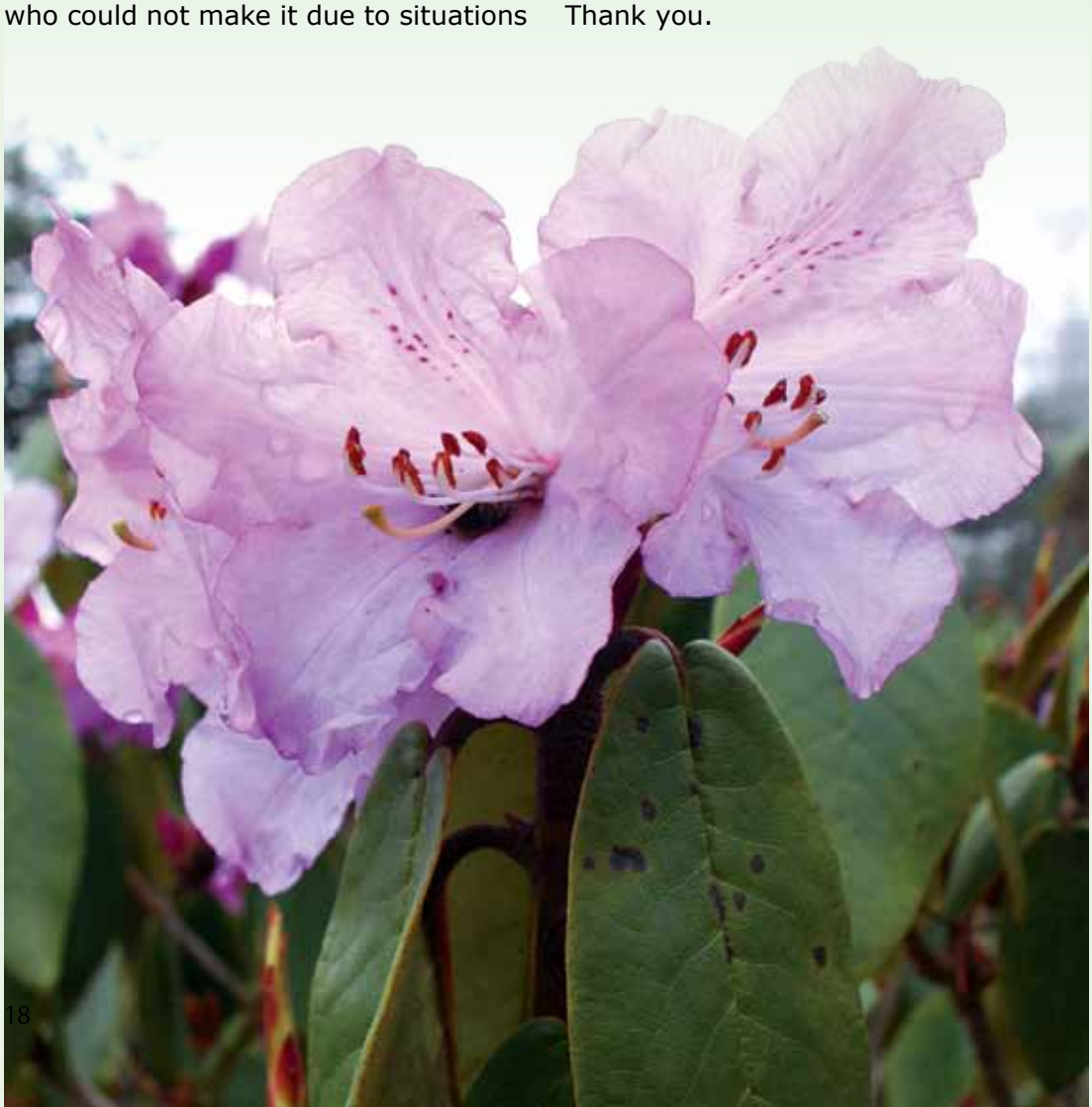
I want to encourage both scientists and friends of *Rhododendron* to avoid pollution of soils and water resources. *Rhododendron* is one of the subjects of research for the benefit of carefully planned forestry and horticultural activities. The Significance of rhododendrons for biodiversity conservation is distinct. Rhododendrons form dominating species all along the cool temperate, sub-alpine and alpine zones in the Sikkim Himalayas. It supports a wide range of plants and animals and, if disturbed, can degrade habitats that threaten associated biodiversity. It provides food preserve for a wide range of birds at an altitudinal gradient. On the occasion of this conference a comprehensive bibliography of the genus *Rhododendron* could be realized and presented at the conference.

Efforts for conservation and management of rhododendrons must drive from a set of clear objectives, mechanism for action, and commitment from all stakeholders. Thus, all of us in the state have to take concerted efforts to protect, conserve and develop the natural resources in a sustainable manner. The high ecological sensitivity of our state should be kept in mind while taking any developmental interventions. The fragile Himalayan ecosystem has to be preserved. In the domain of gene technology Breeding work, especially resistance breeding is of great importance for the environment, but I do believe that economic considerations must not result in developments which at some stage drift out of control. This

would not be in the interest of species protection and wild plant development. These are few pointers for discussions during the conference.

I would conclude with my profound congratulations to the Forest, Environment and Wildlife Management Department for its continued concerted efforts to preserve the ecology and environment of the state and for holding this conference. I thank the esteemed guests from all over the world who could make it to participate in today's conference and also to those who could not make it due to situations beyond control like volcanic eruptions in Greenland and its associated air traffic disruptions. I also congratulate the Organizing Committee for taking initiatives to organize this International Rhododendron Conference 2010 in the beautiful state of Sikkim. The conference, I am sure will go a long way in augmenting the rhododendron research and information sharing and I hope we will come out with a Conference prescription for the world community helping them to know this genus of the plant kingdom better.

Thank you.



KEYNOTE ADDRESS BY SHRI K C PRADHAN

Former Chief Secretary, Government of Sikkim

Historically, the Sikkim rhododendrons came to limelight with the advent of JD Hooker's visit to Sikkim in 1848. During the two years of his sojourn in the Sikkim Himalaya he encountered 24 rhododendron species new to science. This major discovery, unrivalled in the annuals of rhododendrons, followed by the publication of the monumental book titled *Rhododendrons of Sikkim Himalaya* in 1849, well illustrated by Walter Hood Fitch, abruptly brought Sikkim into the limelight. Ever since Sikkim has been synonymous with rhododendrons in the world of plants. This led to the creation of two breeds of plant fanatics: one the breeder and the other the plant explorer. The 19th century England agog with the industrial revolution wealthy entrepreneurs

passionately involved in gardening sent out dare devil plant hunters to all corners of the Himalayas as far as Yunnan and further east in search of exquisite species in the genus. By the turn of the century some 100 species came to light and by now it has touched over 400 species with China alone claiming over 300 species. This is besides some 300 species of Azaleas and over 400 species in Vireyas- both of which botanically fall within the broad family of plant genus- the *rhododendron*. On the other, a host of people were well engaged in breeding to create new hybrids with desired plant shapes and sizes with magnificient flowers well suited to varied landscapes. If *R. arboreum* and *R. griffithianum* from Sikkim gave flower truss size and colours, it was *R. yakusimanum* from the Far East that gave desired plant forms. Despite all these discoveries, Sikkim is still looked upon as the real home that initially sparked the minds of gardeners in landscaping gardens and parks in the temperate regions of the world. It is befitting that the State Government of Sikkim thought it fit to hold the Rhododendron Festival at an international level to showcase not only its floral wealth but also its political will to conserve this prized heritage in its natural habitats in this International Year of Biodiversity.

When I was asked to invite delegates from abroad, my immediate thought went to Scandinavian countries Sweden and Finland which had strong ties with Lachung and Lachen and the Missionaries from these countries were instrumental to bring a semblance of development in keeping with the unique traditions at a time when the whole of Sikkim was still in its infancy as far as any developmental programme was concerned.. In the process the adjoining countries like Norway, Denmark, The Netherlands and Germany came in. Sadly the volcanic eruption in Iceland played havoc and most of the delegates had sadly to forego their visit which they were looking forward to so anxiously. Those who did venture to attend had harrowing tales to tell of their travels- driving miles to reach the nearest airport fit to operate and the hassle they had to undergo in every connecting flight. Some missed the deadline. But ultimately many of them made it and it was a rare sight to see flags of many European countries flying high with perfect mountain background with rhododendrons at their ever best all round. In reality the rhododendron flowering was the best in our living memory. It was also good see that the age-old tradition of ushering in any event in the Valley with offering of prayers to the deity at Chuba Lhakhang in the Dombang Valley is well adhered to. Many may ask why some international experts could not be invited. Yes I did try but in vain. The usual answer was six months was too short a notice to attend as they were committed elsewhere. All for good, after all it was a Festival and not an occasion for very serious debates and presentation of some research works of little relevance for the occasion when the idea itself was conservation with rhododendrons as an eco-tourism product. The way the area was flooded with tourists with over 500 cars plying every day for a whole week with acute accommodation problems, the purpose for the present was well served. But it has also thrown lessons and challenges on how to cope with problems in the future years and at the same time

conserve the area's ecologically fragile ecosystem.

The delegates from both, within the country and abroad went back home quite mesmerized with Sikkim's traditional hospitality and the rhododendrons did welcome them with all their glamour - making them our best ambassadors. The hard work put in by the band of Forest officials over the year and the exquisite souvenirs brought out by the Department and the Directorate of Handlooms and Handicrafts were well appreciated.

The daylong Conference was well conducted and the theme *Rhododendrons Conservation and Sustainable Use* well conceived of with the delegates enthusiastically participating and throwing new ideas and much food for thought. Above all meeting people of diverse cultures and professions, yet bonded by one single passion- love of rhododendrons- created conditions to make new friends to pursue varied goals with ever greater zeal in the days and years ahead.

Thank you

ADDRESS BY SHRI S T LACHUNGPA

PCCF-cum-Secretary
Forest, Environment and Wildlife Management Department, Government of Sikkim

Honorable Chief Minister, Dr. Pawan Chamling, Hon'ble Speaker, Hon'ble Ministers, Hon'ble Members of Sikkim Legislative Assembly, Hon'ble MLAs, Chairpersons, Zilla Adakshyas and Upadhyakshyas, International and National Delegates, Chief Secretary, Director General of Police, Secretaries & Heads of Departments, Officials, Press & Media, Members of TAAS, Anglers Association of Sikkim, University & School Teachers & Students, Public & Panchayats and Rhododendron lovers and friends,

I take great pride in welcoming you all to this International Rhododendron Festival in Sikkim, the home of parents of many of your magnificent hybrids that have long since outnumbered our species. Exactly two decades ago, my friend Udai Chandra Pradhan and I wrote and published *Sikkim-Himalayan Rhododendrons.* Little had we realized that this effort would culminate in an International Rhododendron Festival, as a part of a year long celebration of International Year of Biodiversity and Sikkim Year of Tourism 2010; and bring so many of you together to participate and deliberate upon this magnificent group of plants, in its original home – Sikkim.

The pioneering efforts of Rai Saheb Bhim Bahadur Pradhan, Mr. Tse Ten Tashi, Mr. Britt and Jean Smith who today are not longer with us, has been carried forth through the diligent efforts of Mr. Keshab C. Pradhan who, by helping establish the Sir Joseph Dalton Hooker Chapter of the American Rhododendron Society has played a key role in bringing Rhododendron Groups to our Sikkim Himalaya.

This is the first time that Sikkim and its people are making an organized effort to have an International Rhododendron Festival to remind the world of the original habitat of this group of Himalayan plants and most importantly how it has taken a central stage in unfolding Sikkim's biodiversity to the world of eco-tourism. The Government as a whole is involved in the conservation of these magnificent plants in their native habitat. Institutes like the Botanical Survey of India and Govind Ballabh Pant Institute of Himalayan Environment and Development, Sikkim Circle have been assisting the Government of Sikkim's efforts so that these wonderful plants and their habitats can survive in their near original state for future generations.

Himalayan Rhododendron history began with the visit of Captain Hardwicke to the Siwalik Mountains of Kashmir in 1796 where he encountered our "Lali Gurans" *Rhododendron arboreum.* It was described by Sir James Smith in *Exotic Botany* in 1805. Dr. Nathaniel Wallich introduced the seeds of this species in 1827 to England and interest in Himalayan Rhododendrons developed. It was Dr. Carl Linnaeus who described the genus *Rhododendron* in 1837 in *Genera Plantarum* from the prestigious Gothenburg Botanical Garden.

Sir Joseph Hooker's monumental journey to the Sikkim Himalaya between 1848 and 1850 truly opened the treasure trove of Sikkim Himalayan Rhododendrons. In the course of his travels in the Sikkim Himalayas he gathered and described 34 species and detailed 43 species from the Indian Region.

His beautiful monograph, *Rhododendrons of Sikkim-Himalaya* till today, remains unparalleled in its exhaustive details and very elegant paintings. He distributed seeds collected during his trip to gardens in England, Scotland and Wales where they are still to be found today. We added three more species, *R. leptocarpum, R. micromeres* and *R. sikkimense* later. Since then, a young Swedish botanist from Gothenburg Botanical Garden has recorded another species in Yumthang, a dwarf yellow *Rhododendron mekongenense.*

This brings the number of Sikkim Rhododendrons since Sir Joseph Hooker to 38. I feel that there might be more species yet to be discovered. Many beautiful forms and varieties also exist that are a hybridizer's dream and we hope serious work in this direction will be undertaken by our young Rhododendron enthusiasts in the future. In fact during this International Rhododendron Festival itself, just a couple of days ago, I have recorded yet another beautiful dark pink variety of *Rhododendron* in Shingba Rhododendron Sanctuary. Another yet to be studied and named species! Surely there is a lot of natural hybridizing going on here that warrants further study.

It was my grandfather Karma Yougyal, Block Officer of the Forest Dept. who observed in the '60s, the unusual sighting of Himalayan Alder, our 'Utis' tree in the high altitude Lachung Valley.

This tree is a pioneer species which fast colonizes landslide areas in the lower warmer altitudes. In Lachung, the Larch tree *Larix,* is the pioneer species. However, in recent times, we have noticed the Larix being fast overtaken by the Utis tree. It is an obvious sign of warming of the climate here. Another unusual observation is responsible for us all sitting here today.

I have observed since the last seven odd years, the peak flowering of Rhododendrons is usually around 10-15th May. Since the last few years, there has been very little snowfall, almost no avalanches. Temperatures seemed to be on the rise. We therefore decided to pre-pone this Rhodofest by about 15-20 days. And how appropriate this has been, many of you all saw for yourselves. This lucky shifting of the date to 25th April has proved to become the new peak flowering season. Perhaps this is another proof of global warming. And we have all shared this experience.

After 1995 under the initiative of our Honorable Chief Minister, Dr. Pawan Chamling conservation of Sikkim Rhododendrons became top priority. The village people in areas like Lachung, Lachen and Thangu, Gnathang, who had been using Rhododendrons as fuel wood were provided with LPG thereby reducing the stress on the firewood for their basic needs.

When we were surveying Rhododendrons for our book, *Sikkim-Himalayan Rhododendrons,* the only 'hotel' that existed was the two-room Lachung Bungalow where we did most of our work. Today more than a 100 homestay-style households have come up and they look upon Rhododendrons as a very valuable plant resource that attracts people from all over the world to see, photograph and study. These homestay entrepreneurs now make a decent living through ecotourism devoted to Rhododendrons and other alpine flora of Sikkim.

The damage to the forests seen earlier has now been considerably mitigated. Masses of flowering Rhodos, the young vibrant Silver Fir Forests, carpets of Primulas and other ground flora, grazing yaks and their calves, are opportunities along with angling for brown and rainbow trout, mountain biking, photography, local cuisine and cultural extravaganza, bird watching, the heritage collection of photographs on permanent exhibition at Yumthang, etc. that you have witnessed in the last couple of days, or would be visiting to enjoy in the days to come, are today providing tourists and native people with ample opportunities for making these places, great, exotic and sustainable holiday destinations.

This international Rose-tree festival is a result of the far-sighted vision of our Honourable Chief Minister Dr. Pawan Chamling and we all owe thanks to his suggestion way back in 2008 to host it here and now.

We are very pleased to have you all with us during this festive occasion of great significance to Sikkim and we hope you will enjoy your trip, carrying back fond memories to share with your family and friends, thereby enthusing many of them to visit and re-visit us in the future.

During this International Year of Biodiversity and Sikkim Year of Tourism, on behalf of my entire Forest Family, the Government of Sikkim and all other organizers, I thank you all for being with us to share this historic occasion. I hope this great celebration of Rhododendrons is just a meaningful beginning for more such events in future.

THANK YOU.

WELCOME ADDRESS BY DR. ANIL MAINRA

Addl. PCCF and Convener
Forest, Environment and Wildlife Management Department,
Government of Sikkim

Hon'ble Chief Minister of Sikkim, Hon'ble Speaker SLA , Hon'ble Minister of Forest, Environment and Wildlife Management, Tourism, Science and Technology, Mines and Geology, Hon'ble Council of Ministers, Hon'ble Advisors, Hon'ble Members of Sikkim Legislative Assembly, Hon'ble Chairpersons, Hon'ble Zilla Adhyaksha, esteemed delegates from various countries, delegates from various states, Shri K.C. Pradhan Rtd. CS, PCCF cum Secretary, Senior Forest officers from other states, Secretaries of other Departments, other senior government officials, Retired forest officers, esteemed members of public, dear students, members of media fraternity, distinguished guests, ladies and gentlemen.

It is my honor and privilege to extend a heartiest note of welcome on behalf of the Department to our Chief Guest of today's function Shri Pawan Chamling, the Hon'ble Chief Minister. He has very kindly agreed to spare his valuable time out of his very busy schedule at such a short notice. I am glad to inform you Sir that during the celebrations of Sikkim Year of Tourism, 2010, Forest Department has taken lead and organized International Rhododendron Conference as a part of International Rhododendron Festival. Inaugural function of the IRF was successfully held at Phuni, among the blooming Rhododendrons in the Shingba Rhododendron Sanctuary on 25th April. Snippets of the IRF will be shown shortly for the benefit of those who could not attend the function.

I extend a warm welcome to Shri K. T. Gyaltsen, Hon'ble Speaker SLA, who

has consented to be guest of Honor in today's function and has given his full cooperation and support for the IRF and this function here today.

I also welcome Hon'ble Minister Shri Bhim Dhungel, Minister Forest, Tourism, S&T and Mines and Minerals and Geology on the occasion of this Conference. Sir, you have been the constant motivating force for giving all of us in the Department the required encouragement for organizing this festival as well as the conference.

I also extend welcome on behalf of the Department to all other Hon'ble Cabinet Ministers, Hon'ble Advisors, Hon'ble Members of SLA, Zilla Adhyaksha, Chairmen and all the delegates of this conference which includes Rhododendrons experts from various countries, senior forest officers and others experts from various states, our senior retired forest officers, members of scientific community from GB Pant Institute of Himalayan Environment & Development, BSI, ICAR, Sikkim University, science faculty and students form various colleges of Sikkim and North Bengal, friends from NGOs and members of the media.

For today's conference the experts and scientists working on Rhododendrons, from different parts of the world viz. Sweden, Germany, Finland, Netherland, NZ, Norway, Denmark, Bhutan and India had confirmed their participation but unfortunately due to volcanic eruptions participants from some of the countries could not make it. We also have amongst us here today senior forest officers from various states where Rhododendrons are found in natural habitats.

I would like to inform the august gathering here that among the 80 species of rhododendrons found in India, 70% are reported from north-eastern states, and Sikkim state alone has about 38 species. Therefore Sikkim is known to be a haven for people who love this plant. Original samples taken from the different rhododendrons habitats from here find a pride of place and act as tools of floristic research at the Kew Herbarium of UK.

Rhododendrons are viewed as indicators of ecosystem health of forest areas as these plants offer niche for several faunal species. Interestingly buds of Rhododendrons being highly sensitive to climate variations can be taken as easy to handle tools for monitoring global warming. Concerns over conservation and protection of rhododendrons of the region have been expressed very often and field works in this direction are sometimes taken up by Forest managers without proper understanding of the issues involved in absence of inputs from scientists and experts reaching them.

Theme of the conference, as you are all aware, is Conservation and Sustainable Use of Rhododendrons. Conservation includes *in-situ* and *ex-situ* conservation both of which are equally important. *In-situ* conservation implies that the natural habitat of rhododendrons is fully protected and conserved and should serve as gene pool for the species which is genetic heritage of the entire world.

We have to initiate steps to take into confidence the local communities who are living close to these resources to protect and preserve them. *Ex-situ* conservation implies multiplication, hybridization and genetic manipulations of rhododendrons. We have amongst us prominent rhododendron breeders from India and abroad who will be sharing their experience and will guide us to strengthen our efforts for *ex-situ* conservation.

Sustainable use of rhododendrons is another equally important aspect. In fact conservation can only be achieved if it is linked to socio economic development and livelihood security of local populations. Local communities will protect forest only if they realize that the forest is worth more to them as a forest rather than as felled trees. Non consumptive use of rhododendrons will include promotion of ecotourism activities in the state and this has potential for providing enormous employment opportunities in the remote wilderness areas.

Forest managers, experts and scientists in this field will be sharing a common platform to deliberate on strategies required for conservation and sustainable use of rhododendrons the world over and an Action plan required in Indian scenario with emphasis on Sikkim rhododendrons will be prepared after deliberations. This will give us a frame work for our Conservation and sustainable use strategy for Rhododendrons for the coming years.

In the end, I once again extend a very warm welcome to all delegates specially our Hon'ble Chief Minister and all Hon'ble dignitaries, delegates from foreign countries and other states that have travelled such long distances and have reached here despite disrupted flights. This truly reflects true dedication and commitment to conservation and protection of rhododendron.

I hope that your trip to Sikkim would be a memorable one. Although our officers have tried their best still there may be some shortcomings with respect to logistics including accommodation, transport and other facilities for which I request you to kindly bear with us.

Thank you all.

International Conference

RHODODENDRONS: CONSERVATION AND SUSTAINABLE USE

Organized by: Forest Environment & Wildlife Management Department, Government of Sikkim,

Venue: Saramsa, Gangtok-Sikkim, India

(29th April 2010)

PROGRAMME

Registration: 9.00 - 9.30 am.

INAUGURAL SESSION (9.30-10.50 am)

09.30-09.35	Welcome Address – by Dr. Anil Mainra, APCCF
09.35-09.45	Keynote Address : Shri. S. T. Lachungpa, PCCF cum Secretary
09.45-10.00	An overview on Sikkim Himalayan Rhododendrons –Shri. K. C. Pradhan, Retired Chief Secretary
10:00-10:10	Address by Shri. Bhim Dhungel, Minister, Forest, Environment and Wildlife Management, Tourism, Mines and Geology and Science and Technology, Government of Sikkim
10.10-10.25	Address by Shri. Pawan Chamling, Hon'ble Chief Minister, Government of Sikkim
10.25-10.30	Vote of thanks –Shri. Mukund Srivastava

High Tea: 10:30-10:50

TECHNICAL SESSION I
(10.50 – 11.40 am)

Diversity, distribution and habitats of rhododendrons

Chairpersons: 1. Mr. M.S. Viraraghavan;
2. Prof. Wolfgang Spethmann, Germany

Speakers

1. Dr. A.R.K. Sastry (India): *Diversity, distribution and conservation of Indian Rhododendrons: Some aspects*
2. Prof. Lau Traas (The Netherlands): *Rhododendron in Netherlands*
3. Dr. Rebecca Pradhan (Bhutan): *Wild rhododendrons of Bhutan*

Discussion: 10 minutes

TECHNICAL SESSION II
(11.40 am- 12.30 pm)

Phenological behaviour and climatic relationships and ecological adaptations of rhododendrons

Chairpersons: 1. Dr. A.R.K. Sastry, India;
2. Prof. Lau Trass, The Netherlands

Speakers

1. Dr. Anders Falkstig (Sweden) Rhododendrons species in Sweden and Finland.
2. Dr. Hemant K. Badola (India): *Phenology and climate responses in Himalayan rhododendrons*

Discussion: 10 minutes

TECHNICAL SESSION III (12.30-1.30 pm)

Sustainable use and conservation of rhododendrons

Chairpersons: 1. Dr. Hemant K. Badola, India; 2. Dr. Anders Falkstig (Sweden)

Speakers

1. Prof. Wolfgang Spethmann (Germany): *Rhododendrons in Germany and the German Rhododendron gene bank*
2. Mr. M.S. Viraraghavan (India): *Rhododendron conservation and the protection of the habitat: perspectives from a south Indian tropical mountain eco-system*
3. Mr. L.K. Rai (India): *Conservation of rhododendrons in Sikkim, India*

LUNCH BREAK: 1.30-2.15 pm

GROUP EXERCISE FOR RECOMMENDING STRATEGY AND ACTION PLAN: 2.15-3.30 pm

Group I. *In situ Conservation* (Coordinators: Mr. Anjan Mohanty, India; Ms. Rebecca Pradhan, Bhutan)

Group II. *Ex situ conservation* (Coordinators: Mr. Mukund Srivastava, India and Dr. Anders Falkstig, Sweden)

Group III. *Sustainable use* (Coordinators: Ms. Bharti Mohanty, India and Dr. N.C. Bahuguna, India)

FINAL PRESENTATIONS by Exercising Groups: 3.30-4.30 pm

VALEDICTORY SESSION (4.30-5.30 pm)

1. Chairperson: Mr. M.S. Viraraghavan

Panel for discussion

2. Prof. Wolfgang Spethmann
3. Dr. H.K. Badola
4. Prof. Lau Traas
5. Dr. A.R.K. Sastry
6. Dr. Anders Falkstig

VOTE OF THANKS

Shri. Gut Lepcha (5.30 pm)

TECHNICAL PAPERS

Proceedings, International Conference
RHODODENDRONS: CONSERVATION AND SUSTAINABLE USE
Forest Environment & Wildlife Management Department, Government of Sikkim
Saramsa, Gangtok-Sikkim, India
A. Mainra, H.K. Badola, B. Mohanty (eds) 2010

Rhododendrons in Germany and the German Rhododendron gene bank

Wolfgang Spethmann*, Gerlinde Michaelis and Hartwig Schepker
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*Board of Directors German Rhododendron Society since 1984
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*Invited Speaker

In Germany only three rhododendron species are indigenous: *Rhododendron hirsutum, R. ferrugineum* and *R. tomentosum* (in former years called *Ledum palustre*). Single species from North America and Southeast Europe already were introduced at the beginning of the 19th century. A first planting of rhododendrons in Germany was documented for the castle park in Oldenburg in 1800. Very early nurseries specialized in propagation of rhododendrons. The famous nursery Seidel in Saxony already propagated 175.000 rhododendrons in 1887. In some generations the Seidel family bred more than 600 new cultivars.

Sikkim is one of the most important gene centers of Rhododendron. For the first time, Sikkim rhododendrons were brought to Europe by Hooker in the middle of the 19th century. First they came to Great Britain, then to central Europe and Scandinavia. These species were hybridized very early and the new cultivars were used in gardens and parks. Many rhododendrons indigenous in Sikkim can be grown in Germany outside in gardens and parks but some, especially of lower elevations, can only be grown in greenhouses (Table 1). It is not sure that the species are of Sikkim origin or from neighboring countries, because most species are in culture for many decades with no indication of origin country.

After the Second World War another center for rhododendron nurseries and breeders in Ammerland in Northern Germany became important. Breeders like Hobbie (*R. forrestii* var. *repens, R. williamsianum*-hybrids), Bruns, Heinje, Böhlje, Wieting and others started breeding and propagation of rhododendrons. Near Pinneberg, the Hachmann nursery became famous for its *R. yakushimanum*-hybrids. Production of rhododendrons in Germany increased from 3 million in 1960, 10 million in 1980 to 20 million in 2000. So rhododendron became the most important ornamental woody plant genus for gardens and parks besides the rose genus.

Table 1. Rhododendrons indigenous in Sikkim planted in a German garden and in the Rhododendron Park Bremen

	Private garden Moser		Rhododendron Park in Bremen	
	Most genotypes	Only hardy genotypes	Outside planted	Planted in greenhouse (botanika)
R. aeruginosum	x		x	
R. anthopogon	x		x	
R. arboreum				x
R. arboreum var. *campbelliae*				
R. baileyi			x	
R. barbatum			x	
R. camelliiflorum				x
R. campanulatum	x		x	
R. campylocarpum	x		x	
R. ciliatum		x		x
R. cinnabarinum		x		x
R. dalhousiae				x
R. decipiens			x	
R. edgeworthii				x
R. falconeri			x	
R. fulgens		x	x	
R. glaucophyllum	x		x	
R. grande				x
R. griffithianum				x
R. hodgsonii		x	x	
R. lanatum			x	
R. lepidotum		x	x	
R. lindleyi				x
R. maddenii				x
R. micromeres				
R. nivale		x	x (ssp. *boreale*)	
R. niveum				x
R. pendulum				x
R. pumilum	x		x	
R. setosum	x			
R. sikkimense				
R. thomsonii		x	x	
R. triflorum		x	x	
R. vaccinoides			x	
R. virgatum			x	
R. wightii		x	x	
R. wallichii			x	

Table 2. Rhododendrons species and cultivars in Bremen

about 600 species incl. 110 Vireya	
about 3.200 cultivars	• 1550 elepidote hybrids, • 235 lepidote hybrids • 380 cvs. Tsutsusi Azaleas, • 500 cvs. Pentanthera Azaleas • 500 cvs. Simsii Azaleas

German Rhododendron Society

Many friends of rhododendron joined the German Rhododendron Society. We count 850 members. The Society financed many scientific projects with rhododendrons and the issue of books about rhododendron. In 1992 the 5th International Rhododendron Conference was organized together with the University of Hannover. In Mai 2010 the Society celebrates its 75th anniversary combined with an international conference.

Rhododendron Park in Bremen

The rhododendron park in Bremen is the largest rhododendron park in the middle of Europe (46 ha) and shows the highest number of species and cultivars (Table 2) and is center of the German Rhododendron Society.

Some years ago the Science center *botanika* with a 4000 m² exhibition greenhouse was established. In the greenhouse, rhododendrons which are too tender for outside were planted together with natural companion plants in a mountainous scenario with small hills and water. The highlight is the connection of plants with the culture of the origin countries. So in the Himalayan part Buddhist elements are shown like mani walls and a 6 m long laying bronze Buddha. In the Science Center plant life and botany is demonstrated with rhododendron as example. Soil, climate, physiology, morphology, systematic and especially plant biodiversity regarding the Convention of Biological Diversity is offered.

German Rhododendron Gene Bank

Worldwide 28.000 rhododendron cultivars are documented about 1000 rhododendron species are known. The result of 150 years of intensive breeding in Germany is thousands of cultivars. Aim of the gene bank is an efficient, long term securing of Rhododendron diversity in Germany. All activities should be concentrated in a decentral network. All taxa and cultivars should be conserved as living plants in the participating collections.

- *German Gene Bank Rhododendron is a model and demonstration project of the German Gene Bank of Ornamental Plants in the field of conservation and innovative sustainable use of biological diversity (Convention of Biological Diversity (CBD Rio))*
- *It is financed by different ministries, agricultural chambers and German Rhododendron Society*

The field of activities is building up of the organization structure and conservation network, registration of all important Rhododendron collections in Germany, and the inventory of all species (taxa) and cultivars (important for German breeding work in future). The structure of the Gene Bank is shown in Figure 1.

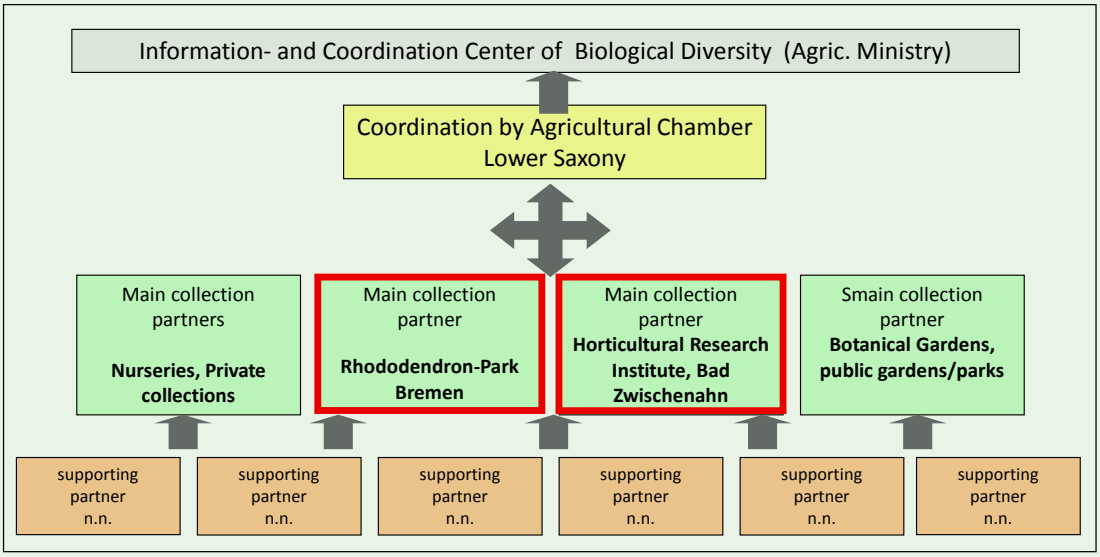

Figure 1. Structure of the German Gene Bank Rhododendron

110 rhododendron collections were registered in Germany; plant inventory lists show 50 collections. Regarding size and number of taxa/cultivars 36 collections were chosen as main partner collections. 7 are nurseries, 10 private collections, 13 botanical gardens, 6 public gardens. Most important collections are in the Rhododendron Park Bremen and in the Horticultural Research Institute in Bad Zwischenahn. The main partner collections are distributed over all parts of Germany. The other collections serve as supporting partners.

Two rhododendron specialists for species and cultivars visit each collection. The labeling and the species/cultivar name

Table 3. Requirements to collection partners

Requirements	Main collection partners	Supporting partners
Collection size min. 50 cultivars / species	x	X
Structure of collection must be visible	x	X
Plants sound and vital	x	X
Routine and competent care	x	X
Up to date documentation	x	X
Correct labeling of plants	x	X
Long term continuance of collection	x	
Action against losses (Rejuvenation, Propagation)	x	
Enlargement possible	x	

Table 4. Result of registration and verification in 2008 and 2009

	Registration in 50 collections	Verification (2008/2009) in 17 collections	Inventory numbers
German and international cvs.	3850	2440	6700
German cvs.	1240	890	
species	600	240	760

Table 5. Highlights of registered partners (without Rhododendron Park Bremen, *see* Table1)

collection	Taxa / species	cultivars
Horticultural Research Institute, Bad Zwischenahn	160	1738
Nursery Fredo Schröder, Wiefelstede		1500
Nursery Hans Hachmann, Barmstedt	33	716
Privat Garden Erhard Moser, Chemnitz	496	346

have to be checked. Digital photos of cultivars were taken and compared with photos in the data bank to make sure that labeling is correct. All species were directly identified with keys. Plant data (habit, leaves, flowers etc.) were documented. Plant data and photos were transferred to the data bank, and each registered plant gets an inventory number on a special label and in the data bank.

Some species/cultivars were found in many collections, but some were found only in one or two collections are suffering. These plants have to be propagated by cuttings or grafts to make sure that they grow in two or more collections.

Verification of a collection needs time, and the time for verification is only during the flowering time, especially for cultivars. Outlook for the next years is to continue registration, inventory and evaluation of the lacking 19 main partner collections. The data bank will be available online soon and is planned to enlarge the gene bank by *Rhododendron simsii*-cultivars.

Ex situ conservation:

For successful ex situ conservation all propagation methods should be improved. Experiences of mass propagation in western countries should be used. If possible seed propagation should be preferred to maintain genetic diversity.

Planting different proveniences/ elevations of a species at one place could be the base for phenological comparisons over years and for following climate change.

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Diversity, distribution and conservation of Indian Rhododendrons: Some aspects

A.R.K. Sastry*
Ex-Joint Director, Botanical Survey of India and
Principal Investigator, DST Project on Indian Rhododendrons

*Invited Speaker

The genus *Rhododendron* Linn. in India is represented by 92 species, 8 subspecies and 9 varieties totaling to 109 taxa in India.

Diversity and Ecology

The species (taxa) exhibit considerable diversity and variation in their habit, hardiness, habitat requirements, altitude, gradient, scales, indumentum, inflorescence size, flower-size, shape, colour and other aspects. They range from small prostrate shrublets ranging from 1 – 1.5 m in length with tiny leaves measuring 3 – 6 x 2 – 4 mm as in *R. nivale* subsp. nivale; to shrubs of 2 – 6 m high, and trees up to 30 m tall with leaves up to 1m length as in the case of *R.sinogrande*; *R.grande* and *R.falconeri* to a lesser degree. Many species are shrubs or small trees. The shape and colour of flowers vary widely sometimes with colour variation in the same species.

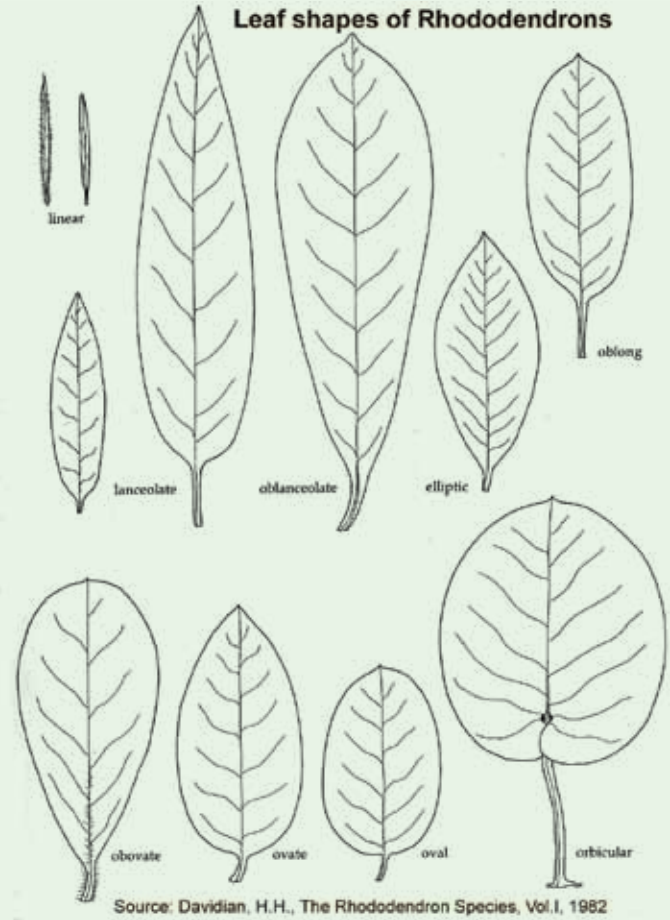
Majority of the *Rhododendron* species in India are terrestrial; about 15 species are sub- shrubs growing as epiphytes on evergreen, broad-leaved large trees in sub-tropical, sub- temperate and temperate forests in association with mosses, lichens, ferns, aroids, orchids, species of other Ericaceous genera like *Vaccinium* and *Agapetes*.

Some other small shrubs and shrub-lets of *Rhododendron* species often grow as lithophytes on moss and lichen covered rock boulders in alpine screes, meadows and mountain cliffs. The species are seen growing in the altitudes ranging from 1,000 – 6,000 m with *R.arboreum* appearing first in the lower altitudes from 1,000 m onwards. It is *R.nivale* subsp. nivale that is recorded from the highest ever altitude growing in the snowline areas between 5,800 – 6,000 m in Sikkim. Many of this species grow as under growth in the altitudes of 2,500 – 4,500 m in dense forests associated with Oaks, Michelias, Magnolias, Acers, Laurels and Pines etc.

Rhododendron species prefer well drained acidic loamy soils loaded with humus while some of the species in the alpine areas grow in sheltered wet gravelly sands along the mountain

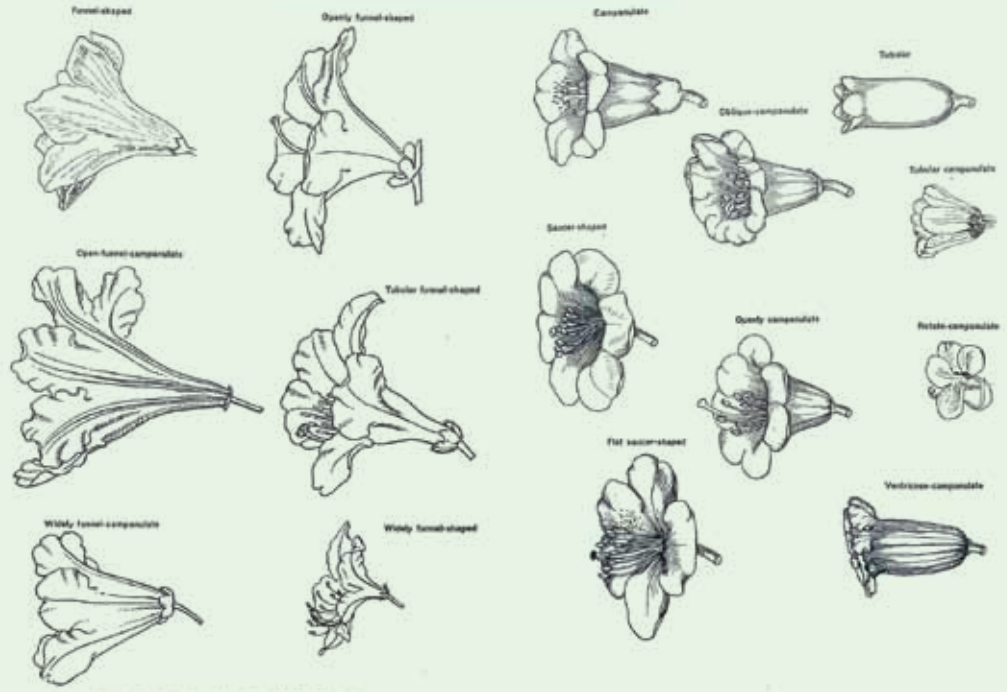
streams and rivers. Seedlings of *R. arboreum* and some such other species are usually seen along freshly cut moist exposed hill sides. Other shrubby species like *R. anthopogon*, *R. lepidotum, R. hodgsonii* etc. are often found growing in large pure and mixed populations in the high altitudes associated with Junipers, Abies and Bamboo forming 'Rhododendron thickets'.

To withstand snowy winters, *Rhododendron* species produce tightly overlapping thick scales forming 'leaf-buds' at apices of branchlets to effectively enclose and protect the inner growth buds which remain dormant during the harsh snowy winter nights and bright sunny days. The leaves of young species are thick and leathery often with a waxy coating or bloom and are rolled inwards along their margins to minimize exposure to snow and damage during adverse seasons. Many other species are clothed with dense indumentum or scales which protect the young plant parts and reproductive bodies.



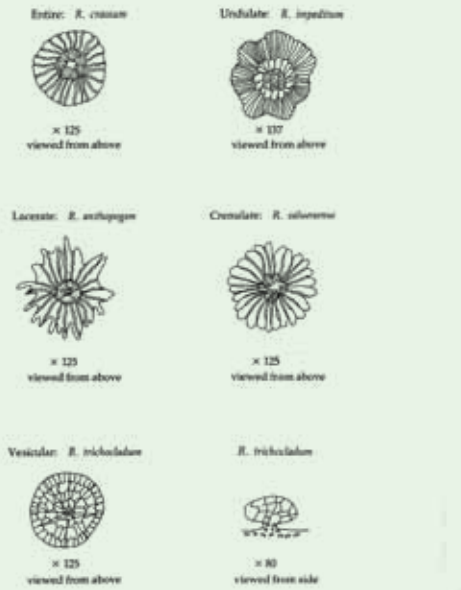
Source: Davidian, H.H., The Rhododendron Species, Vol.I, 1982

RHODODENDRON FLOWER SHAPES

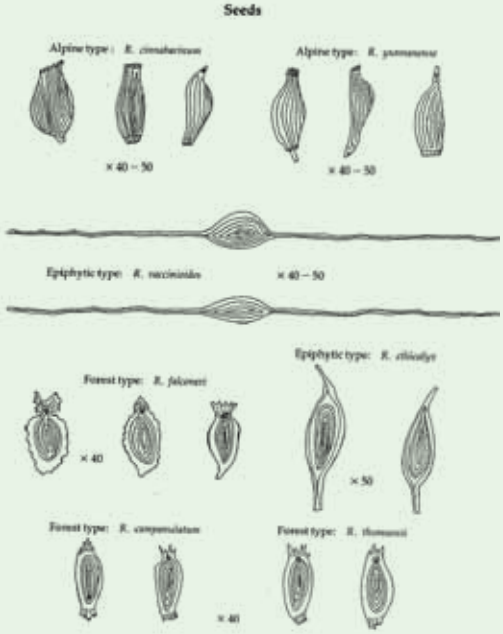


Source: Rhododendron Year Book, 1963. RHS, London

Scales



Seeds



Source: Davidian, H.H., The Rhododendron Species, Vol.I, 1982

lacerate, undulate, vesicular, stalked, sessile, and are in contiguous or discontiguous patterns of the distribution usually with golden-brown, black, dark brown shades. Similarly the seeds of different species also show variation and have been broadly classified into Alpine type (*R. cinnabarinum*), epiphytic type (*R. vaccinioides, R. santapaui*) and forest type (*R. falconeri*) and are usually very small with scanty endosperm. The seeds of *R. vaccinioides* and *R. santapaui* are drawn into long tails on either side characteristic of the species of section *Vireya.*

Global distribution

Over a 1000 species are recorded all over the world and are chiefly found in the N. Hemisphere. Maximum species concentration is seen in areas where the eastern Himalaya, the Xizang Plateau and the mountain ridges of Myanmar and S.W China meet. Some other species are found in Arctic region. The tropical or the Malaysian species which are mostly grouped under the section *Vireya* of the subgenus *Rhododendron* are distributed in the area between and including the Malay Peninsula extending up to the Northern tip of Australia with their concentration and greatest density and diversity on the island of New Guinea. N.W. Yunnan in China with more than 500 species is treated as the prime centre of diversity and evolution of the genus.

Distribution in India

Of the 109 taxa that occur in India, a few species are distributed throughout the Himalayas from Jammu- Kashmir to Arunachal Pradesh (Table 1). The Western Himalayan region from J & K to Uttaranchal has only 6 species while the Eastern Himalayan region comprising Sikkim, Darjeeling and Arunachal Pradesh is represented by 75 species with maximum species diversity in Arunachal Pradesh especially in its eastern most part which lies contiguous with Xizang Plateau, S.E China and Northern Myanmar. The forested hills in the N.E. India account for about 10 taxa of which 6 species are endemic. Only *R. arboreum* subsp. *nilagiricum* endemic to Nilgiris and other nearby mountain regions in Peninsular India is a lone migrant from the Himalayas.

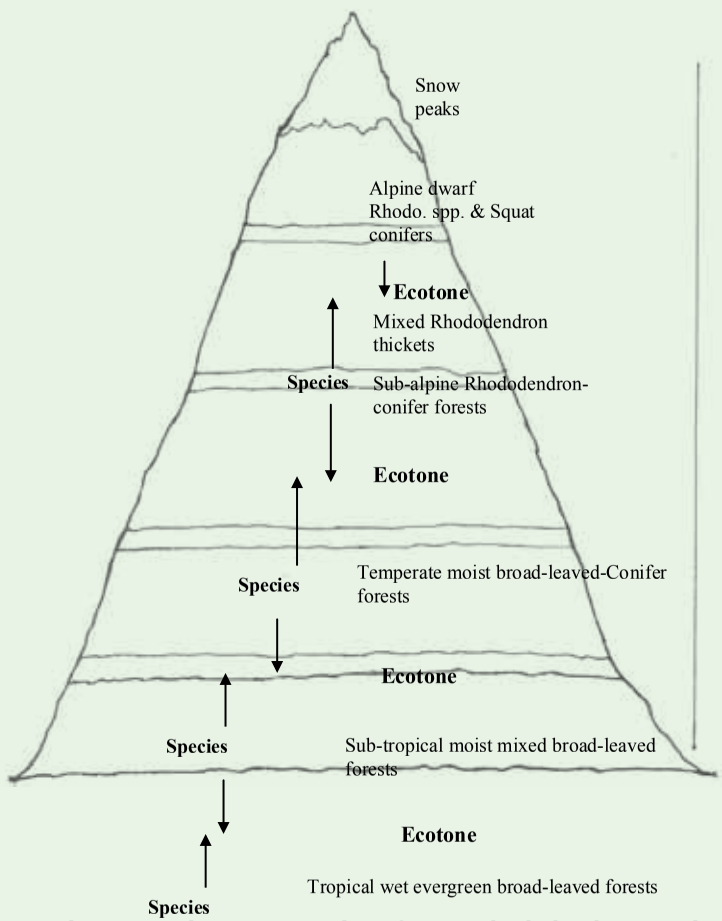
It should be borne in mind that many species are common to some or most of the distribution areas / states in the above 3 geographical regions or biogeographic zones.

Threats and conservation

Extensive natural and man made alterations of *Rhododendron* habitats and excessive dependence on some

Table 1. Distribution of the genus Rhododendron in India

Biogeo-graphic Zone	Western Himalaya			Eastern Himalaya			North East India				Peninsular India
State	J&K	Himachal Pradesh	Uttarakhand	Sikkim	Darjeeling	Arunachal Pradesh	Meghalaya	Manipur	Nagaland	Mizoram	Nilgiris
Species	6	5	5	34	13	75	1	5	2	2	0
Subsp.	1	1	1	1	0	4	0	1	0	0	1
Vars.	0	0	0	2	2	7	2	3	1	0	0



Altitude Range	Some representative Rhododendrons
	R. nivale ssp. nivale
	setosum, lepidotum, chaemaethomsonii, fulgens, campanulatum, campylocarpum, calostrotum
5800 m	
	thomsonii, campanulatum, camelliflorum, wallichii, crinigerum, falconeri, cinnabarinum, collettianum, cephalanthum, lanatum, baileyi, barbatum, calostrotum, maddenii, vaccinioides, anthopogon, keysii, fulvum, hookeri, hodgsonii, lepidotum, ciliatum, barbatum
4200 m	
4100 m	
3600 m	
3500 m	
	anthopogon, hodgsonii, arizelum, vaccinioides, wightii, beenianum, calostrotum, camelliiflorum, lindleyi, campanulatum, arboreum, campylocarpum, concinnoides, dalhousiae, subansiriense, edgeworthii, santapaui, macabeanum, wattii, arb.ssp delavayi var. peramoenum, kendrickii, ciliatum, barbatum, elliottii, falconeri, arboreum, arb. ssp. cinnamomeum, dalhousiae, grande, griffithianum, hookeri, boothii, coxianum, johnstoneanum, walongense, xanthostephanum
2200 m	
2000 m	
1000 m	
800 m	arboreum, formosum var. inaequale, dendricola, nuttallii, veitchianum etc.
	arboreum ssp. nilagiricum
	arboreum ssp. arboreum
0 m	
	None in India

Diagrammatic representation of some Rhododendron species in different vegetation zones in the Himalayas & N.E. India; some with wide altitudinal amplitude. Maximum species are found in Temperate - sub-alpine altitudes

species for fuel wood purposes are the main factors that have rendered many of them to become rare and vulnerable and loose their presence in several places in their distribution range. Some species are naturally rare, sporadic and endemic in their occurrence with niche preference as in the case of epiphytic species. Road building activities, shifting agricultural practices, clear felling of large associated trees in Rhododendron-mixed forests have brought about ecological degradation of Rhododendron habitats and species population. Natural calamities like deficient or excessive rainfall, hot, dry and prolonged summers and snowy winters, landslides and forest fires also take a toll of the species that grow in the high altitudes. These adverse factors negatively influence germination and regeneration of several species.

Rhododendron species also suffer from pathogenic fungal diseases. 10 rust fungi have been reported on the leaves of Asiatic species. Though many species from the Himalaya are in cultivation in the Western countries, not enough care is taken with regard to the species in their natural habitats in India. The Sikkim Forest Department's initiative to designate and protect *Rhododendron* rich areas near Yumthang and Barsey as 'Rhododendron sanctuaries' is a laudable step for insitu conservation of some species. The Shingba sanctuary also protects the locally growing species. Many of the *Rhododendron* species can be grown in the Himalayan region in sheltered areas with well drained, humus rich, moisture holding, acidic soils with pH in the range of 4 – 5.5 under the shade of broad-leaved forests that offer desired filtered sunlight. They can also be propagated from seeds and cuttings. There is an urgent need to develop Arboreta of different *Rhododendron* species in Sikkim and Arunachal Pradesh to conserve and undertake further research in Ecology and Horticulture.

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Finnish experience on Himalayan rhododendrons: climate responses

Osmo Jussila*[1], Kristian Theqvist[1] and Anu Väinölä[12]
1Finnish Rhododendron Society, 2University of Helsinki, Finland
*Invited Speaker (in absentia)

Climatic parameters of Southern Finland

Finland is one of the northernmost countries in Europe, situated between latitudes 60 °N and 70 °N. The climate of Finland is cold-temperate and relatively mild given to its geographical position. In addition to drastic day length variation during the year, our climate is influenced by two major factors: the Atlantic Ocean on the west and the Eurasian continent on the east. It has both maritime and continental characteristics depending on the direction of airflow. Air masses that originate from the Atlantic Ocean bring cool summers and mild winters. Every now and then the continental air masses from Russia and polar region flow to Finland. In winter this leads to very cold and dry weather and the temperature can drop as low as to -35°C even in most sheltered parts on the southern coast.

The rainfall is almost evenly distributed throughout the year and is on average 600-700 mm per year. In Southern Finland 50% of precipitation falls in the growing season. Annual maximum snow depth ranges from about 65 cm in Southern Finland to 110 cm in the north being in average 27 cm in Helsinki.

The growing season in Finland is short and cool. Low temperature sum is major limiting factor for agriculture in Finland. For example culture of corn, rice or grapevine is either unthinkable or economically too hazardous. Baseline for growing degree days GDD calculation is 5°C and average GDD in Helsinki is 1366.

Finland and its adjacent areas, including large parts of Sweden and Russia, lie in the southern boreal region (SB), only the southwestern coast of Finland belongs to hemiboreal region (HB), which is an intermediate zone between boreal and temperate region. Coniferous trees predominate in the hemiboreal zone but there are also a significant number of deciduous species such as oaks, maples, ash trees, birches and hazels. Most of the Finnish Rhododendron collections are located in this area.

On USDA Plant hardiness zone map most of the southern Finland belongs to

USDA zone 5 (average minimum -23.3 … -28.9°C), only southwestern corner and archipelago to zone 6 (average minimum -17.8 … -23.3°C). Finland has also its own hardiness zone map, but in our presentation we'd like to refer to USDA map as it provides an easy and well known guideline for categorizing plants for an average winter.

Introducing plant material for Finnish gardens

If we like to find new plants from other parts of the world to be introduced in our country, we should locate plants that can tolerate low temperature sums and short growing seasons. In addition to low winter temperatures, effective temperature sum and the length of the growing season, photoperiod has a profound effect on plant life in general. At high latitudes the light climate is very different from that of other parts of the world with similar low winter temperatures, for example in mountains.

The photoperiod affects the duration of vegetative growth. Growth continues for longer during the long days in the north than during short days further south. Secondly, winter survival of trees and shrubs is often primarily dependent on the proper timing of acclimation in the fall and de-acclimation in the spring. In many plants the acclimation itself is initiated by photoperiod, first as cessation of growth and then as development of dormancy. Only genotypes that acquire adequate frost resistance before the winter are able to survive.

Evaluation of cold hardiness of some Sikkim Rhododendron species

Introduction of Sikkim rhododendrons to European gardens began already on the 19th century by Englishmen Dr. J. D. Hooker and Dr. A. Campbell among others. Most of the species thrive in maritime climate on the coasts of the Atlantic and Pacific Ocean. In terms of USDA hardiness zones these areas belong to zone 9 with an average minimum temperature of - 7°C.

The hardiest species from high altitude in Sikkim have been introduced also to more continental locations in Europe. Largest collections in Germany, Great Britain, Denmark, Norway and Sweden include species like *Rhododendron campanulatum, R. campanulatum* ssp. *aeruginosum*, *R. wallichii, R. campylocarpum, R. thomsonii*, *R. nivale* and *R. pumilum*. In recent years even more tender species from Sikkim have been introduced to West European collections and gardens which belong to the transient zone from maritime to continental climate and USDA zone 8 (-12°C) and 7 (-17°C). Beyond Zone 7 there are very few *Rhododendron* species from Sikkim living in European collections.

Rhododendrons in Finland

In Finland we have very little experience of Sikkim *Rhododendron* species. Apparently the first introductions of Sikkim species occurred on the eve of the Second World War and because of hard winters in the 1940's and Russian occupation of the most ambitious collection of that time, interest to the Himalayan *Rhododendron* species

waned for decades. In our most renowned collection of rhododendrons at Arboretum Mustila 60° 44' N, 26° 29' E, (60m), southeastern Finland (USDA Zone 4) there are hundreds of *rhododendrons* with some 30 *species* from around the world, mainly from Japan, Northern China, Korea, Russia, Europe and North America. There are no plants from Sikkim.

Not until the 1960's Finns began to collect again decorative plants for their gardens. From that time we have at least *R. campylocarpum* and *R. campanulatum* as mature specimens in some gardens. In the 1970's Turku Botanical Garden made an expedition to Nepal and since then a few *R. campanulatum* specimens are still living in its collection. Since the late 1990's Finland has experienced gardening renaissance and *Rhododendron* are among the most favored families nowadays. Reasons for that are for example advance in education and economical wealth and joining European Union with its open borders, but also the new winter hardy cultivars bred at the University of Helsinki. Rhododendrons are now available also for people living in central and north-central Finland up to 65 °N. Furthermore, winters in Finland have become milder and summers longer and warmer. This climate change permits people to successfully experiment with species and clones which were outright killed in the 1940's and the 1950's.

Our own experiences

Our own experiences of species from Southern Himalayan range are also rather limited. Osmo Jussila's (OJ) garden lies in Naantali and Kristian Theqvist's (KT) garden on an island in the Turku Archipelago, both in southwestern coast of Finland. Minimum temperature during the last 20 years has been -28°C (OJ) or -26°C (KT) and average minimum temperature of last 18 years is -20.6°C thus leading the area to USDA zone 6. Table 1 provides details of rhododendron species experimented in Finland by Osmo Jussila.

Table 1. Rhododendron species, experimented in Finland by Osmo Jussila

Species	Year of purchase	Year of transplant[1]	Year of exitus	Source
R. arboreum cw	1999	2001	2003	Lähteenmäki, Nepal
R. arboreum op	1999	2001	2003	SRS Sweden
R. arizelum op	2001	2004	2005	Scotland
***R. campanulatum* blue cp**	1999	2001		RF, Denmark
***R. campanulatum* cw**	1999	2001		Lähteenmäki, Nepal
R. campylocarpum ssp. *caloxanthum*	2001		2001	Scotland
***R. grande* op**	2000			Scotland
***R. hodgsonii* cp**	2000	2002		ARS USA
R. lanatum	2004	2007		Glendoick
R. lepidotum	1993	1994	1995	SRS Pakistan
R. macabeanum	2001			Scotland
***R. macabeanum* cp**	1998			ARS USA
R. nivale ssp. *nivale*	2001	2001	?	Växus, Sweden
R. pumilum cw	2004		2004	ARS, India
***R. semnoides* op**	2001			Scotland
***R. thomsonii* op**	1999	2002		SRS, Sweden
***R. tsariense* 'Yum Yum'**	2004	2007		Glendoick, Scotland
***R. tsariense* op**	2001			Scotland
R. wallichii cp	1996	1999	2003	ARS, India
***R. wightii* op**	2001			Scotland

[1]Species with no entry on the Year of transplant column were either killed before planting or are in some cases retained in a winter-storage and used for hybridization. - Those written in bold are still alive.

Most of OJ's experiments with southern Himalayan species have been short-lived. However, there are some exceptions: *R. campanulatum*, *R. thomsonii* and rather surprising even *R. hodgsonii* have survived several winters in Naantali. On the other hand, *R. arboreum* seems to be too tender for our climate. *R. thomsonii*, which is now approximately one meter high and has had its first flowers, is presumably a hybrid, and thus it is not correct to say, that *R. thomsonii* would be hardy in Finland. According to the ARS hardiness rating *R. wallichii* should be as hardy as *R. campanulatum* (-21°C), but was killed after a harsh winter 2002/2003.

Almost all of KT's rhododendrons from the Southern Himalayan range are still small seedlings. They have been

Table 2. Rhododendron species with their source, experimented by Kristian Theqvist *(species that have survived transplanted in the garden several winters are written in bold)*

Species	Year of sowing	Year of transplant	Source
R. aeruginosum cw	2006		SRS, Sikkim, Yumthang, 4300 m
R. aeruginosum, low alpine form cw	2006		ARS, DK Expedition to Sikkim, 4700 m
R. anthopogon cw	2006		RHS, Arunachal Pradesh, 4100 m
***R. campanulatum* cw**		2002	Lähteenmäki, Nepal, 3900 m
R. campanulatum cw	2006		SRS, Sikkim, Yumthang, 4300 m
R. campylocarpum cw	2006		RHS, Arunachal Pradesh, 4100 m
R. fulgens cw	2006		RHS, Arunachal Pradesh, 4000 m
R. hodgsonii cw	2005	2008	RHS, Arunachal Pradesh, 3960 m
R. lepidotum cw	2005	2008	RHS, Arunachal Pradesh, 4200 m
R. nivale var. *nivale* cw	2006		ARS, DK Expedition to Sikkim, 4700 m
R. pumilum cp	2005	2008	ARS, Ole Jonny Larsen, Norway
R. pumilum		2006	Hachmann, Germany
R. setosum cw	2006		ARS, DK Expedition to Sikkim, 4700 m
R. thomsonii cw	2006		RHS, Arunachal Pradesh, 4100 m
R. tsariense		2004	Hvidbjerg Planteskole, Denmark
R. tsariense Poluninii Group cw	2006		RHS, Arunachal Pradesh, 4178 m
R. tsariense var. *trimoense* aff. cw	2006		RHS, Arunachal Pradesh, 4268 m
R. wallichii cw	2006		RHS, Arunachal Pradesh, 4100 m
R. wightii cw	2007		RHS, Arunachal Pradesh, 4100 m

grown from seed batches from various seed exchanges. *R. campanulatum*, *R. tsariense* and *R. pumilum* have thrived as planted in the forest garden without any damage for several years. At least some seedlings of all batches are alive. Kristian Theqvist has experimented with many species (Table 2).

Using Sikkim Rhododendron species in hybridizing

Several Sikkim rhododendron species have been used in hybridizing with hardy rhododendrons by the Rhododendron

Table 3. Rhododendron species used in Finnish hybridization

Species	Used in Finnish hybridization, crossed with
R. arboreum	*brachycarpum* var. *tigerstedtii*
R. barbatum	*brachycarpum* var. *tigerstedtii*, 'Hellikki', 'Mikkeli', 'P.M.A. Tigerstedt', 'Pekka'
R. campanulatum	'Haaga', 'Kullervo', 'Mikkeli'
R. campylocarpum	'Elsie', 'Kullervo', 'Mikkeli', 'P.M.A. Tigerstedt'
R. cinnabarinum ssp. *cinnabarinum*	*tomentosum*
R. cinnabarinum ssp. *xanthocodon*	*tomentosum*
R. edgeworthii	*tomentosum*
R. falconeri	'P.M.A. Tigerstedt' x (*hodgsonii* x *falconeri*)
R. grande	*brachycarpum* var. *tigerstedtii*, 'Helsinki University', 'Pekka'
R. hodgsonii	'Hellikki', 'Kullervo', 'Mauritz', 'P.M.A. Tigerstedt', 'Pekka'
R. lindleyi	*tomentosum*, *dauricum*
R. thomsonii	*brachycarpum* var. *tigerstedtii*, *brachycarpum*, (*brachycarpum* var. *tigerstedtii* x *smirnowii*), *smirnowii*, 'Elsie', 'Hellikki'
R. wightii	'Mikkeli', 'P.M.A. Tigerstedt'

Society members Osmo Jussila, Kristian Theqvist and Jaakko Saarinen as a hobby. The hybridizing team makes crosses between rhododendrons with desired characteristics (red or yellow flowers, large leaves, attractive indumentum) and species or hybrids which are hardy in Finland (Table 3). The most important seed partners are *R. brachycarpum* var. *tigerstedtii*, *R. smirnowii, R. tomentosum* and hardy Finnish cultivars. The results obtained so far are encouraging although the plant material from those crosses is still too young for evaluation.

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Phenology and climate responses in Himalayan rhododendrons

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The Climate change and global warming are well acknowledged alarming phenomenon today, threatening natural resources, commonly and beyond the political boundaries of the nations worldwide. In the 20th century, global average temperature increased to 0.6+0.2 ^{0}C; however, global air temperature is predicted to rise 1.8 to 4.0 ^{0}C over the current century (Intergovernmental Panel on Climate Change, 2007). The deteriorating impacts of changes, on natural resources, due to global warming have been seen, drastically, in recent times. These changes can be examined on physical and biological resources/ systems, taking appropriate indicators using scientific tools. The resulting impacts of global climate change can earlier be looked at in various physical systems (glaciers, rivers, lakes, etc.) and biological systems (biodiversity components, plant phenology, habitats, etc.) worldwide. Particularly, the terrestrial biodiversity depicts consistently the perceived and observed trends and changes. However, under on-going changing environmental scenario, especially global warming, there is limited probability that the natural resources can retain their natural forms. Perpetual availability of natural resources, including the fresh water and food, is under threat in coming time. In the south-Asian sub-region, especially the Himalayan ecological system is the most sensitive to climate (Figure 1) change and global warming. Himalaya comprises of 33000 Km^{2} of melting glaciers, which are considered vulnerable to global warming. In coming decades several glaciers in Himalayan region are likely to retreat, whereas, the smaller glaciers may disappear entirely (IPCC, 2007a; 2007b).

From the biodiversity point of view, there are many impacts of climate change which often be observed in natural as well as man made eco-systems, such as, the earlier onset of spring events in biological species, lengthening growing season in plants, etc. Studies on the shifts in timing and lengthening of the growing season, based on phenological, satellite and climatological observations have increased in recent times; the evidence points to a lengthening of the growing season of ca. 10–20 days in the last few decades, where an earlier

Figure 1. Himalayan ecosystem is the most sensitive to climate change

onset of the start is most prominent, such extension of the growing season has been associated with recent global warming (Linderholm, 2006). Various fragmentations are reasonably noticeable, such as forest fragmentation, habitat degradation, species loss, and alterations in crop cycle and increasing susceptibility for pests and diseases, etc., which eye encounters easily. Unseen resource fragmentations are there, such as varying adaptability and altered seasonal biological rhythms of wild taxa, etc. The variability in 'adaptation mechanism' of species against the shifting environments, either the result of global warming or by means of local factors, is a quiet process, which exercises negative pressures on the existence of genetic resources, especially those of high value and/or endemic or rare and already recognized threatened taxa.

Influence of the climate on biota

In living organisms the distributional change, mainly of those geographical ranges are controlled by temperature can be used in predicting global warming (Walther *et al.,* 2003). For having a series of climatically highly changeable zones fall within short distances and altitudinal differences, the Himalayas display diverse micro-habitats and potentially rich biodiversity. Simultaneously, however, Himalayan Mountains and associated areas are greatly sensitive to global warming and markedly display the signatures

of landscapes' degradation and habitat fragmentation (Xu and Wilkes, 2004). In case of high altitude plants especially of Himalaya, even minor changes in microclimate may exert a possible impact on the species distribution and survival (Purohit, 2002). Widespread reporting on the upward movement of the tree line and encroachment of woody vegetation on alpine meadows due to global warming are on hand (Eriksson *et al*., 2009).

The insects are exceedingly sensitive to changes in temperatures; their life cycle, activities; phenology and even survival are influenced by the temperature (Karban and Strauss, 2004). A lot of high altitude medicinal herbs could be very sensitive to high temperature for their susceptibility towards insect infestation (Badola and Butola, 2005). Over decade of experiments on several Himalayan plants, I have personally recorded the high altitude taxa when brought to low and warmer altitudes during cultivation and domestication, attain early flowering; however, owing to rapid growth and development, the fruits do not mature enough and get aborted and/or infested with the insects (Badola, 2002); similar preliminary observations are in notice on rhododendrons. Also, the shifts in the timing of flowering and fruiting have been observed in case of Himalayan rhododendrons in central part and Himachal Pradesh of Indian Himalaya over a decade each and in Sikkim for over half a decade (Badola; unpublished.

Phenology - an indicator of climate change

Phenology, the discipline of the timing of recurring biological events, influenced by seasonal environmental factors, such as temperature and precipitation, etc. (Badola, 1994; Jeffrey *et al*., 2009), offers a high-temporal resolution of on-going changes using their date wise records (Menzel *et al*., 2001; 2006) is well acknowledged as one of the most preferred indicators of climate change. In temperate climates, plant phenology is intricately linked to the variation in weather on short term (days to weeks) and in climate on long term (years to centuries), supply back to the atmosphere and climate system, and influences the ecological interactions at multiple scales from individual to community to ecosystem and trophic (producers to consumers) levels (Jeffrey *et al*., 2009.

The bud phenology of trees, especially of rhododendrons (Figure 2), may provide vital information on the timings of phenological events, necessary for tree improvement, important to tree physiologists and siliviculturists, and give essential clues to develop climate driven simulations (models), helpful to predict climate change in long run. Determined by the genetics and environmental factors, phenology is relatively a less costlier and simple to handle as one of the potential tools to match global warming pattern (Menzel *et al*., 2006, Badola, 2009), which may match the warming pattern, both at location specific areas as well as at wider level, across countries, using individual species to a group of species. Different species may attain greater resilience to global warming. Phenology of plants is greatly sensitive to climatic factors (Badola *et al*., 1992; Badola, 1994).A slightest change in global warming can likely be detected by using phenology.

Figure 2. Rhododendron buds- highly appropriate tool providing important clues on climate change (Photo by: H.K. Badola)

Systematic recording of phenology was led by Europe in 19th century onwards, which is however, least practiced in south-east Asian countries. Mostly, the phenological data were available in old records pertain to horticultural recording in orchards by amateur practitioner, not by the scientists in general. One of the good examples of using long years' phenological data was on *Betula pendula*, where Hari and Hakkinen (1991) used the phenology time series especially on bud burst date of period from 1907 to 1950 and assessed that temperature sum predicted the date of bud burst. Out of total publications appeared on phenology and climate change worldwide during 1997 to 2006, about 5 percent appeared between 1997 and 1998 and over 15 percent between 2005 and 2006, which showed a tremendous interest of using phenology as indicator of climate change. For China, Zheng *et al*. (2002) assessed the change of plant phenophase in spring and the impact of climate warming on the plant phenophase for the last 40 years, using data from 26 stations in the 'Chinese 'Phenology Observation Network' on plant phenology, and showed that the response of phenophase advance (or delay) to temperature change was non-linear.

Worldwide, in several countries, phenological observations are used to monitor global warming for several decades by establishing phenological gardens and other stations. There

are phenological network data sets are available and being managed periodically in the present time (Menzel *et al*., 2006). A massive interpretation of phenological data sets, obtained for the year between 1971 and 2000, of 542 plant and 19 animal species, from 21 European countries, including 14 international phenological Gardens, indicated the advancement of 78% events, with an average advance of 2.5 days/decade of spring/summer in Europe during the year 1969-1976 (Menzel *et al*., 2006). There are examples include few identified Indian Himalayan taxa (including medicinal herbs and rhododendrons) and experienced gained worldwide, which can be helpful addressing phenological monitoring programme on climate change in Himalaya, especially Sikkim. Amongst identified taxa, rhododendrons offer one of the potential resource to monitor global warming and climate change.

Why rhododendrons?

For centuries Rhododendrons have fascinated the world, with a total diversity of approximately 960 species. The vast section of southeastern Asia, extending from northwestern Himalayas (Nepal, Sikkim, eastern Tibet, Bhutan, Arunanchal Pradesh, northern Myanmar and western and central China), and subsequently southward through Thailand and Vietnam to the Malay Sates, Indonesia and the Philippine islands, about ninety percent of world's rhododendron wealth found in this region (Leach, 1961). The western China alone represents about 542 species, of that 227 species are recorded from Yunnan-China (Fang, 1999).

Rhododendrons in China represent a large reservoir of 571 species, including 409 endemics. In eastern sub-region of Himalaya, rhododendron rich part is north-east India, especially the Arunachal Pradesh with 61 species, the Sikkim representing 36 species and Darjeeling hill maintains 12 reported species. For India, only 80 species of Rhododendrons are known. Nepal represents over 30 species and Bhutan has 46 reported species; the later is particularly more affluent in terms of a smaller geographical area. At the same time, species such as *Rhododendron arboreum* (national flower of Nepal), *R. niveum* (state flower of Sikkim), etc have been given due honour by various Governments.

The *Rhododendron arboreum* (Gurans/ Burans) is a beautiful scarlet flowering tree and a key stone species of Himalayan forests (Figure 3), and besides having medicinal properties, the petals of the flowers are used for making health juice (Badola, 1992) and to stop excessive bleeding in female when mixed with water (Pradhan

Figure 3. *Rhododendron arboreum*, a key stone species of Himalayan forests and potential candidate for monitoring global warming
(Photo by H.K. Badola)

and Badola, 2008), etc. However, the efforts for rhododendron conservation are relatively bleak, as the wood of the plant is a very good source of fuel and in addition, the habitat degradation in many areas has already shown the sign of its heavy depletion. The Sikkim, on the other hand, a state has given full protection to the rhododendrons, mainly by establishing two unique rhododendron sanctuaries, *viz*. Singba Barsey (Badola and Pradhan, 2009), besides Khangchendzonga Biosphere Reserve, which is a home for many rhododendron species. Rhododendrons play a great role in ecological stability of ecosystems, as the indicators of forest health, and sensitive to climatic variability (Badola and Paliwal, 1987; Badola et al., 1992, Badola, 1994).

Owing to stunning colour range and large size of flowers, and also of the seasonal colouration of leaves, a typical light green hue during bud flushing, etc, i.e. all high grade phenological expressions, the rhododendron populations are easily distinguishable in fascinating landscapes (Badola and Pradhan, 2010) and that make convenient to monitor broad phenological changes at community level, both through conventional methods or by taking help of remote sensing data. Even data record from arboretum and herbarium sheets help understanding long term fluctuations in the phenological dates in relation to changing climate figures over time.

Primack *et al*. (2004) made a comparison of existing flowering dates of identified individuals, in 10 native genera including *Rhododendron* growing in the Arnold Arboretum (Boston), with available herbarium records on flowering time over a long stretch between the years 1885 and 2002, and revealed that the current flowering dates averaged nearly eight days earlier over the last 100 years; they further suggested the sensitivity of plants towards warmer temperatures especially in the months of February to May.

Rhododendrons- Phenology and climate response

In trees, phenology differs to a limited degree as a consequence of regular variations between the individuals; and a larger degree within geographical distribution of the species. Rhododendrons have great vertical spread in their distribution in natural habitats in Himalaya; for example, *R. campanulatum* and *R. wallichi* goes up to 4150 m.a.s.l., where temperature may occur <)-15^{0}C. In rhododendrons, spring bud burst can be observed several days later in individuals growing at higher altitude than in individuals from lower elevations (Badola, 1994).

The other very suitable example is *Rhododendron arboreum*, which is distributed in W Guizhou, S Xizang, Bhutan, N-E India, Kashmir, Nepal, N Thailand, N Vietnam, thus covering a diversified and wide landscape; and high sensitivity of buds (of meristematic cells) for flushing and flowering towards a slight change in weather conditions offers it as ideal taxa for monitoring climate change on long term basis. The characteristic flexible vertical distribution limits of *R. arboreum*, ranging from sub-tropical to high alpine zones (average, 1500-4000m), thus sustaining maximum temperature limits of all rhododendron species and grows even where frost is not frequent

(Vetaas, 2000), and consequently this species becomes immensely suitable candidate to be used in monitoring climate change and global warming.

The *R. arboreum* is an indicator species and important forest element. As the *R. arboreum* commonly found in north-western, central and north-eastern parts of Indian Himalaya, it provides an interesting example of phenological variations within time limits along altitudes. The developmental events following spring bud flushing turns overblown and leads to rapid changes at higher elevations, comparing to those at lower altitudes; here, all bud phenological events have a bearing with various climatic factors (Badola and Paliwal, 1987). It is interesting to know that *R. arboreum* exhibits several levels of ecological adaptabilities, i.e. adopting large size tree habit at low temperate to dwarf habit at alpine region. Temperature governs growth patterns are highly indicative of phenological expressions at different altitudinal zones, which can be taken as an indicator of periodical climate related monitoring. Very high eco-climatic adaptability is an indicative that this species may sustain global warming up to greater extent.

The eyes normally presume the spring growth with the event of bud sprouting or flushing in temperate species, which form robust winter buds; however, in actual a conspicuous changes in metabolic level, expressing mild bud swelling, occur within apical shoots especially in the bud scales and basal pith region especially in case of rhododendron (Badola and Paliwal, 1987; Badola *et a*l., 1992).

In early spring, the buds in temperate trees, externally looked dormant, in fact undergo speedy cell division many weeks prior to swelling or sprouting initiated in temperate trees (Owens 1984; Badola and Paliwal, 1987; Badola, *et al*., 1992; Badola, 1994). Internally, in case of *R. arboreum*, the buds when undergo winter dormancy accumulate high amount of insoluble polysaccharides (starch) and tannins and on the onset of spring, when temperature rises, the tannin (hydrolysable type) gets fragmented and starch granules dissolved and utilizes as energy source for metabolic process helping morphogenesis (Badola and Paliwal, 1986; 1987). Such a temperature determined bud awakening is crucial for spring shoot growth and blooming, as one of the marked phenological phase.

In most of the rhododendrons, especially in *R. arboreum* (Badola and Paliwal, 1987), *R. grande* and *R. dalhousiae* (Badola, unpublished), the temperature determined shoot elongation appear as a result of internal elongation between leaf primordial and partly between bud scales, which in turn vividly expressed morphologically. These events year to year are correlated with climatic data, especially temperature.

At the time of spring, rising temperature also reactivate the cambium, which indicates a firm relationship between bud phenology and trunk growth, which further govern by climatic factors (Figure 4); the relationship between bud phenology and temperature is significant; here, it is interesting that there is nuclear area/ cell area in the buds indicate the temperature stimulated mitotic activity (Badola *et al.*, 1992; Badola, 1994).

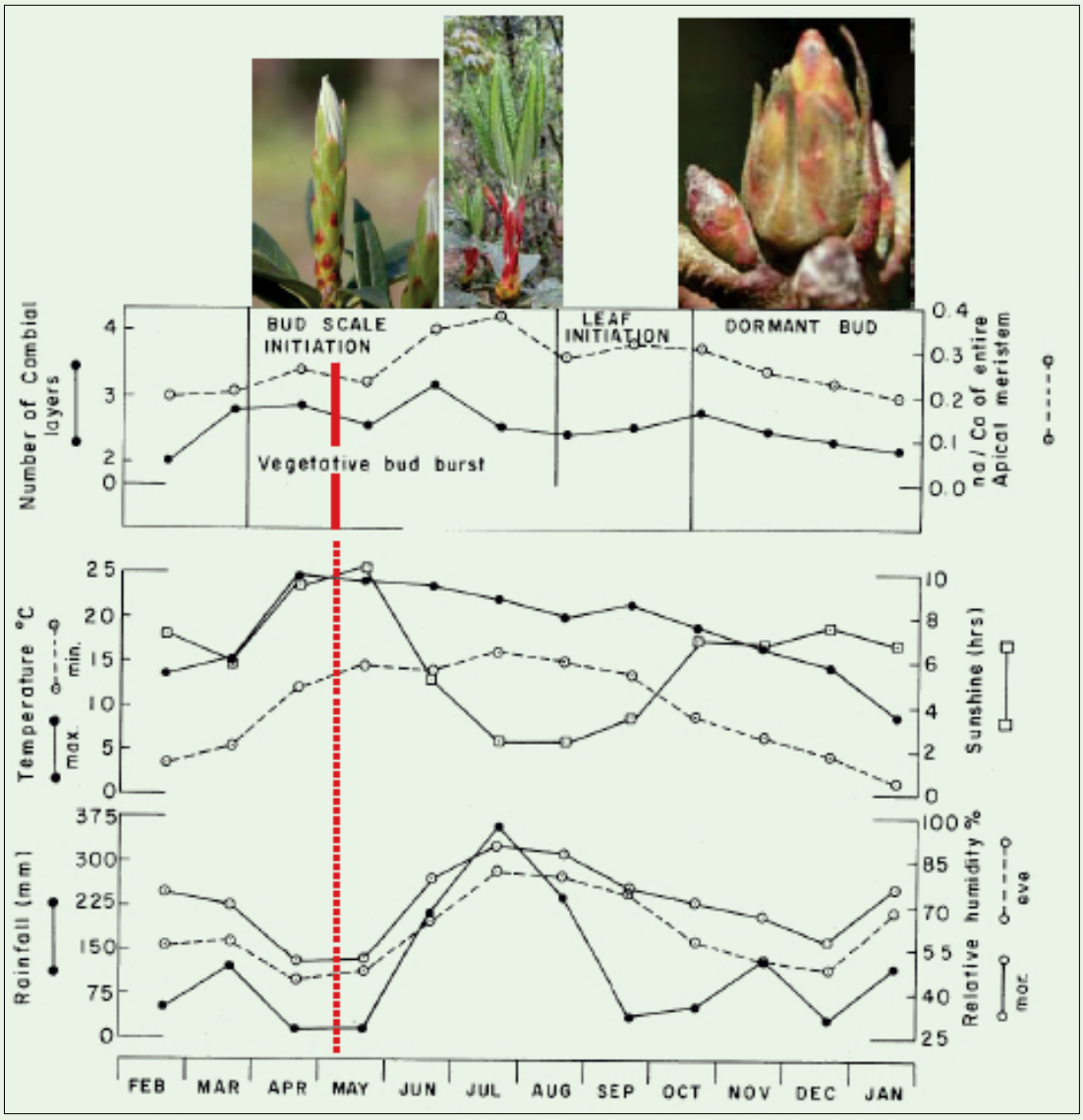

Figure 4. Bud phenology and climate response in *Rhododendron arboreum* (Modified, *based on* Badola *et al*., 1992; Badola, 1994)

Weather sensitive species, the *Rhododendron dalhousiae*, aesthetically acclaimed worldwide and widely distributed in Nepal, India (Darjeeling, Sikkim, and Arunachal Pradesh), Bhutan and China (S. Xizang), is experienced as an indicator species of healthy forest eco-system and rich forests (commonly found) in eastern sub-region (India), is another potential candidate for the phenological monitoring of global warming, as discussed (Figure 5). Here, author has investigated the bud sproutings (both vegetative and floral)

are significantly correlated with both maximum and minimum temperature (Badola, unpublished).

There are other rhododendron species too, which show vital clues for their distribution range and for adapting to climatic conditions invariably. The cases of *R. maddenii* and *R. grande* are there. Recently, using phenological expression, a new massive population was explored in north Sikkim, where number of plants were estimated to be as high as 0.14 million within 10 hectare area, thus questioning the rarity and endangerment of the species, envisaged if any (Badola and Pradhan, 2010); however, study interpreted with these gregarious population with global warming and recommended the need for more explorations covering wide wilderness, relatively un-explored in Sikkim and elsewhere in Himalaya.

Conclusion

The warming of climate may cause change in several levels in plants. The early flowering but loss of mature fruiting or aborted fruiting or infestation of insects on fruits; or viability loss of developed seeds or empty seeds due to faster rate of development over naturally slow development in natural temperature are bound to be encountered. Many of the rhododendrons, especially of high altitude zones, are very sensitive to specific climatic conditions and may be susceptible to slight change in temperature.

In recent years, global warming and climate change have emerged as unprecedented truth; consequences of which the world is bound to face, unless some sound mechanism is placed at policy level (implementation) and by following scientifically based guidelines.

Figure 5. *Rhododendron dalhousiae* in Sikkim, a potential candidate for phenology based monitoring of climate change (Photo by H.K. Badola)

Due to global warming various perceived and observed trends and alterations are depicted in terrestrial biodiversity.

The paper concludes, spring phenological signal, especially from the buds of rhododendrons should be used to monitor global warming, as perfect indicator for climate change impacts; rhododendrons are ideal taxa to monitor climate change; need for establishing phenological gardens along varied altitudinal zones , more or less similar physiographical conditions, across Himalayan regions; formation of identified group of scientists and area managers from related parts of sub-region, for simultaneous monitoring, using common approach; and, an agreement amongst Himalayan countries and states, developing a common pool of information to establish facts under scientific analyzed data sets with common credit sharing amongst partners.

An Action Plan for Sikkim Himalaya, with wider application elsewhere in Himalaya, using Rhododendron phenology in monitoring climate change is provided below:

- Permanent monitoring plots (ideally, 30x60 m approx) and Phenology Gardens preferably at 5 altitudinal zones, viz., Zone- 1 (1600-2100m). Zone- 2 (2100-2600m), Zone- 3 (2600-3100m), Zone- 4 (3100-3600m), and Zone-5 (3600-4100m).
- Mark each individual of targeted taxa, as per availability in the identified altitude belt: *Rhododendron arboreum, R. dalhousiae, R. grande, R. campanulatum*, etc. (limit 10 to 20 individuals at each zone).
- Install the Automatic Weather Station at each altitude zone.
- Establishment of permanent monitoring Huts at each altitude zone.
- Field Staffs need to be trained and exposed to phenology science.
- Weekly data recording throughout year would be important; daily observations during spring time are vital *(Tag the buds in standardized numbers at winter time, measure them, start observations following early spring)*
- Data computation and analysis as periodical process.
- Modeling (simulations) for on-going and future trends.
- Publish and disseminate data based outcome in various forms (both print and digital in web sites).
- Use outcome for area management and policy implementations.
- Develop strong programme teams of expert scientists/ phenologists and area managers, in collaboration, are a must for the successful venture.

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Rhododendron conservation and the protection of the habitat: Perspectives from a south Indian tropical mountain eco-system

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In this paper I attempt to highlight the current status of the rhododendron species endemic to the Palni Hills and adjacent areas of the Western Ghats in South India, and the impact of various developments on the habitat of the rhododendron. Our rhododendron, *R. arboreum* subspecies nilagaricum, is the only species which occurs over the Palni Hills, an eastern offshoot of the Western Ghats, as also in the Nilgiri Mountains to the north, as well as in some other high altitude portions of the main Western Ghats chain. This species is found only at altitudes in excess of 1500 meters, where a quasi-temperate climate prevails – strictly speaking, tropical mountain climate. In Kodaikanal, altitude 2000 m., the chief town of the hills, the temperature range is narrow---25 degrees C. summer maximum and 4 degrees C winter minimum and this is typical of this type of climate.

This species is distinguished as a subspecies of *R. arboreum* itself, which is the typical low altitude rhododendron of the Himalayas, but bears a surprisingly close resemblance to *R. arboreum* eco-types in India's north-eastern states. When we look at problems of conservation, environmentalists have learnt (painfully!) that it does not pay to focus on a glamorous animal, like the tiger, or a glamorous plant, like the rhododendron – our conservation efforts have to be squarely on protecting the habitat.

The habitat I am talking about is the Palni Hills, an area of some 2000 sqkm, of which the upper plateau, about 400 sqkm, with altitudes of 1500-2500m. is the habitat of this rhododendron. The unique feature of the Palni Hills is that, being an eastern offshoot of the Western Ghats, the species distribution is somewhat different from the main Western Ghats, and includes many species typical of the Eastern Ghats mountains of peninsular India.

Another distinctive feature is that this area receives its maximum rainfall during October to December, i.e. during

the retreating South West Monsoon, which is called the North East Monsoon. This is of vital importance as it provides much needed post South West monsoon supplementation of irrigation supplies during the crucial period before the main rice crop of the Tamil Nadu State plains is harvested, from January onwards. It is indeed surprising that such an important eco-system is under gave threat from various factors. Before analyzing this I would like to describe the main features of the forests of the region which essentially, and especially in the upper plateau consists of 2 components;

1. The shola forests—the unique evergreen quasi-temperate forests, with many broad-leaved species, and
2. The grasslands.

This pattern had ensured that the area's vital role as the major water source for southern Tamil Nadu was adequately performed in the past. Briefly, the shola forests with their deep leaf-litter retained as much as 1/3rd of the rain which fell on them and thereafter slowly released the stored water into the streams which originated from them, which were rendered almost perennial, and the grasslands provided erosion control, fodder for the animal species, and an immediate supply of water after rain. Sadly, this pattern has been seriously disturbed by conversion of vast areas of grassland to commercial plantations, chiefly of wattle *(Acacia dealbata*), the bark of which is used by the tanning industry, and eucalyptus (*E. globulus*), as a source of raw material for wood-pulp based industries.

Another threat is unplanned urbanization. The consequences of this conversion of grasslands are immediate and obvious. One very serious effect is that animal species like the gaur are deprived of fodder and therefore invade cultivated lands, thereby intensifying man-animal conflicts. This factor, along with unplanned agriculture expansion, cutting across elephant corridors, and increasing elephant attacks on farmlands has led to serious alienation of the local community from efforts to protect the forests. No conservation programme will be successful unless it has the whole-hearted support of the local community—and this is an entirely man-made dilemma. Such considerations have come in the way of a proposal to notify a Palni Hills Sanctuary, pending for more than 10 years.

Another factor threatening the habitat is the change in the climate of the hills, arising from local deforestation as well as climate change arising from global factors. Studies have shown that of the total rainfall of more than 1600 mm. in the Palni Hills, nearly 30% falls as summer rains, from March to May, and the quantum of this has reduced, and the intervals between successive showers increased, leading to predictable consequences. That the climate of the hills is changing is exemplified by the fact that species like *Tithonia diversifolia* and *Ipomea indica*, earlier found below 1800 m. are now climbing to mountain-tops within the last decade.

Our rhododendron is the typical inhabitant of the interface between shola forests and grasslands. At present it does not seem to be seriously threatened in

our area, but the situation is certainly much worse in the Nilgiri Mountains, where the eastern parts especially have seen a substantial decline in rhododendron populations, consequent on the expansion of plantation crops and farming. It is significant to note that in the western parts, the rhododendron is better protected by the local tribe of the area, the pastoral Todas, who indeed, worship the rhododendron, which is an integral part of their culture, which again underlines the importance of local community participation in conservation.

Our rhododendron survives to a large extent because of the thick bark protecting it from forest fires which are a major hazard. But we should not be lulled into false complacency by the plant in focus being comparatively unthreatened. In the Palni Hills there are already many plants either extinct or gravely threatened, by over-collection or by climate change— for example, the orchid Aerides *crispum, Lilium neilgherrense*, *Hoya wightii* subspecies Pulneyensis and the tree fern, *Cyathea crinata.* Even the folklore plant, the Kurunji (*Strobilanthes kunthianus*), which has the unique feature of flowering only every twelve years, is in sharp decline. This threat to other species is a clear pointer of habitat decline, which cannot be without an impact on the rhododendron.

A few words on *R. arboreum* itself – the typical form is a plant of tree-like proportions with brilliant red flowers though there is a colour range in different plants, from light pink, dark pink and red. One of the most interesting recent developments is the discovery of a white form of the species in an area called Avalanche in the Nilgiris by Dr Tarun Chhabra. The existence of this white form, which surprisingly escaped the quite intensive botanizing of the area before and after Independence, is entirely because Dr Chhabra is one of the few non-tribals to have gained the confidence of the Todas, who led the way to the discovery. This white form is indeed quite distinctive, flowering in late autumn rather than in late winter, like the typical species, and with foliage closely resembling *the R. arboreum* of the Himalayas. It has been registered with the International Registration Authority as *R. arboreum* ssp. nilagaricum. 'Tarun'.

But the occurrence of such a variant, perhaps even a new species, is a pointer to the need to intensify our efforts at locating desirable ecotypes which deserve special attention in our conservation programme. We cannot talk of conservation of rhododendron species without singling out important ecotypes. To illustrate this we may note that of the various ecotypes of *R. yakushimanum*, so extensively used in modern hybridization, it is the dwarf form which inhabits the top of Mount Yakushima which is the one employed in breeding. Similarly, the Lachung form of *R. arboreum* is an eco-type very distinct and attractive. Other examples include the forms of *R. wightii* with well shaped trusses, and talking of Vireyas, the *R. zoelleri* form which occurs nearly at sea level in Papua New Guinea. These are a few examples which illustrate the vital need to ensure that desirable eco-types are part of the focus on species conservation.

Again, in the context of global warming, we have to reassess our conservation

strategies. Of the two methods of species conservation –in situ conservation and ex situ conservation, the latter may perhaps become increasingly important in a situation of climate change. There is talk of melting Himalayan glaciers at an increasing rate. Without going further into this question on which there seems to be some conflict of views, we may note that there are some disturbing trends – for example, the decline of the apple crop in Himachal Pradesh area of the Himalayas, which is attributed to the fall in the number of hours of chilling in recent years.

The need for intensifying ex situ conservation has come precisely at a stage at which the zeal to protect genetic resources has led to increasing problems in access to indigenous species even by reputed non-commercial organizations. A change in policy is indeed required. Two additional points on habitat protection and conservation are relevant. The first is the need to base protection efforts on careful scientific observations lest our efforts become counter productive. A typical case is the Valley of Flowers National Park in central Himalayas where the creation of the park led to the over-running of the *meconopsis* (Himalayan Blue Poppy) population by the overwhelming increase in *polygonum* species, which had earlier been kept under control by grazing.

The second issue is eco-tourism. This is by no means free of hazards and unless strictly regulated, could lead to unsustainable increase in the demand for scarce resources, especially water. I have in mind the instance of a proposal to tap a major stream in our hills to cater to the needs of tourism, much to the detriment of the habitat.

May I conclude by noting that the problems of the Palni Hills habitat are likely to be an indicator of similar situations in many tropical mountain ecosystems- in Srilanka, Malaysia, Indonesia and Papua New Guinea which are home to a host of rhododendron species?

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Rhododendrons in the Netherlands and Belgium

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*Invited Speaker

The Netherlands do not have Species Rhododendrons that originate in that country. In private gardens and public parks in the Netherlands you find many Rhododendrons both species and hybrids. But the species come from elsewhere and the hybrids only for a small percentage come from Dutch hybridizers.

The period from 1910-1940 was the high-day of the Dutch hybridizers. During that period the cultivation of species rhododendrons and hybrids was concentrated in nurseries in the town of Boskoop. During the First World War (1914-1918) the Netherlands was a neutral country (not involved in this war) consequently there was no war damage and no young man (soldiers) were killed so no knowledge about the cultivation and hybridizing of Rhododendrons was lost. Compared with neighboring countries like France, Belgium, England and Germany after World War I the nurseries in the Netherlands had the knowledge and the capabilities to produce rhododendrons and export them to surrounding countries especially to the richer people with large estates. These large estates had often missed the necessary care during the war years so there was after the war an important back demand for rhododendrons.

The Dutch hybridizers used for their crosses mainly rhododendrons that have their origin in Sikkim or North East India in general. They used especially, *Rhododendron griffithianum, R. arboretum* and sometimes also *R. campylocarpum*. Well known crosses that originate from that time are, Harvest Moon, Mrs. Charles E. Pearson, The Honorable Jean Marie de Montague, Van Nes Sensation, Brittania, *etc*. In 1940 World War II started and during the war years the interest in the cultivation of rhododendrons quickly disappeared.

After the war – so after 1945 – and during the 1950ies, Europe had to be rebuilt. There was shortage of almost everything and gardening had a very low priority in the spending pattern of the European consumer. That changed in the 1960´s. However, by that time, capable hybridizers of the twenties and the thirties were too old to pick up the job again or had lost their interest in

hybridizing. The general public in that time was more interested in heathy gardens than in rhododendron gardens. So the sixties and the seventies of the last century was a period of almost no demand for rhododendrons in the market.

In the eighties and nineties of last century there was a revival of the interest in rhododendrons. People traveled more within Europe and saw the fantastic woodland gardens especially in England and to a lesser extent in Germany and France with magnificent displays of rhododendrons. Also nice new hybrids came on the market, mostly small growing plants well suited for small gardens. These new hybrids came from the USA, Germany and England. Dutch hybridizers had disappeared from the market almost completely. Our nurseries now offer the hybrids that suit the present taste in the market. The present taste is for plants that grow slowly (say 1 meter in 10 years), flower quickly (say within 3 years) and can stand cold winters (say minus 15°C). These plants excellently fit into the needs of a gardener with a small garden.

Well-known arboreta in the Netherlands with large collections of rhododendrons are Trompenburg and Belmonte. The Trompenburg arboretum is a public park in Rotterdam. Originally, it was in private hands. The family Van Hoei Smith was the owner. But the operational cost became too high for a private family. So now the park is brought into a special foundation sponsored heavily by the local government of Rotterdam. Another well known arboretum in the Netherlands is the Belmonte. The Belmonte arboretum was set up as cooperation between the Agricultural University of Wageningen, the Dutch Rhododendron Society and the local government of Wageningen, which is owner of the ground. The Dutch Rhododendron Society is responsible for a well balanced collection of rhododendrons in the arboretum. The local government pays for the operational cost of the garden.

In Belgium, in the 19th century a group of nursery men started to develop azaleas' that could stand cold winters. This group was situated in the environment of the city of Gent and the azaleas they developed were called "Harde Gentse" which means "winter hardy azaleas' from Gent". These azaleas became quite famous in the second part of the 19the century, all over Europe. Some years ago a member of our Belgium/Dutch chapter formed with two people interested in the history of azaleas, a study group that started to collect information about Hardy Gentse, their characteristics and the hybridizers that developed them. Recently they published a book about these azaleas. The book is in Dutch, but the nice pictures in it tell the story independently of the text. We offered a copy of this book to Keshab Pradhan who was very helpful in making possible the visit of the Dutch delegates to the Rhododendron Festival in Sikkim. We would have loved to bring more copies with us, but the book is very heavy so the high rates for overweight of the air companies prevented that.

Important arboreta in Belgium are first "Het Leen" owned by the local government of the region where this arboretum is located. This arboretum was recently started on a piece of

land of about 40 ha within a woodland setting of more than 400 ha. Until a few years ago this area of 400 ha was in use with the Belgium Army. But the Army had no need for this land any longer. The arboretum is young but looks very promising for the future. Apart from rhododendrons they cultivate in "Het Leen" also camellia's, magnolia´s and conifers.

The most important collection in Belgium however, is the rhododendrons of Viscount Phillipe de Spoelbergh on his large estate in the neighborhood of the city of Louvein. The Phillipe´s collection is one of the best in Europe. Next to his estate with the rhododendron collection, Philippe has realized a large collection of magnolias, camellias, conifers and other decorative shrubs, incorporated in a special foundation. Philippe de Spoelbergh is a member of the Dutch/Belgium chapter of the Rhododendron Society and a Director of the American Rhododendron Species Foundation (RSF).

The nurseries, which are specialized in Hardy Gentse azaleas include, nursery Mathys and nursery Hendrik van Oost. At the end of my paper about rhododendrons in the Netherlands I will draw the readers' attention to a special Website developed in our country. The name of this website is "Hirsutum". It was developed by Herman van Rhee, a member of our Dutch Rhododendron Society.

Hirsutum is a large database with a lot of easily accessible information about rhododendrons. As a visitor you can make in this website all kinds of connections. For example you can start with a species rhododendron and ask how many different hybrids are made with that species. Ask then which hybridizer developed a certain hybrid and next find out which other hybrids were made by that hybridizer. Also on other types of information connections can be made for example on colors, hardiness, etc. The website is so successful now that persons from all over the world mail material to the Webmaster Mr. van Ree; material to be included in the Website, especially photographs. So it is now a really global project that results in information on a really global level. I recommend every person to pay a visit to this wonderful source of information.

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Assessment of endangered status and conservation initiatives on the rhododendrons from the Sikkim Himalaya

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Part I. Assessment of conservation status

The genus *Rhododendron* (ca. 1 000 sp. worldwide) has the greatest diversity record in the Sino-Himalayan mountains spreading within a short arc covering the highlands of Nepal, India and China (east of Yunnan and Sichuan). In India the species of rhododendron is represented in the states of Arunachal Pradesh (75), Darjeeling in West Bengal (13), Himachal Pradesh (5), Jammu & Kashmir (5), Manipur (5), Mizoram (3), Nagaland (2), Sikkim (36) and Uttarakhand (5). In the Sikkim Himalaya (Sikkim and Darjeeling Hills combined, ca. 10 000 sq km) the rhododendrons are found between upper temperate and sub-alpine zone (1 600-3 600 m masl). Some 45 taxa of rhododendrons (in the form of 36 species, 3 sub-species, 4 varieties and 2 ecotypes) have been recorded from the region. The rhododendron habit of the ground species may be dwarf tussocks, small shrub or robust bushes which may sometimes form impenetrable thickets at places. A few species grow to tree proportions (*Rhododendron arboreum, R. barbatum, R. falconeri, R. hodgsonii*) attaining heights up to 18-20 m. Great morphometric variations may be observed between the same species and this often transcends to the population level too. Over the Sikkim Himalayan landscape the rhododendron also plays a pronounced role as a keystone species and especially at the sub-alpine zone it provides the ecological stability to the vegetation communities and associated niche, and also to the community continuum.

Within the last few decades the rhododendron of this region has been witnessing a marked increase in anthropogenic pressure and due to this the likelihood of its survival has come under the scanner. The many rhododendrons which were relatively few in numbers earlier have become suddenly scarce (*R. leptocarpum, R. pendulum*), population at places have turned acutely localized (*R. ciliatum, R. glaucophyllum, R. niveum, R. virgatum*) and the stands are markedly shrinking (*R. cinnabarium, R. hodgsonii and R.*

lanatum). Chronologically, all these events are of much recent date but the pace of its occurrence is of much significance and in the conservation aspect this might be fairly unsettling.

It was observed that till the middle of the 1980's rhododendrons never did show any discernible signs of disturbance in the wild. Later, the origin of human interference over its habitat spread its tentacles in 3 major areas, viz. – i. Increase of settlements at the fringe areas giving rise to increase in population, ii. Construction of road networks, and ii. Surge in tourist influx. Although not working in unison these factors independently were enough to wreck havoc in and around the rhododendron habitats. Escalation in population called in for increased firewood supply and the newly-built roads helped to bring in the rhododendron woods with minimum efforts on larger trucks. Earlier, the woods had to be ferried in by man or the beasts but the changed situation meant no good for the plants. Moreover, the road construction and repair jobs incessantly relied on rhododendron logs for heating and melting the hundreds of coal tar barrels and the work force garrisoned nearby also took its share of the rhododendron woodlands. The inflow of tourists marked the next phase of damage to the rhododendrons where the habitat was infringed openly, flowers were picked and seedlings trampled underneath. Where the first two factors were responsible for direct damage to the existing plants the last one contributed in fixing up the plant's regeneration system for good. Out of India's estimated 49 000 species of plants 20 percent of it are found to be under threat of extinction and from this about 70 species are listed as critically endangered by the Botanical Survey of India. These plants constitute those species which are found in the country's north-eastern region covering the 8 states of Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura (Naithani and Bahadur 1983, Paul *et al*., 2005).

The first ever inroads made into the regional rhododendron group came up with a major treatise on the genus by Hooker (*The Rhododendrons of the Sikkim Himalaya* 1849) and at a later date still more descriptive work was done on the plants by Pradhan & Lachungpa (*Sikkim-Himalayan Rhododendrons* 1990). Covering a time span exceeding 140 years the much needed revision on the genus was thus made possible at this point. In time several works gradually followed on the regional rhododendrons with the contents mostly dwelling upon the findings and identification of rare and endangered rhododendrons and the assessment of its conservational status (Sastry and Hajra, 1983; Starling, 1984; Justice, 2000; Maiti and Chauhan, 2002, Rai, 2002, Singh *et al*., 2003, Tiwari, 2004). Still much was aspired in terms of intensive research on its availability status in the wild, the ex situ approaches in conservation, population status and its dynamics, as well as ushering in stakeholders for participatory resource management in regard to these plants. In essence, so less is the volume of research works done on the regional rhododendrons that it is fairly difficult to compare the disparate results or analyze the emerging patterns.

Consolidated result for all species

This work was perceived and designed for finding out the conservation status of Sikkim Himalayan rhododendrons.

In regard to this it was structured to assess the population status of the genus and under this situation it was basically a field-oriented research work which asked for going to the field and assessing the rhododendron population at two levels, viz., i. assessment of the population through area covered, and ii. Assessment of the population through direct count. The assessments were made on the number of populations (areas of occurrence = AoO) as well as its size (extent of occupancy = EoO) for determining the conservation status of the species at three levels (viz., critically endangered, endangered and vulnerable). Smaller sub-populations were assessed which finally made up a population for a particular area, for example, the Lachung population, Kyongnosla population, Sandakphu population, etc. The status of the genus, barring a few much localized species, can not be conclusively established unless all the sites in the region are covered, therefore, the results shows the latest scenario and not the final conservation status of the taXA.

The conservation status description of the species is given in site-wise format with the individual count of the populations and its availability status discussed in the discussion part. The final result of the field assessment is given in the following table where 7 species and 2 varieties were found to be in critically endangered status and 4 species and 1 subspecies under vulnerable status.

Table 1. Conservation status of the rhododendrons found in the Sikkim Himalaya (Conservation status derived from IUCN (2004). V= vulnerable, CR= critically endangered)

Sl. №	Species	Availability (individuals per km^2)	Conservation status	IUCN Criteria used for conservation status
1	*Rhododendron baileyi*	56.50	V	B1, B2
2	*Rhododendron campanulatum* subsp. *aeruginosum*	43.5	V	B1, B2
3	*Rhododendron dalhousiae* subsp. *tashi*	38.6	CR	B1, B2, C, D
4	*Rhododendron decipiens*	43.00	V	B1, B2
5	*Rhododendron fulgens*	27.50	V	B1, B2
6	*Rhododendron griffithianum*	13.13	CR	B1, B2, C, D
7	*Rhododendron leptocarpum*	200.50	CR	B1, B2, C, D
8	*Rhododendron maddeni*	57.25	CR	B1, B2, C, D
9	*Rhododendron niveum*	67.50	CR	B1, B2, C, D
10	*Rhododendron pendulum*	22.57	CR	B1, B2, C, D
11	*Rhododendron pumilum*	4.0	CR	B1, B2, C, D
12	*Rhododendron sikkimense*	5.5	CR	B1, B2, C, D
13	*Rhododendron thomsoni* var. *candelabrum*	12.50	CR	B1, B2, C, D
14	*Rhododendron virgatum*	69.75	V	B1, B2

Discussions

To be fair, if the area of Sikkim (ca. 5000 km^2, i.e., area not under perpetual snow) is considered, all the rhododendron species comes under Endangered status. In the case where the entire Sikkim Himalaya (Darjeeling 3000 km^2 + Sikkim 5000 km^2= 8000 km^2) is considered then all the species becomes Vulnerable in status (Table 2). These concern the state of affairs when Extent of Occurrence (Criterion B1, red letters in Table 1) is considered. In a similar vein if we take the case of Sikkim only (Sikkim 5000 km^2) every taxa within it becomes Endangered.

But if the species are subjected to Area of Occupancy (Criterion B1, red letters in Table 3) the scenario changes into the state where 14 species, 1 subsp. and 2 var. falls under Critically endangered status, 13 species and 1 var. falls under Endangered status, and 8 species falls under Vulnerable status.

Table 2. Rhododendron species when subjected under criterion B1 of the IUCN assessment

IUCN Threatened criteria	IUCN Threatened Status		
	Critically Endangered	Endangered	Vulnerable
B. Geographic range in the form of either B1 (extent or occurrence) AND/OR B2 (area or occupancy)			
B1. Extent of occurrence	< 100 km^2	< 5,000 km^2	< 20,000 km^2
B2. Area of occupancy	< 10 km^2	< 500 km^2	< 2,000 km^2

Table 3. Rhododendron species when subjected to criterion B2 of the IUCN assessment

IUCN criteria and species	IUCN Threatened Status		
	Critically Endangered	Endangered	Vulnerable
B2. Area of occupancy	<10 km^2	<500 km^2	<2,000 km^2
Rhododendron anthopogon		•	
Rhododendron arboreum			•
Rhododendron arboreum var. cinnamomeum		•	
Rhododendron baileyi	•		
Rhododendron barbatum			•
Rhododendron camelliiflorum		•	
Rhododendron cinnabarinum		•	
Rhododendron campanulatum		•	
Rhododendron campanulatum subsp. *aeruginosum*	•		

Rhododendron campylocarpum		•	
Rhododendron ciliatum	•		
Rhododendron cinnabarinum	•		
Rhododendron dalhousiae			•
Rhododendron dalhousiae subsp. tashi	•		
Rhododendron decipiens			•
Rhododendron edgeworthi	•		
Rhododendron falconeri		•	
Rhododendron glaucophyllum	•		
Rhododendron grande		•	
Rhododendron griffithianum	•		
Rhododendron hodgsonii		•	
Rhododendron lanatum		•	
Rhododendron lepidotum			•
Rhododendron leptocarpum	•		
Rhododendron lindleyi	•		
Rhododendron maddeni	•		
Rhododendron nivale			•
Rhododendron niveum	•		
Rhododendron pendulum	•		
Rhododendron pumilum	•		
Rhododendron setosum			•
Rhododendron sikkimense	•		
Rhododendron thomsoni			•
Rhododendron thomsoni var. *flocculosum*	•		
Rhododendron triflorum		•	
Rhododendron vaccinioides		•	
Rhododendron virgatum		•	
Rhododendron wallichi	•		
Rhododendron wightii		•	
	17	14	8

Finally, along the procedure followed under this project, i.e., when we assess the plants under quantitative measure the final status of the rhododendrons comes to 7 species and 2 vars. under Critically endangered status and 4 species and 1 subspecies under Vulnerable status. Thus, in regard to the above three parameters of reckoning the following three set of results are reached (Table 4).

Table 4. Rhododendron species as assessed under quantitative estimation for B1

IUCN Threatened criteria	IUCN Threatened Status		
	Critically Endangered	Endangered	Vulnerable
B. Geographic range in the form of either B1 (extent or occurrence) AND/OR B2 (area or occupancy)			
B1. Extent of occurrence State of Sikkim Sikkim Himalaya	- -	36 sp, 1 subsp, 2 var -	- 36 sp, 1 subsp, 2 var
B2. Area of occupancy	14 sp, 1 subsp, 2 var	13 sp, 1 var	8
Quantitative ground assessment (of the target species in the present study)	7 sp, 2 var	4 sp, 1 subsp	

Considering the precise measurement that was carried out at smaller land units under the present work, all at population and sub-population levels, it can be justified that the results arrived through this stands a better chance of recognition than the two other derivations where a large area is considered for arriving at the results.

Population characteristics (physical): Some of the populations were found to be extremely localized for the region, e.g., the population of *Rhododendron thomsoni* var. *flocculosum* is the single population which is found at Shingba, Lachung. Similarly, *Rhododendron leptocarpum* is found only at Tsokha and nowhere else in the region. Exactly four populations are found for the Madden's rhododendron, *Rhododendron maddeni*, which are at Chungthang, Cheo-binbin, RatayChu catchment and at the Chola range. The population of *R. dalhousiae* var. *tashi* is also found restricted to the Pangthang and Benshoi areas so far. But comparatively difficult situation exists for *Rhododendron pumilum* and *R. sikkimense* which are located within a very limited area and with very few individuals. Relatively smaller populations survive for *Rhododendron campanulatum* subsp. *aeruginosum*, *Rhododendron virgatum*, *R. wallichi, R. lanatum* and *R.ciliatum.* The populations which were extensively scattered and with relatively few individuals forming small populations were noted in the cases of *Rhododendron griffithianum, R. lindleyi, R. edgeworthi* and *R. vaccinioides*.

In conclusion there are three types of population structure found in Sikkim Himalaya, viz., i. very small populations growing on only one location, viz., *R. pumilum* (Bhirum chhu), R. sikkimense (Chachujak) and *R. leptocarpum* (Tsokha), *R. thomsoni* var. *candelabrum,* small but scattered populations, e.g., *Rhododendron maddeni, R. ciliatum, R. campanulatum* subsp. *aeruginosum* and the other populations which are large and widespread in the region.

Conservation issues

Human interventions: In regard to the survival of the rhododendrons two factors are involved and these are - (i) anthropocentric causes, or are in the form of (ii) natural origin. The anthropocentric factors are normally the locals who reside close to the rhododendron habitats, the many army personnel and their camps, road builders, and the visiting tourists. The resident human (i.e., the locals, army, road-builders) are seen to put more harm to the plants than the seasonal human (the tourists) who do not stay in the habitat area and a majority go back after spending a day or rarely two days at a stretch. The resident human are found at the locations in Lachung, Lachen, Yuksam, Hillay, Dentam, Uttaray, Chewabhanjyang, Maneybhanjyang, Tonglu, Rimbik, Dhajia, Kyongnosla, Ribdi, Bhareng, Sherabthang and Thegu. These remotely situated hamlets still are heavily dependent upon the forest resources, especially for firewood supply. Though thinly populated the daily firewood consumption is quite large (10950 kg per annum compared to 7000 kg per annum state average) and this takes a toll on the forest trees and rhododendrons too. Despite the government providing LPG for cooking purposes at various sites the firewood is still used. It is also because of the locations are at cold places firewood is required for heating also.

The abundantly found fir (*Abies webbiana*) is not used by the villagers for burning purposes because it is a softwood. Also because the rhododendron wood burns well even at semi-wet condition it is preferred. The species over which the axe is targeted are *Rhododendron hodgsonii*, *R. decipiens* and *R. lanatum* in Sikkim, and *R. arboreum* and *R. barabatum* in the Darjeeling hills. The coming up of broad metaled road and bigger trucks have simply aggravated the extraction of fuelwood in the locations. This is more evident in case of the populations which grow on the Lachung-Yumthang route. Although evidences points to an earlier availability of rhododendrons in the Kyongnosla region between 8000-11000 ft elevations the road building activities might be responsible for eliminating it from its habitat

Natural causes: Natural causes affecting the rhododendron populations constitute, in order of frequencies - the landslides, avalanches and flashflood conditions. Landslides are a common feature in the region and can occur at any elevations where the land is sloping at an angle of more than 40°, with or without the presence of trees and forests. The species found most affected by landslides are *Rhododendron arboreum*, *R. barbatum*, *R. campanulatum* and *R. hodgsonii* and this happens not because of it growing on a landslide-prone area but because of its ubiquity. However, the landslides are not decidedly injurious to rhododendrons and only a landslide of bigger proportion can harm it by covering the plants under mud and rock debris. Small landslides, landslips and mudflow only shift the plants from one place to another making the plants slanted in stance but still standing upright. However, if the slide is continued and falls into the stream all the plants get destroyed. This is the case commonly found in the Yumesamdong area where large patches of *Rhododendron anthopogon*

is continually falling into the Lachung Chhu river. In any case, recent slides of any noticeable proportion harming a large population of rhododendrons have not been recorded.

The avalanches are found to be less frequent but more disastrous in nature compared to the landslides. These are more common in the Yumthang valley; a few that occurs at the Khangchendzonga Biosphere Reserve does not warrant much because of the species that grow here do not fall under critically endangered. Avalanche of noticeable effect was recorded from Yakchay and Phuni in Yumthang valley in the late eighties. It destroyed a lot of *Rhododendron niveum* plants within an area of 1 km^2. The recurrent avalanches experienced at Phuni within the Yumthang valley where it adversely affects *Rhododendron thomsoni* was of more consequence from the survival point of view. It was noted that owing to incessant onslaught of avalanches in the area the plants growing at the slopes have been destroyed and only the ones growing over the level land of river terrace are surviving. Flash floods due to cloud bursts occur in the region and this happens to be one destructive factor with serious consequences to the rhododendron plants. Information was taken on the flash flood which occurred in 1992 when alpine lakes feeding the Lachung Chhu burst open and a considerable area along the first 10 km were damaged. The worst affected in the event was the Lachung population of *Rhododendron pendulum* which was almost cleared from its habitat. The flashflood was of a considerable power and the ensuing deluge swept away the bridge over Lachung Chhu towards Dombang. A few scattered individuals at higher grounds remain now marking the place of its earlier habitat.

Uses: Apart from the usage as fuelwood the plants do not provide much direct utility to the people in the fringe areas. The use of *Rhododendron anthopogon* as incense however remains as steady as always and locals and to a lesser extent the trekkers take away the plants by cutting the twigs with leaves. The plants are deep rooted and become a labour-intensive exercise to uproot it and as to this it has scope of bringing about new branches and leaves. However, repeated clippings of branches will be deleterious for the plants. The use of plant parts in making wicks (*R. pendulum*), packing butter (*R. falconeri, R. hodgsonii, R. decipiens*), etc. are not practiced at present because of alternative options easily available in the form readymade cotton wicks and plastic bags. However, to some extent it was found that saddlebacks for yaks and horses are made from the wood of *R. hodgsonii* and *R. decipeins*. Making of khukri handles out *Rhododendron arboreum* is not generally practiced by the locals.

Part II. Rapid and mass multiplication of some important Sikkim Himalayan rhododendron using biotechnological tools

The rhododendron species are propagated by vegetative means as well as through seeds. The rate of vegetative propagation is very slow in many rhododendron species and seed germination in nature is also very poor. Micro propagation is an ideal technique for cloning the elite germplasm and conservation of rare and threatened rhododendron species of the region. Tissue culture is the only method to

maintain and propagate the genetically identical clone rapidly in large numbers and in long term culture. The present paper highlights the methodology for rapid and mass multiplication of some important Sikkim Himalayan rhododendron using biotechnological tools.

An efficient and reproducible procedure for the large scale propagation of two important rhododendrons, namely *R. dalhousiae* subsp. *tashi* and *R. maddeni* have been described. On the basis of their status, life-history traits, constraints in germination, the paper focuses on the need of developing selection procedures for initiating future *in vitro* work on rhododendron of the region. The procedure will not only ensure mass scale availability of planting material of selected species including creamy white flowered *R. dalhousiae* subsp. *tashi,* and *R. maddeni* a scented flower, which are in great demand, but will also help in conservation of important genetic resources.

R. dalhousiae subsp. *tashi*, Lady Dalhousie's Rhododendron, Nepali-Lahare Chimal: *R. dalhousiae* subsp. *tashi* seeds were found to germinate within 15-20 days of inoculation on hormone-free MS medium. On MS medium containing 0.8% (w/v) agar, germination was first recorded on the 15th day of inoculation and after 30 days of inoculation an average germination of about 80% was observed (Figure 1A). Six weeks old seedling, cotyledonary nodal parts were used for shoots multiplication. *In vitro* raised shoot tip explants from *R. dalhousiae* subsp. *tashi* were used to produce multiple shoots on MS medium supplemented with 2iP in various combinations. While comparing the effect of cytokinin type on shoot formation, the best response was achieved in MS medium supplemented with 2iP (Table 5). It was found that mean number of shoots per explant was highest on media containing 2iP. Maximum percent of multiple shoot (68%) and maximum mean number of shoots (8.78 ±0.85) were recorded at 5.0 mg L^{-1} 2ip after 12 weeks of culture (Table 5). The number of shoots induced from each nodal segment decreased as the concentration of 2iP increased in the MS medium (Table 1). In most cases, shoots formed rosettes and/or compact calli at the basal end. Presence of IAA in medium also proved to be beneficial for shoot elongation. The combination of MS medium supplemented with 5.0 mg L^{-1} 2iP and 0.1 mg L^{-1} IAA resulted in further growth of plantlets (Table 5; Figure 1B). Regenerated shoots were subcultured every three weeks onto the freshly prepared same medium that was subjected to produce the highest proportional shooting response. Highest number of shoot regeneration was recorded at fourth subculture. The superiority of 2iP over all growth regulators for multiple shoot induction has been reported in many rhododendron species. *In vitro* grown shoots were separated from the shoots of the primary culture and placed in MS-liquid medium containing different concentrations of IBA. Rooting was induced within 3 weeks of transfer. A maximum frequency of root formation (80%) and the highest number of roots (5.80 ±0.80) with maximum root length (1.58 ±0.16 cm) was achieved on MS medium with 0.2 mg L^{-1} IBA after 9 weeks (Figure 1C). Higher concentration of auxin lowered the rooting percentage as well as root number. Control shoots

that did not receive auxin treatment did not root. Similar observations were made in other plants. Plantlets with fully expanded leaves and well developed roots were washed with sterile distilled water then dipped in systemic fungicide (Bavestin, 0.15%, w/v; 20 min) and planted in plastic pots (Figure 1D) containing autoclaved fresh peat moss and soil (1:3). After two month these were planted in polythene bag containing normal garden soil, and placed for hardening under high relative humidity (80%) in the mist chamber of a greenhouse (25°C). After 180 days of transplantation 93% of the plants were found to survive with progressive growth. This is the first report for *in vitro* regeneration of *R. dalhousiae* subsp. tashi where large number of plants have been successfully produced and transferred to the field.

Table 5. Effects of cytokinin combined with IAA on shoots proliferation from cotyledonary node of *R. dalhousiae* subsp. tashi on MS medium

Plant growth regulators (mg L^{-1})		Percent of explants producing shoot	Mean number of shoots/explant	Shoots length (cm)
2iP	IAA			
3	-	50.33 ±2.20	6.45 ±0.80	0.72 ±0.07
3	0.1	58.00 ±1.65	6.77 ±0.68	1.14 ±1.45
5	-	68.00 ±3.55	8.78 ±0.85	2.70 ±0.55
5	0.1	72.00 ±1.45	11.65 ±0.50	3.64 ±0.25
LSD at the 5% level		54.38	6.14	2.80

Values represent means ± standard error. Data were recorded 12 weeks after transfer to MS medium

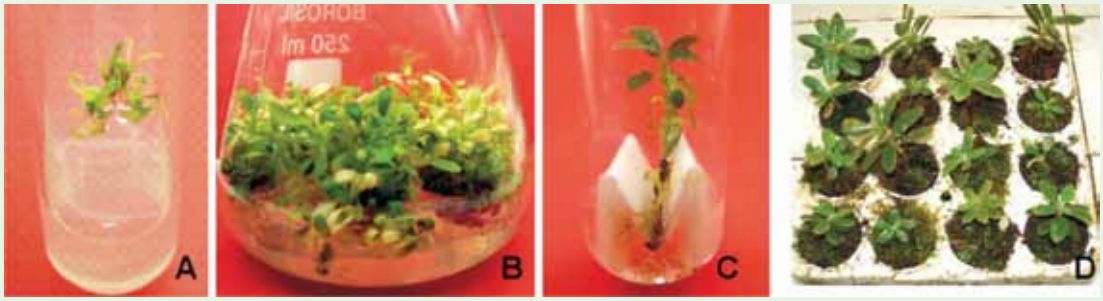

Figure 1. *In vitro* propagation of *R. dalhousiae* subsp. *tashi.* A. germinating seeds in MS medium. B. multiplication of shoots on MS medium with 2iP (5 mg L^{-1}). C. root induction from *in vitro* regenerated shoot on liquid MS medium with IBA (0.2 mg L^{-1}). D, hardened *in vitro* raised plants after transfer to fresh peat moss and soil in green house

R. maddeni Hook.f., Major Madden's Rhododendron, Nepali- Major Madden ko Chimal: *In vitro* multiplication may prove to be one of the best techniques for its conservation. Micro propagation of *R. maddeni* has been achieved using cotyledonary nodes taken from *in vitro* grown seedlings. The sterilized seeds of *R. maddeni* were found to germinate within 3 weeks of inoculation on hormone-free MS medium. Cotyledonary nodes and shoot tips from *in vitro* grown seedling were cultured on AM medium supplemented with different concentrations of cytokinins (2iP) for multiple shoot regeneration. Among the various hormonal supplements used, best response towards multiple shoot regeneration was observed from nodal segment on AM medium containing 7 mg L^{-1} 2iP with 0.3% phytagel and additives (Singh, 2009) [Figure 2 A]. In the present study cotyledonary node explants were found to be superior for obtaining multiple shoots in AM medium containing 7.0 mg L^{-1} 2iP + 0.1 mg L^{-1} IAA. In this combination, an average of 95% multiple shoot regeneration was achieved from cotyledonary node explant. Incorporation of 0.1 mg L^{-1} IAA in the medium during subculture, improved the overall growth of cultures with slight increase shoot length (Singh, 2009). A regular subculture in every 4 weeks increased the multiplication rate which became maximum after three to four subculture cycles. For root induction, microshoots were placed on AM medium supplemented with various concentrations of IBA (Singh, 2009). Rooting occurred in all concentrations but with different rooting percentages, and the optimal response was observed with 0.2 mg L^{-1} IBA on liquid AM medium containing activated charcoal (0.5%, w/v) in terms of average number of roots (6.45) and mean root length of 2.58 per shoot (Figure 2B). The roots developed directly from the base of shoots without callus. After four weeks in rooting medium, plantlets were transferred in thermocole cups containing a mixture of autoclaved fresh peat moss and soil (1:3) and placed for hardening under high relative humidity (80%) in the mist chamber of a greenhouse (25°C). After one month these were planted in polythene bag containing normal garden soil, 86% survived under green house conditions (Figure 2C,D). The micro propagated plants, following hardening and establishment in the greenhouse were transferred to the field at Arboretum of the Institute and unique kind of Rare and Threatened Plant Conservation Park of Himalayan Zoological Park, Bulbulay-Gangtok, Sikkim and compared with seedling plants of similar age, in terms of growth performance. This achievement can be applied to commercial mass production and provides a uniform product quality.

Vegetative propagation of Sikkim Himalayan Rhododendron from leafy stem cuttings using "Air-wet method: So far no attempt has been made to develop efficient vegetative propagation methods and large scale production of rhododendron species which are under the threat of extinction. Air wet techniques were conducted for the study which investigates the simple propagation techniques and optimal conditions for the vegetative propagation of the rhododendron species from leafy stem cuttings. Method used for raising of planting materials by stem cutting under this experiment is based on the air wet technique. The

Figure 2. *In vitro* propagation of *R. maddeni.* A. multiplication of shoots on AM medium with 2iP (7 mg L^{-1}). B. root induction from *in vitro* regenerated shoot on liquid AM medium with IBA (0.2 mg L^{-1}). C, D. hardened *in vitro* raised plants after transfer to fresh peat moss and soil in green house

stem cuttings of rhododendron species were taken in early winter when active growth is arrested. The preparation of cutting materials was done in the morning between 8.00 and 11.00 a.m. Conventional propagation of *R. dalhousiae* subsp. *tashi, R. arboreum* and *R. griffithianum* through 'air-wet techniques', using semi-hard wood cutting with unbroken vegetative buds was carried out. The hardwood cuttings measuring 7 to 8 inches were wounded on the distal stems but only on the upper side and placed on moistened absorbent paper. The hard wood cutting with two-four leaves were cut to two equal halves and small squares of the absorbent paper (1 1/2 in.) were used to cover the wounded sites and misted so that satisfactory moisture is maintained at all the times. The container was covered with Saran Wrap plastic sheeting. Hand misting is done as needed to maintain appropriate moisture levels. The container was kept under white fluorescent light 60 mmol m^{-2} s^{-1} photon flux, 16 hr photoperiod at 17 ±1 ^{o}C temperature and 60% relative humidity. After 10-15 weeks, initiation of callus and sprouting of dormant buds were observed in both the species. After 10-15 weeks, when significant callusing has taken place, the cuttings were transferred to 9-inch pots with potted mixed with equal parts of peat moss and Solirite. Clear plastic sheeting is then laid over the potted plants to maintain high humidity until rooting. Rooting of one two node cuttings were compared for *R. grifithianum, R. arboreum* and *R. dalhousiae* subsp. *tashi*. One-node cuttings had the same rooting ability as bi-nodal cuttings. Observations of initiation of rooting after six weeks were 40% in *R. griffithianum* 80% in *R. arboretum* and 50% in *R. dalhousiae* subsp. *tashi* (data not shown). Within 8-12 months the cuttings developed root and leaves. Well-developed rooted plant were transferred in thermocole cups containing a mixture of autoclaved fresh peat moss and soil (1:3) and placed under high relative humidity (80%) in the mist chamber of a greenhouse (25°C). After one month these were planted in polythene bag containing normal garden soil. All rooted stem cutting survived under green house conditions (Figure 3A-D). There are several advantages to propagate plants using air wet technique:

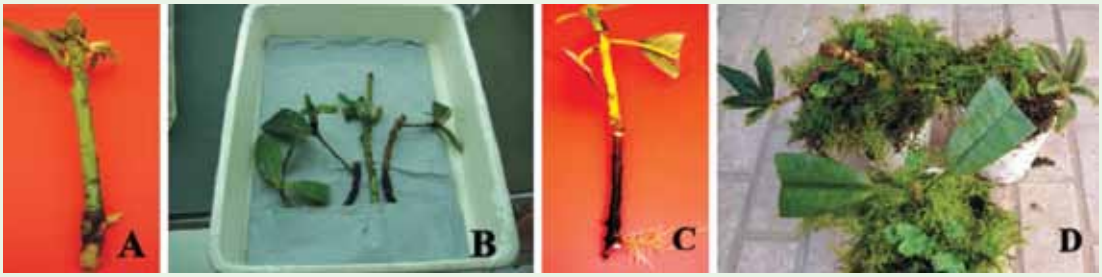

Figure 3. Stem cuttings of *R. arboreum.* using air-wet technique. (A & B) The stem cuttings with moistened absorbent paper; (C & D) Growth performance of rooted stem cutting developed form air-wet technique

1. New plant will be identical to the parent plant. Propagating a plant by cuttings will allow you to keep the special characteristics of that plant. Plants grown from seed will often be different from the parent plant and from each other.
2. Propagating a new plant via cuttings avoids the difficulties of propagating by seed. Additionally, some seeds are difficult to germinate, taking two to three years for the seedling to appear.
3. A new plant grown from a cutting will frequently mature faster and flower sooner than a plant grown from a seed.

This is the first report for rooted stem cutting of rhododendron species where large numbers of plant have been successfully produced. Experimentation with rhododendron using an "Air-wet technique" has proved successful and seems to be a promising alternative and has been used effectively for rooting of rhododendron. This would prove indispensable for saving many threatened and endangered species.

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ABSTRACTS

PROCEEDINGS
International
Rhododendron Conference

Proceedings, International Conference
RHODODENDRONS: CONSERVATION AND SUSTAINABLE USE
Forest Environment & Wildlife Management Department, Government of Sikkim
Saramsa, Gangtok-Sikkim, India

A. Mainra, H.K. Badola, B. Mohanty (eds) 2010

Conservation of selected rhododendron species, and New Zealand hybrids in New Zealand – 2010: Aotearoa- Land of the long white cloud

Kathryn Millar*

Wendrum', RD3 Leeston, New Zealand

*Invited Speaker

Rhododendrons are not part of the natural New Zealand (NZ) flora; the first to arrive in NZ were those imported from United Kingdom in 18th centruary (ex Hookers collections). European settlement was in its infancy; whalers and sealers of the southern oceans had shore bases in NZ in early years; they were not flower gardeners.

The Maori grew wonderful sweet potatoes in their vegetable gardens, they were not flower gardeners. The early pioneers, some of them squatters from Australia, by necessity put survival of themselves, their family and animals and enterprise before flower gardening. Much of NZ is dry and not conducive to woodland plants unless modern water reticulation was made available. So, it was not until the late 1800's that a few settlers with means, had a dream of establishing gardens such as their families had on the great estates of the United Kingdom – they were keen to bring into NZ shrubs and trees of quality. Such plants came in wardian cases. At the same time, Hooker was collecting rhododendrons in the Himalaya.

Those first rhododendrons which came into the port of Lyttelton near Christchurch in the South Island, and accordingly to local legend, sat forlornly on the wharf waiting their owner to come 60 miles by horse and cart from his property in the foothills of the southern alps. Plants such as these, and their op seed were the parents of many fine hybrids and species seedlings still to be seen- usually in the environs of country estates. A second early arrival of early significance was the packet of seeds brought to New Zealand by Sir John Cracroft Wilson of Cashmere Estate near Christchurch. The Ilam garden and homestead is now part of the campus of the University of Christchurch; however until the 1950s it was the home of Edgar Stead; Mr Stead's breeding programme and importations from the UK had a huge influence on the rhododendron and azalea breeding in New Zealand, and that still does. He registered

plants with the RHS in London; he also wrote for their journals; these notes are valuable to us as we look back to find what species he has, and which he deemed useful/successful for breeding to NZ conditions (especially Canterbury with its dry summers and nor'westers. He visited United Kingdom and had entry. Without recording and date bases over the past decade we would by now have lost track of the whereabouts of many plants of significance; however, many remained vulnerable. We need to remain vigilant and put in place procedures which are realistic.

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Growing Rhododendron species in Sweden

Björn Aldén*
Gothenburg Botanical Garden, SE-41319 Gothenburg, Sweden
E-mail: bjorn.alden@vgregion.se]

*Invited Speaker

Sweden is a northerly situated country and judging only from its latitudinal range, from about 55 to nearly 70°N, it should be unsuitable for *Rhododendron* growing. However, the surrounding seas are influenced by the North Atlantic Drift of the Gulf Stream, and this makes the climate of southern Sweden fairly mild. Besides this, it should be noted that there are very hardy *Rhododendron* species found for instance in subsection *Lapponica*, like *Rhododendron lapponicum*, even growing wild in Sweden - well above the Arctic Circle! Compared to W Norway and the British Isles it is, however, colder and drier in most parts of the country. This certainly has a suppressive effect on the number of species that will grow, in particular those from milder parts of C and SE Asia. Compared to the British Isles cultivation of species of *Rhododendron* is a fairly new business in Sweden. Outside the botanic gardens one of the first persons to establish a very fine species collection was the former King of Sweden, Gustaf VI Adolf, at his summer house Sofiero in SW Sweden. Mainly hybrids were planted there in the early 20th century. In the 1930s, after Gustaf VI Adolf inherited the estate, also different species were introduced. As the climate in SW Sweden is sufficiently mild for growing *Rhododendron*, Gothenburg botanical garden, situated on the Swedish West coast and founded in 1923, were among the those taking an early interest in the genus. It soon emerged as the prime public garden for cultivating a variety of species. Inspired by the Gothenburg collection, the Swedish Rhododendron Society was founded in 1970. In 2000 the Society split up, and a new group, the South Swedish Rhododendron Society, was formed. It is now a chapter of the American Rhododendron Society. In Gothenburg botanical garden the goal is to cultivate at least 200 species outdoors. In noting that, we should perhaps mention that we do have a fairly conservative species concept. In any case, the current collection numbers around 230 taxa in- and out-doors. These in turn comprise around 1,500 plants and are spread over most parts of the garden's 175 hectars.

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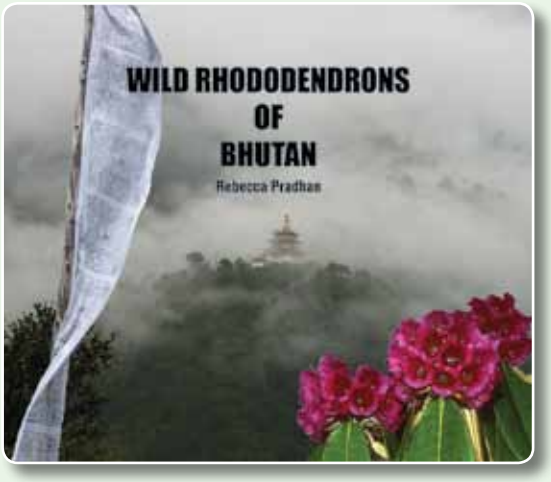
About some rhododendron species, variants and hybrids in Sikkim

Hans Eiberg*
University of Copenhagen, Copenhagen, Denmark
*Invited Speaker

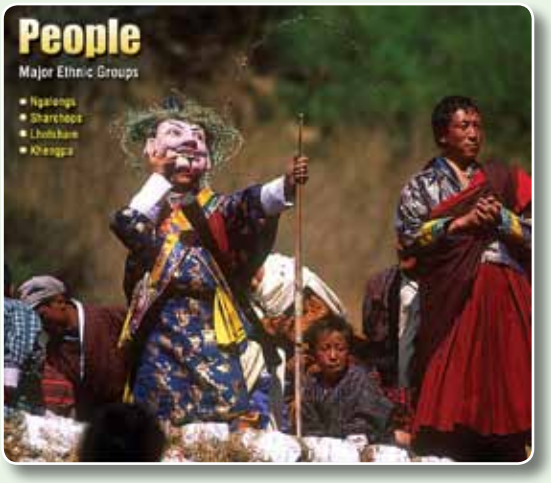
Recent developments in DNA-analysis of the genus Rhododendron have enabled reconstruction of phylogenetic relationships within the genus and thus chart the evolutionary history of the Rhododendrons. It is reassuring that analyses of genetic sequences selected from different parts of the genome give rise to identical phylogenetic trees and evolutionary histories of the genus. This finding directly corroborates our view of Darwinian theories of evolution where speciation is the result of mutation, migration, isolation and selection in a changing environment, but not by hybridization between different species. Segregation of sub-populations so as to prevent interbreeding with the parent species is key to speciation and Sikkim's unique geography provides ideal conditions for the emergence of new species and variations and hence makes it particularly attractive for evolutionary studies of the genus Rhododendron.

SELECTED PRESENTATION


WILD RHODODENDRONS
OF
BHUTAN
Rebecca Pradhan


Location: Bhutan
CHINA
(TIBET)
NEPAL
Bhutan
INDIA
BANGLADESH
Latitudes..26040' and 28015'N
Longitudes..88045' and 92010'East.

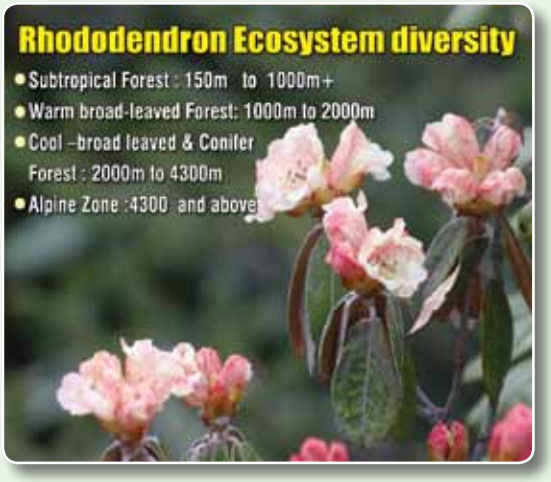

Country Profile
Capital City: Thimphu
Total Land Cover: 38,36459 sq. km (BAP 2009)
Population: 0.7million(NSB 2009)
Forest Cover: 65.5%(BAP 2009)
Cultivated area: 8%(BAP 2009)

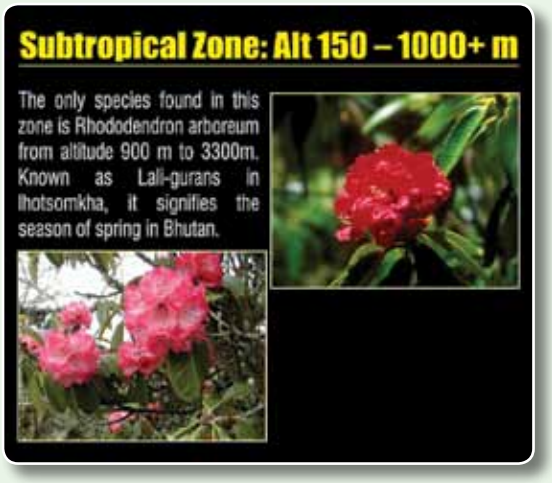

People
Major Ethnic Groups
Ngalongs
Sharchops
Lhotshams
Khengpa


Rhododendrons of Bhutan
In Bhutan many species of rhododendrons are found to exist in assemblages that vary according to changes in altitude, aspect and longitudinal east west axis. 46 species of Rhododendrons are described in Flora of Bhutan Vol. II Part 1. Out of these 46 species, four are endemic to Bhutan.
1. R.kesangiae Long & Rushforth
2. R.pogonophyllum Cowan & Davidian
3. R.bhutanense Long & Bowes Lyon
4. R.flinckii Davidian.
R. bhutanense
*R. kesangiae, named in honour of HRH The Queen Mother of Bhutan, Ashi Kesang Choden Wangchuck
** R. kesangiae var. album Zhitoy, symbolizes the 50th Anniversary of the United Nations (1945-1995)


R. kesangiae var.

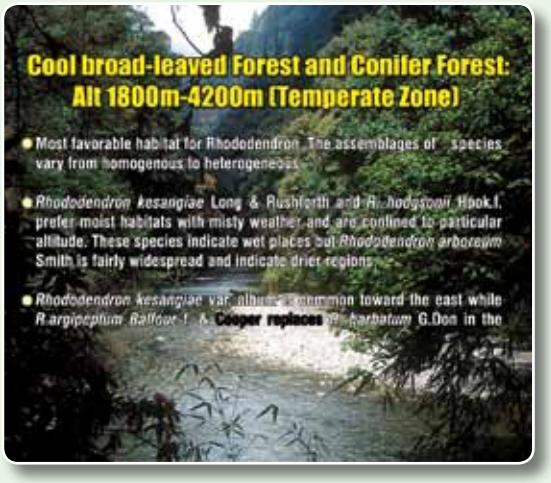

Features & Characteristics
Family: Ericacae
Rhododendrons vary in shape, size and form ranging from low creeping shrub of 10cm tall to big trees of 20m with 70cm girth. Several species are tall trees: some form the under storey of conifer broad-leaved forests and some form dominant vegetation patches in alpine meadows above tree line, while others tend to be epiphytic.
Rhododendrons hybridize readily in the wild where several species occur in group.


Rhododendron Ecosystem diversity
Subtropical Forest : 150m to 1000m+
Warm broad-leaved Forest: 1000m to 2000m
Cool –broad leaved & Conifer Forest : 2000m to 4300m
Alpine Zone :4300 and above


Subtropical Zone: Alt 150 – 1000+ m
The only species found in this zone is Rhododendron arboreum from altitude 900 m to 3300m. Known as Lali-gurans in Ihotsomkha, it signifies the season of spring in Bhutan.


R.arboreum var.


Warm broad-leaved Forest ... 1000 – 2000+
Rhododendron species found:
1. R. arboreum
2. R.griffithianum,
3. R. grande
4. R.papillatum,
5. R.maddenii
6. R.dalhousiae,
7. R.dalhousiae var. rhabdotum,
8. R. lindleyi
9. R. virgatum
10. R.edgeworthii


Cool broad-leaved Forest and Conifer Forest: Alt 1800m-4200m (Temperate Zone)
Most favorable habitat for Rhododendron. The assemblages of species vary from homogenous to heterogeneous.
Rhododendron kesangiae Long & Rushforth and R. hodgsonii Hook.f. prefer moist habitats with misty weather and are confined to particular altitude. These species indicate wet places but Rhododendron arboreum Smith is fairly widespread and indicate drier regions.
Rhododendron kesangiae var. album is common toward the east while R.argipeplum Balfour f. & Cooper replaces R. barbatum G.Don in the

Rhododendron species found in this zone:

1. R. arboreum, 2. R.griffithianum, 3. R. grande, 4. R. kesangiae, 5. R.falconeri, 6. R. hodgsonii, 7. R. campylocarpum, 8. R.kindrickii, 9. R.niveum, 10. R.wightii, 11. R. lanatum, 12. R. tsariense, 13. R.papillatum, 14. R.maddenii, 15. R.dalhousiae, 16. R.dalhousiae var. rhabdotum, 17. R. lindleyi, 18. R. virgatum, 19. R.edgeworthii, 20. R.wallichii, 21. R. barbatum, 22. R. argipeplum, 23. R.succothii, 24. R.neriiflorum, 25. R.fulgens, 26. R. pendulum, 27. R.ciliatum, 28. R. triflorum, 29. R. vacciniodes,30. R. cinnabarinum, 31. R. keysii, 32. R. camelliiflorum, 33. R. glaucophyllum, 34. R.baileyi

Some species are understorey of Cool broad-leaved forest and some are understorey of conifer forest. *R.falconeri*, *R. kesangiae* and *R grande* colonize and form a pure thick forest of single species.

Alpine Zone: Alt 3000 – 5200 m

Rhododendrons found in this zone:

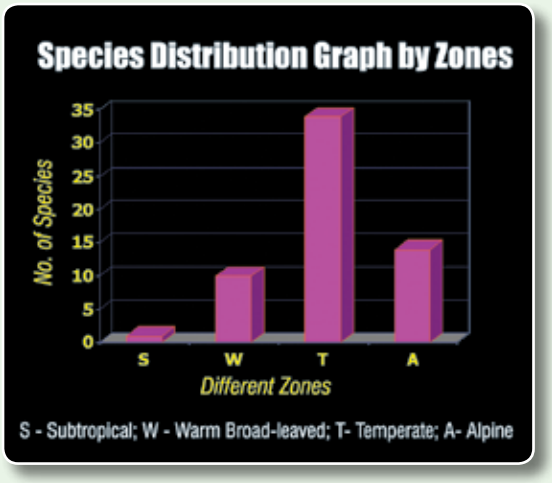
1. R. bhutanense, 2. R.lanatum, 3. R. flinckii, 4. R. aeruginosum, 5. R. thomsonii, 6. R.nivale, 7. R.pumilum, 8. R.cinnabarinum 9. R.setosum, 10. R.lepidotum, 11. R.anthopogon, 12. R.pogonophyllum, 13. R. fragariiflorum, 14. R. campanulatum

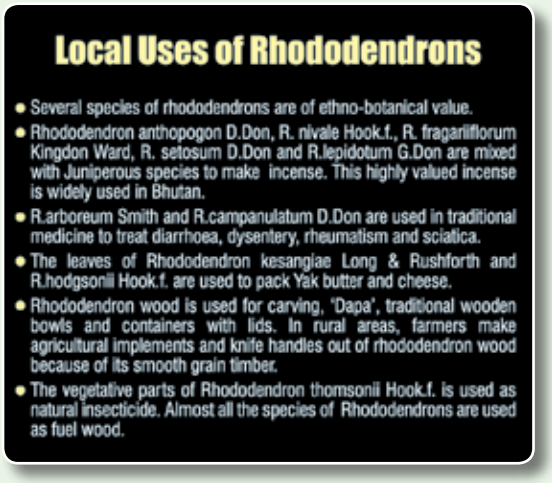
These species are found in open meadows and marshy areas and are colonized. Some places are very difficult to penetrate. These places also provide shelter to Musk deer, Tragopans and Pheasants.

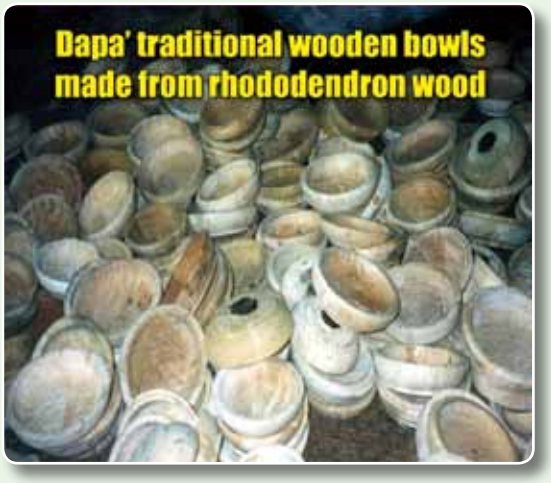
Dwarf rhododendrons are quite common at the altitude range of 3500m to 4500m


R. fragariflorum
R. anthopogon
R. thomsonii
R. aeroginosum


R. fragariflorum

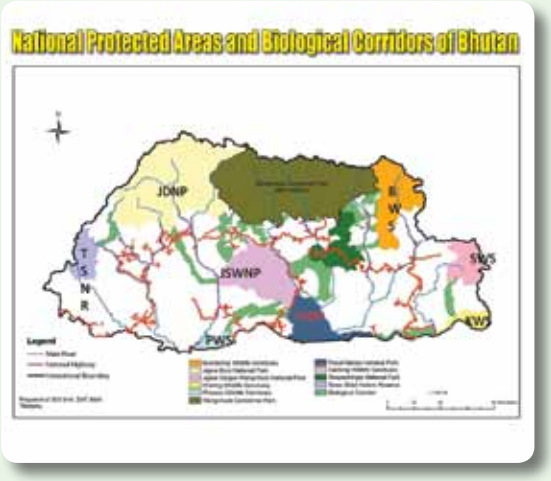

Species Distribution Graph by Zones
No. of Species
35
30
25
20
15
10
5
0
S
W
T
A
Different Zones
S - Subtropical; W - Warm Broad-leaved; T- Temperate; A- Alpine


Local Uses of Rhododendrons
• Several species of rhododendrons are of ethno-botanical value.
• Rhododendron anthopogon D.Don, R. nivale Hook.f., R. fragariflorum Kingdon Ward, R. setosum D.Don and R.lepidotum G.Don are mixed with Juniperous species to make incense. This highly valued incense is widely used in Bhutan.
• R.arboreum Smith and R.campanulatum D.Don are used in traditional medicine to treat diarrhoea, dysentery, rheumatism and sciatica.
• The leaves of Rhododendron kesangiae Long & Rushforth and R.hodgsonii Hook.f. are used to pack Yak butter and cheese.
• Rhododendron wood is used for carving, 'Dapa', traditional wooden bowls and containers with lids. In rural areas, farmers make agricultural implements and knife handles out of rhododendron wood because of its smooth grain timber.
• The vegetative parts of Rhododendron thomsonii Hook.f. is used as natural insecticide. Almost all the species of Rhododendrons are used as fuel wood.


Dapa' traditional wooden bowls made from rhododendron wood

Threats and Conservation Efforts

- As of now Rhododendrons in Bhutan do not face severe threats. However, the climate change and global warming may affect rhododendron habitat in future. In certain areas natural regeneration is poor because of human interference leading to ecological disturbance Rhododendron thrift disease are seen. In higher altitudes yak herders set fire to rhododendron patches to make fuel wood.
- Although threat to rhododendrons is not a serious issue at present, it would be unwise to remain complacent speculating future guarantee. Fortunately, most of the rhododendron rich areas have already been included within the National Parks.
- In addition, about 2 hectares of rhododendron forest in the Thrumsingla National Park, harbouring 22 different species, has been identified as an in situ Rhododendron garden. It was inaugurated on 2nd May 2002 as one of the commemorative activities for the International Year of Mountains 2002



In-situ Rhododendron Garden, Thrumshingla National Park Bhutan

ACTION PLAN AND STRATEGIES

All participant experts were divided into three groups, viz. (i) *In-situ* conservation, (ii) *Ex-situ* conservation and (iii) Sustainable use. A brain storming session was conducted to discuss issues pertaining to conservation of rhododendrons and steps for augmentation:

Strategies and Action Plan for *In-situ* conservation

Group coordinator:

Mr. Anjan Mohanty, CCF (India)

Ms. Rebecca Pradhan (Bhutan)

Creation of base line data

- Identification of Natural Areas where different species occur.
- Status of individual species in their respective ecosystems.

Assessment of threats

- Identifying human induced threats.
- Creation of nurseries with the help of seeds collected from the natural areas.
- Aided natural regeneration in the gaps.
- Strengthening regulating authorities.
- Sensitizing defense and road maintenance personnel.

Involvement of local communities

- PRA exercise would precede all actions to be taken.
- Awareness programmes particularly for children and youth.
- Alternate livelihood for the locals dependent on resources in and around in-situ conservation areas.
- Ecotourism in selected areas for popularizing Rhododendrons and educating about their conservation values.

Research and monitoring

- Creation of preservation plots within the identified in-situ zones.
- Long term phenological monitoring of targeted rhododendron, taxa addressing the climate change and global warming should be one of the top priorities in Sikkim and other potential rhododendron growing regions in Himalaya; in each of identified and potential in-situ zones along altitudinal transects permanent monitoring stations need to be established, evolving collaborative approach of phenologists/scientists and area managers.
- Conducting research in targeting taxa and ecosystems

Strategies and Action Plan for *Ex-situ* conservation

Group Coordinator:

Mr. M.L. Srivastva (India)
Dr. Anders Falkstig (Sweden)

1. There should be co-coordinated efforts to have national and international collaboration on different aspects of *ex-situ* conservation of rhododendron species growing in India.

2. While adopting *ex-situ* conservation, individual plants of different species, particularly rare and threatened and endemic species of different eco type or different altitudinal ranges is considered.

3. Irrespective of importance of the bio diversity loss the transfer of materials of rhododendron and other species for pure research purposes should be entertained with end goal of having a continued survival of species in one or other places.

4. Because of socio economic importance attached to it some species used by people; some of those species be taken for mass cultivation so that the requirements of the population are addressed.

5. In the context of the climate change, global warming and changing patterns of rainfall conservation of Rhododendron species to be of utmost importance. The Government of Sikkim, Arunachal Pradesh and Government of India should pay attention towards this particular aspect of conservation

6. There should be coordinated programmes to identify desirable and endangered ecotypes of various rhododendron species in India particularly in Sikkim and other potential areas in Himalaya.

7. The threat factors responsible for decline of species need further identification and suitable remedial measures should be placed.

Strategies and Action Plan for Sustainable Use

Group Coordinator:

Mrs. Bharati Mohanty, CCF, India

Dr. N C Bahuguna, APCCF,India

Alternatives to firewood use of rhododendrons

- By extensive surveys.
- Providing LPG connection to villagers.
- Obligatory LPG use by trekkers, as per norms.

Rhododendron oriented tourism

- Education upliftment of local villagers.
- Restricted tourism in in-situ environments.
- Involvement of unemployed educated youth.
- Publishing local literature.

Strengthening economic packages

- Alternative livelihood through handicraft manufacturing.
- Long term planning for Protected Areas.
- Expanding rhododendron plantation cover outside forest.
- Growing rhododendron on commercial basis for incense making and other produces.

Awareness building

- Creation of Rhododendron society in state and other parts of rhododendron rich areas.
- Strengthening research base.
- Creating awareness about rhododendrons amongst stakeholders and public.

Photo Gallery


International Conference on


International
Rhododendron
Festival, 2010
Sikkim


Rhododendrons
Conservation a
April 29, 2010,