Medicinal Plants of Indian Himalayan Region- An Elixir of Life

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Abstract—*The Indian Himalayan Region (IHR), covers an area of 5 Lakh km^2 and accounts for approximately 16.2% of country's total geographical area. The IHR with a wide altitude range (300-8000 m) is home to rich diversity of plants and animals. It is estimated that there are approximately 10,381 species of plants growing in IHR out of which approximately 1,748 species of plants are presently being used for their medicinal properties. The therapeutic potential of medicinal plants has been acknowledged since time immemorial. The "Charak Samhita", an ancient Indian text on Ayurveda, describes Himalayas as the best habitat of medicinal plants. The fact that the Himalayan range is home to 21 forest types in itself is an indication of its diverse habitat which supports rich diversity of plants out of which many are endemic.*

A growing preference of plant based medicines by a large section of people, all over the world, has added more thrust in this area. However, the problem lies in the fact that majority of the plants used for their medicinal value are primarily extracted from the wild. Over the years, this practice has already affected the very existence of a number of plants of high commercial value. Furthermore, habitat destruction and over exploitation has brought many medicinal plant species to the verge of extinction. According to the IUCN's Red Data Book, many medicinal plant species of IHR are either threatened or are at the verge of extinction. In order to save these valuable natural resources from extinction there is an urgent need to focus our attention on their conservation. Practices such as judicious use of the medicinal plant resources, their cultivation and propagation is thus urgently needed for national as well as global interest.

Medicinal Plants: Past, Present and Future

The history of medicinal plants finds its root in deep antiquity. The primitive man found out the therapeutic potential of plants by observing the animals around him who used to search for specific plants during a certain ailment, eventually by trial and error for a good many centuries he found out what worked best for him [1]. The ancient civilizations in India, China, Egypt, Greece and Mesopotamia utilized the therapeutic potential of herbs. In India the oldest record of the use of plants as medicine is mentioned in the Rigveda (4500-1600 BC). The authoritative works of Charak (1000-800 BC) and Susruta (800-700 BC) marks the beginning of herbal science in India. Today medicinal plants are an integral part of Ayurveda, Siddha, Unani, Tibetan, Chinese and other traditional systems of medicine. According to World Health Organization (WHO), nearly 80% of the people in developing countries consume traditional medicines for sustaining health and vitality [2]. Even in developed countries there has been a renewed interest in traditional system of medicine with increasing preference for natural and plant based substances in healthcare [3].

The Indian Himalayan Region (IHR)

The Indian Himalayan Region (IHR) (26°20'-35°40'N and 74°50'-95°40'E) which includes parts of Trans, North West Himalayas, West Himalayas, Central Himalayas and East Himalayas covers an area of 5 Lakh km^2 and accounts for approximately 16.2% of country's total geographical area and forms the northern boundary of the country [4]. The IHR covers states viz. Jammu & Kashmir, Himachal Pradesh, Uttaranchal, Sikkim, Arunachal Pradesh, Meghalaya, Nagaland, Manipur, Mizoram, Tripura, and hill regions of 2 states viz. Assam and West Bengal (see Fig. 1) [4, 5].

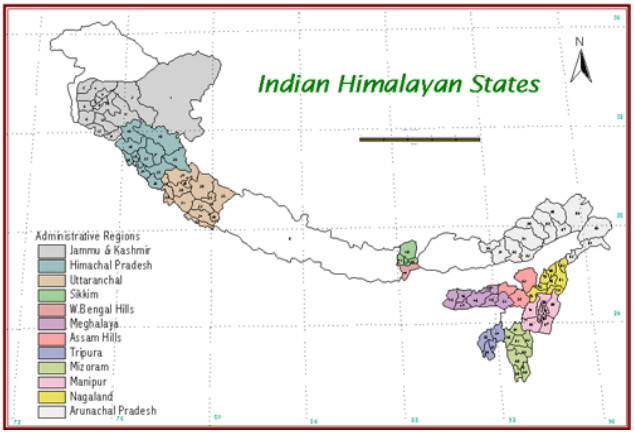

Fig. 1: Location Map: Indian Himalayan Region (Source: ENVIS, [4])

Medicinal Plants of IHR

The IHR has wide altitude range (300-8000 m asl), which provides rich diversity of habitat for both plants and animals. The IHR is one of the richest reservoirs of biological diversity in the world and is considered as a store house of the valuable medicinal plant species [3, 6]. The "Charak Samhita", an

ancient Indian text on Ayurveda, also described Himalayas as the best habitat of medicinal plants.

The vegetation of IHR comprises of tropical, subtropical, temperate, sub-alpine and alpine types [7]. It is estimated that the flora includes 8,000 species of angiosperm (40% endemic), 44 species of gymnosperm (16% endemic), 600 species of pteridophyte (25% endemic), 1737 species of bryophyte (33% endemic), 1,159 species of lichen (11% endemic) and 6,900 species of fungi (27% endemic).Out of these 10,381 species of plants growing in IHR, approximately 1,748 species of plants are presently being used for their medicinal properties in both traditional and modern therapeutic practices [6, 8]. The medicinal plants of IHR have a great potential of providing novel biomolecules as they are subjected to various environmental stress which are unique to this region. Thus, there lies a great potential which if exploited judiciously can not only benefit the healthcare sector but can also serve as a source of income generation for the local population.

A growing preference of plant based medicines over synthetic drugs and antibiotics, by a large section of people all over the world, has added more thrust in this area. However, the problem lies in the fact that at least 90% of medicinal plant species are extracted from the wild [9] and 69% of the material is collected through destructive harvesting. Over the years, this practice has already affected the very existence of a number of plants of high commercial value [10]. Furthermore, overexploitation, excessive anthropogenic pressure and climate change poses a serious risk to the medicinal plant species growing in the Himalayas. According to IUCN's Red Data Book, many medicinal plant species of IHR are at the verge of extinction. In order to save these valuable natural resources from extinction there is an urgent need to focus our attention on their conservation. Practices such as judicious use of the medicinal plant resources, their cultivation and propagation is thus urgently needed for national as well global interest.

Diversity of Medicinal Plants of IHR

In India out of 17,000 species of higher plants, 7500 are known for their medicinal value. This proportion (44%) of medicinal plants is highest amongst other countries of the world (see Table 1) [11, 12].

Table 1: Distribution of medicinal plants

Country or region	Total number of native species	Number of medicinal plants	% of medicinal plants
World	297000	52885	10
India	17000	7500	44
IHR	8000	1748	22

(Source: Shiva 1996, [11]; Kala et al 2006, [12])

The IHR harbours 50% of the total medicinal plant species available in the country [13].The rich diversity of medicinal plants in IHR is due to its rich geographical and climatic diversity [14].The medicinal plants of IHR belong to three taxonomic groups ie. Angiosperms, Gymnosperms and Pteridophytes, the species richness is maximum in herbs, followed by trees, shrubs and pteridophytes [6]. Within IHR, maximum species of medicinal plants are reported from Uttaranchal, followed by Sikkim and North Bengal [15].According to the Red Data Book, out of the total species of medicinal plants of IHR, 31% are native, 15.5% endemic and 14% are threatened.

Nativity, Endemism and Rarity

Nativity of a species is determined by its place of origin, it is estimated that out of all the plant species growing in the Himalayas 68.5% are considered non native, this suggest their ability to establish in diverse environmental conditions. Only 25.8% species are native to the Himalayan region and 5.66% are native to Himalayan region and other neighbouring biogeographic regions [6].

It is interesting to note that the majestic snow clad mountains and deep valleys along with other environmental conditions play important role in restricting distribution of species beyond IHR, due to this out of the total number of higher plants, approx. 46% are endemic to IHR and out of the total medicinal plants species, 62 species are endemic to IHR whereas 208 species are near endemic, which extend their distribution to regions adjacent to IHR [16].

Habitat destruction and continuous exploitation over the years have resulted in decline of population of many high value medicinal plant species of IHR. The other possible causes of rarity are specificity, land use disturbances, invasive species, habitat alteration, climatic changes, heavy livestock grazing, explosion of human population, population bottleneck, and genetic drift [17, 18, 19]. In addition to this, natural enemies such as pathogens, herbivores, and seed predators, could drastically restrict the abundance of rare medicinal plant species in a given area [20, 21].

Utilization and Commercial Exploitation of Medicinal Plant Resources

Medicinal plants primarily find their application in traditional as well as modern system of medicine and plant-based pharmaceutical industries. Apart from their use in medicine and pharma sector, over 200 species of medicinal plants of IHR are consumed raw, roasted, boiled, fried, cooked, or they are used in the form of oil, spices, jams or pickles [6, 22]. Some species are used by the native people for various purposes such as food, fodder, fuel, timber, for making agricultural tools and other miscellaneous uses. Some of the medicinal plants used in common ailments are listed in Table 2 [23] and some commonly used medicinal plants used in pharmaceutical preparation are listed in Table 3 [24].

Table 2: Common ailments and medicinal plants used in traditional health care system

Ailment	Common medicinal plants
Antipyretic	*Picrorhiza kurrooa, Aconitum balfourii, Berberis asiatica, Bergenia ligulata, Viola odorata*
Antiseptic	*Saussurea obvallata, Arnebia benthamii, A. euchroma*
Appetizer	*Angelica glauca, A. archangelica, Allium sp.*
Astringent	*Rheum emodi, Orchis latifolia*
Leukoderma	*Heracleum candicans, Swertia chirayita*
Jaundice	*Nardostachys jatamansi, Berberis aristata*
Cuts, Burns, Boils	*Arnebia benthamii, A. euchroma, Saussurea obvallata*
Conjuctivitis	*Delphinium elatum*
Cough & Cold	*Aconitum heterophyllum, Saussurea obvallata,*
Tonic	*Swertia chirayita, Swertia angustifolia*
Menstrual disorder	*Podophyllum hexandrum, Organum vulgare, Polygonum tortuosum*

(Source: Dhar et al 2002, [23])

Table 3: Some important medicinal plants of IHR used in pharmaceutical preparations

Botanical name	Common name	Used in no. of preparation
Terminalia chebula	Hararrh	219
Terminalia bellirica	Bahera	219
Embelica officinalis	Amla	219
Glycyrrhiza glabra	Yashtimadhu	141
Justicia adhatoda	Vasaka	110
Withania somnifera	Ashwagandha	109
Cyperus rotundus	Mustaka	102
Tinospora cordifolia	Gulancha	88
Berberis aristata	Daruharidra	65
Tribulus terrestris	Gokshuru	65
Aegle marmelos	Bael	60
Boerhaavia diffusa	punarnava	52
Acorus calamus	Vacha	51

(Source: Ved 2001, [24])

Plants with Anticancerous Properties

It is interesting to note that apart from proving with medicinal plants that are used in common diseases/ailments, the IHR is bestowed with several species of plants that have anticancerous properties. A total of 36 species of plants belonging to 32 genera in 28 families have anticancerous properties. These species represent trees (18 sp.), shrubs (7 sp.), herbs (8 sp.) and fern (1 sp.). Family Anacardiaceae (3 sp.) and Acanthaceae, Asclepiadaceae, Asteraceae, Mimoseae, Moraceae, Rutaceae (2 sp. each) represent the maximum species of anticancerous plants [7].Some of the anticancerous plants of IHR are summarized in Table 4. These medicinal plants hold a tremendous potential in providing valuable prototype biomolecules that can be developed into more effective drugs against cancer.

Medicinal Plant Sector and its Challenges

The burgeoning human population has put tremendous pressure on natural resources, including medicinal plant species. Habitat destruction and over-harvesting of many plant species from wild has resulted in loss of existing species. A growing preference of plant based medicines by a large section of people, all over the world, has further increased the pressure on the existing medicinal plant resources. Furthermore, the problem lies in the fact that majority (95%) of the plants used for their medicinal value in India are primarily extracted from the wild [25, 26].

Table 4: Some medicinal plants of IHR with anticancerous properties

Family	Scientific Name	Local Name	Life Form	Part Used	Active Compounds
Acanthaceae	*Hygrophila auriculata* (Sechum.) Heine	Gormidi	H	St,Lf, Rt	Spasmol, hypoten, flcontain, apigenin & glucuronide
	Hygrophila spinosa Anders.	Kikirigach	H	St,Lf, Rt	Spasmol, hypoten, flcontain, apigenin & glucuronide
Anacardiaceae	*Buchanania lanzan* Spr.	Char	T	Wp	Amino acid, tannin
	Buchanania latifolia Roxb.	Pial	T	Wp	Amino acid, tannin
	Mangifera indica	Aam	T	Lf, Fl	Ethyl glate, vitamin A, B, C and D
Annonaceae	*Annona squamosa* L.	Sitaphal	T	Rt, Sd, Lf	Hydrocyanic acid, anonaine, Vitamin-C

Apocynaceae	*Catharanthus roseus* (L.) Don	Nayatara	Sh	Wp	Ursolic acid, leanolic acid, vincarine, vinervine, tombozine, leurosine, vindoline, catharanthine lochnerine and tetrahydroalrtonine
Araceae	*Scindapsus officinalis* (Roxb.) Schott.	Harjora	H	Wp	Sterol, Sciandapsin A and B
Aristolochiaceae	*Aristolochia indica* L.	Kalesar	H	Lf, Rt	Isoaristolochic, oil conatins: Carbonyl compounds and isovanillin
Asclepiadaceae	*Calotropis gigantean* (L.) Br.	Amadar	Sh	La, Lf, sd, Rt	Caloptrin, akundarin, uscharin, calotoxin, calactin, α-calotropeol, β- amyrin and calcium oxalate
	Calotropis procera Br.	Aak, Madar	Sh	La, Rt,Lf	Cardiac steroid, glycd. With some aglycone, calatropagenine, uscharin, calotoxinand calatin
Asteraceae	*Ageratum conyzoides* L.	Ajgandha	H	Lf	Phenols, (eugenols), ethyl eugenol, caryophyllene, γ-cadinene, agerotochromene, Stigmaestrol, β-sitosterol, ditriacontene
	Elephantopus scaber L.	Bis-hari	H	Rt	Germancranolide, elephantopin
Berberidaceae	*Berberis aristata* DC.	Kilmora	Sh	Rt	Berberine
Caesalpiniaceae	*Cassia fistula* L.	Amaltas	T	Lf, Fr, Sd	Anthraquinone, tannin, fistucacidin, sennosides A and B
Cochlospermaceae	*Cochlospermum religiosum* (L.) Alston	Gong	T	Bk, Fl, Fr	Saponins, tannins and terpenoides
Combretaceae	*Anogeissus latifolia* Bedd.	Bakla		Bk, Rt	
Convolvulaceae	*Cascuta chinensis* Lam.				Dulcitol, D-mannitol, leutolin, caucutalin and cuscutin
Dicranopteridaceae	*Dicranopteris linearis* (Burm. F.) Underw.		Fn	Wp	β-sitosterol, flavonoid
Euphorbiaceae	*Tragia invoulcrata* L.	Bishati	T	Fr, Lf, Rt	
Fabaceae	*Mucuna pruriens* (L.) DC.	Konch	Sh	Fr, Sd	Mucuadine, mucuadinine, mucuadininine, and pruriendine, and small amount of nicotine etc.
Liliaceae	*Drimia indica* (Roxb.) Jessop.	Ban-piaj, Ramkanda	H	Bk	Hentrialontanol, octanosanoic acid, sitisterol, anhydroscilli
Lythraceae	*Woodfordia fruticosa* (L.) Korz.	Dhai	Sh	Fl	Astrin
Malvaceae	*Gossypium herbaceum* L.		Sh	Rt, Bk, Sd	Gossypol
Meliaceae	*Azadirachta indica* Juss.	Neem	T	Bk, Lf, Fr	Margosic acid, nimbin, nimbinin, nimbidin, bakaganin
Mimosaceae	*Acacia catechu* (L.f.) Willd.	Khatta	T	Bk, Rt	D-glucose, L-arabinose, D-ramnose, L-Gluconoic acid
Moraceae	*Ficus recemosa* L.; F. glomerata Roxb.	Gular	T	Bk	Ceryl behente, lupeol, a-amyrin, stigma-sterol
Myrtaceae	*Syzygium cuminii* (L.) Skeels	Jamun	T	Lf, Bk, Fr, Sd	Jambolin, ellagic acid, tannins, gallic acid, lactic acid, proteins
Oleaceae	*Nyctanthes arbortristis*	Parijat	T	Lf, Bk	Mannitol, β-amyrin, β-sitosterol, hentriacontane, benzoic acid
Podophyllaceae	*Podophyllum hexandrum* Royle	Bankakri	H	Rh	Podophyllin, podophyllotoxin and podophyllol resin
Rutaceae	*Glycosmis arborea* (Roxb.) DC.; *G. mauritiana*	Bannimbu	T	Fr, Rt, Bk	Glycozolidine, carbazolederivates, dictamine, arborinine, triterp
Simaroubaceae	*Brucea mollis* Wall ex. Kurz	Koinine	T	Fr, Sd	
Taxaceae	*Taxus baccata* L. subsp. Wallichiana (Zucc.) Pilger*	Rakhal	T	Bk, Lf	Taxol

Abbreviations used: H=Herb; S=Shrub; T=Tree; Fn-Fern; Wp=Whole plant; Rt-Root; St=Stem; Fl=Flower; Lf=Leaf; Bk=Bark; Fr=Fruit; La=Latex; Sd=Seed; Rh=Rhizome; *=Near Endemic (Source: Samant et al 2011, [7]).

Over the years, this practice has already affected the very existence of a number of plants of high commercial value [12]. In addition to this, over-exploitation of many species has brought many medicinal plant species to the verge of extinction. Global climate change also poses a serious risk to the medicinal plant species growing in the Himalayas. Continuous depletion of medicinal plant resources have not only adversely affected its supply and resulted in loss of genetic diversity, but it has also seriously affected the livelihoods of native people living in the forest margins [28].

According to the International Union for the Conservation of Nature and Natural Resources (IUCN), 32 species of medicinal plants of IHR are categorized as Critically Endangered (CR) (*Aconitum heterophyllum, Acorus calamus, Angelica glauca, Dactylorhiza hatagirea, Delphinium denudatum, Fritillaria roylei, Nardostachys grandiflora, Podophyllum hexandrum, Saussurea costus, Swertia chirayita, Taxus baccata* subsp. *wallichiana,* and *Valeriana wallichii*); Endangered (EN) (*Berberis aristata, Betula utilis*, *Ephedra gerardiana*, *Gloriosa superba, Meconopsis aculeata, Picrorhiza kurrooa, and Rauwolfia serpentina*); Vulnerable(VU) (*Bergenia ligulata, Clerodendrum serratum, Curculigo orchioides, Hedychium spicatum, Malaxis muscifera*, *Paeonia emodi, Polygonatum verticillatum*, *Rheum australe* and *Thalictrum foliolossum*); Low Risk- Near Threatened (LR-NT) (*Celastrus paniculatus, Hyoscyamus niger* and *Cinnamomum tamala*); and Low Risk- Least Concern (LR-LC) (*Evolvulus alsinoides*) [29]. Medicinal plants of IHR which are in short supply and are thus prioritized for research and development are listed in Table 6 (see Table 5) [12]. Some of the institutions in India which are involved in funding projects in the area of medicinal plant research in India are - NMPB, DST, CSIR, ICMR, AICTE, DBT, DRDO, ICAR, MoEF, NABARD, UGC, HRDI and GBPIHED [12].

In order to preserve these valuable medicinal plant resources from extinction, their conservation by both *in-situ* (protected areas viz. national parks, sanctuaries, biosphere reserves) and *ex-situ* (commercial cultivation, botanical gardens, micropropagation, cryopreservation of seeds) means is urgently required. Furthermore, their commercial cultivation through sustainable methods such as agroforestry, will not only meets their escalating demands in the market, but it also helps in conserving their wild genetic diversity. For medicinal plant sector to flourish, coordinated efforts are needed in the field of research, cultivation, collection, storage, processing, manufacturing and marketing of medicinal plant resources [12]. A successful medicinal plant sector will not only provide employment to several people, boost both national and world economy but it will also contribute to the health of millions.

Table 5: Important medicinal plants in short supply and prioritized for R & D

Botanical name	Hindi name	Part used	Important uses	Species in short supply[a]	Species prioritized for R & D[b]
Aconitum heterophyllum Wall.	Atees	Rt	Fever, cough, piles, stomachache	√	√
Commiphora wightii (Arn.) Bhandari	Guggul	Rs Bk	Asthma, typhoid	√	√
Nardostachys jatamansi (Don) DC.	Jatamansi	Rh	Bronchitis, blood purifier, hysteria	√	√
Picrorhiza kurrooa Benth.	Katuki	Rh	Headache, fever, dysentery, anemia,	√	√
Saraca asoca (Roxb.) De Wilde	Ashok	Bk, Lf	Heart disorder, tonic	√	√
Saussurea costus (Falc.) Lipsch.	Kut	Rt	Dysentery, asthma, ulcer	√	√
Swertia chirayita (Roxb. ex Flem.) Karsten.	Chirata	Wp	Malarial fever, blood purifier	√	√

Abbreviation used : Rt=Root; Rs=Resin; Rh= Rhizome; Bk=Bark; Lf=Leaf; Wp=Whole plant;
a-Medicinal plants in short supply and quantity required according to the Planning Commission, Government of India
b- Species of medicinal plants prioritized for research and development according to the National Medicinal Plants Board, Government of India. (Source: Kala et al 2006, [12]).

References

[1] Rai, L. and Sharma, E., "Medicinal Plants of the Sikkim Himalayas-Status, Usage and Potential", GBPIHED: Himavikas Occasional Publication No. 5, 1994.

[2] Malik, C.P., Garg, P., Singh, Y. and Grover, S., "Medicinal uses, chemical constituents and micropropagation of three potential medicinal plants", International journal of life science and pharma research, 2, 3, Jul-Sept 2012, pp. 57-76.

[3] Samant, S.S., Pant, S., Singh, M., Lal, M., Singh, A., Sharma, A., and Bhandari, S., "Medicinal plants in Himachal Pradesh, north western Himalaya, India", Int J Biodiv Sci Manag, 3, 2007, pp. 234–251.

[4] ENVIS, Environmental Information System, Ministry of Environment, Forest and Climate change, Government of India, http://envis.nic.in/.

[5] Rodgers, W.A., and Panwar, H. S., "*Planning a Wildlife ProtectedArea Network in India",*Vol I. Report, Dehradun: Wildlife Institute of India, 1988.

[6] Samant, S. S., Dhar, U., Palni, and L. M. S., "Medicinal Plants of Indian Himalaya: Diversity Distribution Potential Values", Almora: G.B. Pant Institute of Himalayan Environment and Development, Nainital: Gyanodaya Prakashan, 1998.

[7] Samant, S. S., Vidyarthi, S., Pant, S., Sharma, P. (Sr.), Marpa, S., and Sharma P. (Jr.), "Diversity, Distribution, Indigenous Uses and Conservation of the Medicinal Plants of Indian Himalayan Region Used in Cancer", J Biodiversity, 2, 2, 2011, pp.117-125.

[8] Singh, D. K., and Hajra, P. K., "Floristic diversity", in: Gujral GS, Sharma V eds. *Biodiversity Status in the Himalaya*. New Delhi: British Council, 1996, pp.23–38.

[9] Anonymous, "*Conservation Assessment and Management Plan Workshop Process",* WWF, India; 1997

[10] Dhar, U., Rawal, R. S., and Upreti, J., "Setting prioritization for conservation of medicinal plants: a case study in the Indian Himalaya", *Biological Conservation,*95, 2000, pp. 57–65.

[11] Shiva, M. P., "Inventory of Forestry Resources for Sustainable Management and Biodiversity Conservation", New Delhi, Indus Publishing Company, 1996.

[12] Kala, C. P., Dhyani, P. P., and Sajwan, B. S., "Developing the medicinal plants sector in northern India: challenges and opportunities", *Journal of Ethnobiology and Ethnomedicine,* 2, 32, 2006, pp.1-15.

[13] Rao, R. R., "Medicinal Plants of India: Diversity, Conservation and Bioprospection- A Priority Agenda for 21st Century". in IP Tripathi (ed.) Chemistry, Biochemistry and Ayurveda of Indian Medicinal Plants, 2013, pp.13-40.

[14] Kumari P., Joshi, G. C., and Tewari, L. M., "Diversity and status of ethno-medicinal plants of Almora district in Uttarakhand, India", International Journal of Biodiversity and Conservation, 3, 7, 2011, pp. 298-326.

[15] Kala, C. P., "Revitalizing traditional herbal therapy by exploring medicinal plants: A case study of Uttaranchal State in India", in *Indigenous Knowledges: Transforming the Academy, Proceedings of an International Conference* Pennsylvania: Pennsylvania State University, 2004, pp.15-21.

[16] Chatterjee, D., "Studies on the endemic flora of India and Burma", *Journal of Royal Asiatic Society Bengal* 5, 1939, pp. 19-67.

[17] Kala, C. P., "Status and conservation of rare and endangered medicinal plant in the Indian trans-Himalaya", *Biological Conservation,* 93, 2000, pp. 371-379.

[18] Weekley, C. W., and Race, T., "The breeding system of *Ziziphus celata* Judd and D.W. Hall (Rhamnaceae), a rare endemic plant of the Lake Wales Ridge, Florida, USA: implications for recovery", *Biological Conservation*, 100, 2001, pp. 207-213.

[19] Kala, C. P., "Indigenous uses, population density, and conservation of threatened medicinal plants in protected areas of the Indian Himalayas", *Conservation Biology*, 19, 2005, pp. 368-378.

[20] Bevill, R. L., Louda, S. M., and Stanforth, L. M., "Protection from natural enemies in managing rare plant species", *Conservation Biology*, 13, 1999, pp. 1323-1331.

[21] Dhyani, P. P., and Kala, C. P., "Current research on medicinal plants: Five lesser known but valuable aspects", *Current Science*, 88, 2005, pp. 335.

[22] Dhyani, P. P., and Dhar, U., "*Myrica esculenta* Box myrtle Kaphal: A promising underexploited tree crop of the Himalaya", Almora: G.B. Pant Institute of Himalayan Environment and Development, 1994.

[23] Dhar, U., Manjkhola, S., Joshi, M., Bhatt, A., Bisht, A. K., and Joshi, M., "Current status and future strategy for development of medicinal plants sector in Uttaranchal, India", Current Science, 83, 8, 25 October, 2002, pp. 956 – 964.

[24] Ved, P., "Indian Medicinal Plants; Current Status", in Samant SS, Dhar U, Palni, LMS (eds), *Himalayan Medicinal Plants: Potential and Prospects*. Nainital: Gyanodaya rakashan, 2001, pp. 45–65.

[25] Uniyal, R. C., Uniyal, M. R., and Jain, P., "Cultivation of Medicinal Plants in India: A Reference Book. New Delhi: TRAFFIC India and WWF India, 2000.

[26] Kala, C. P., "Commercial exploitation and conservation status of high value medicinal plants across the borderline of India and Nepal in Pithoragarh", *The Indian* Forester, 129, 2003, pp. 80-84.

[27] FAO: State of the World's Forest. Rome: Food and Agricultural Organization, 2003.

[28] Rao, M. R., Palada, M. C., and Becker, B. N., "Medicinal and aromatic plants in agro-forestry systems",*Agroforestry Systems,*61, 2004, pp. 107-122.

[29] Pal, M., and Samant, S. S., "XII World Forestry Congress, Quebec City, Canada, 0926-A1, 2003.