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Depleting Indigenous Knowledge of Medicinal Plants in Cold-Arid Region of Nanda Devi Biosphere Reserve, Western Himalaya

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Abstract

Medicinal plants play a vital role in local health care system of indigenous communities in remote areas. However, a declining trend is prevailing with respect to the indigenous knowledge of wild plants across the globe. Based on semi-structured questionnaire surveys and in-depth interviews, the study attempts to document the indigenous knowledge on medicinal plants of an ethnic community in Nanda Devi Biosphere Reserve of India. The study revealed that the locals are knowledgeable of about 38 medicinal plants used for curing 24 different human ailments. However, the practice of utilising medicinal plants in their local healthcare system is sharply declining due to lack of education facility; that has lead to lack of knowledge as well as transfer of knowledge to youger generations. The richness of knowledge about medicinal plants was assessed using Knowledge Richness Index among different age groups. To promote awareness and enhance access on ethno-medicinal wisdom, the management authorities must necessitate educational facilities in the region and the traditional knowledge information portal as recognised by the Convention on Biological Diversity and people's biodiversity register are required to develop.

Keywords: Ethno-medicine; Ethno-botanical knowledge; Knowledge richness index; Traditional knowledge; Bhotiya

Introduction

The Himalayan region has been regarded as a veritable emporium of phyto-resources, largely medicinal and aromatic plants. Medicinal plants (MPs) play a vital role in the formulation and development of new drugs [1]. More than 80% of the human population in developing countries still depends on traditional medicines; mostly plant derived drugs, to meet their primary health care needs [2]. Over 50,000 plant species are used for medicinal purposes worldwide out of which almost 13% are angiosperms [3]. Two-third of the estimated medicinal species in use is still harvested from the wild, out of which 4,000-10,000 species may now be endangered [4]. India, with over 53 million tribal people belonging to 550 communities of 227 ethnic groups [5,6] holds a vast repository of traditional knowledge (TK) associated with biological resources. Sixty five percent of the human population depends on traditional medicine [7] where over 8000 plant species have been recorded as being used in traditional and modern medicines [8]. Moreover, studies [9-12] have reported the use of ca. 7000-8000 MPs in Ayurveda, Unani, Siddha, Chinese, Amchi and Homeopathic systems in the country. Local communities in the country use less than 2000 species of MPs for the treatment of various ailments [13]. Every year about 960 species of MPs are traded in the country, of which 178 species are extracted in excess of 100 Metric tonnes [14]. Due to rising demand for MPs; along with degradation and fragmentation of natural habitats, more than 300 species of Indian medicinal plants have now been pushed to the 'Threatened' category as per IUCN criteria [10]. The Indian Himalayan Region (IHR), recognized for its rich biodiversity, supports about 18,440 plant species (i.e. 8,000 angiosperms, 44 gymnosperms, 600 pteridophytes, 1,737 bryophytes, 1,159 lichens and 6,900 fungi [15], of which over 1,748 species (Angiosperms 96.3%, Pteridophytes 3.0% and Gymnosperms 0.6%) are known for their medicinal value [16]. About 90% of wild plant species collected from sub-alpine and alpine regions of the Himalaya is used in various herbal industries [17]. The Western Himalaya (WH), comprising Himachal Pradesh (Eastern part) and Uttarakhand, contributes 50% of the total plants used by the medicine industry as per the British Pharmacopoea [18]. WH caters to 80%, 46% and 33%, demands for medicine in Ayurvedic, Unani and Allopathic systems, respectively and contributes a major share in the economic earnings of rural farmers and tribals [18]. Among the Indian Himalayan states, the highest i.e. 964 species [19], of medicinal and aromatic plants (MAPs) have been recorded in the state of Uttarakhand followed by Sikkim and North Bengal with 707 species [16] where as, the Trans-Himalayan region of Ladakh and Lahul Spiti supports 337 medicinal species with low population density and narrow distribution range [20].

The Convention on Biological Diversity (CBD) and the Aichi Biodiversity Targets (article 8(j) and target 18, respectively) recognize the role of indigenous people in the conservation and management of biodiversity through the application of indigenous knowledge. Issues on biological resources and associated indigenous and TK have expanded from the deliberations and have been taken into consideration as an important agenda in biodiversity conservation. Traditional and indigenous knowledge about use of various phyto-resources and local system of using them also work towards conservation of these resources. Thus, various organizations (e.g. WHO) across the globe have advocated for their preservation and development. However, recent economic developments, exposure to market economy and modernization of infrastructure have brought a transition in the traditional lifestyle of local communities which is leading to the erosion of TK in many parts of the Himalaya [21,22]. In the remote regions of Himalaya, plants are a vital part of the indigenous health care system of local communities. However, the current scenario is one where use of

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traditional knowledge is changing; as the use of most wild plants earlier preferred as a source of food, fibre and medicine has declined in the Western Himalaya [23]. This is primarily due to changes in lifestyle and economic status with increasing modernization and easy availability of market products. The changing trend in the traditional health care system (Sowa-rigpa) in Western Ladakh has been reported [24], where younger generations showed a lack of interest in the practice of their traditional system. A similar trend has been found in Uttarkashi district of the state of Uttarakhand, India [25] and in tribal district of Andhra Pradesh [26]. These are not isolated incidents restricted to India; as the loss of TK about plant use has also been reported in the Sierra de Manantlan Biosphere Reserve of Mexico [27]. Moreover, the studies [4,28] reported the loss of TK of MPs due to modernization. Taking these facts into consideration, the present study was carried out to document existing TK about MPs of the inhabitants in Nanda Devi Biosphere Reserve (NDBR) of India.

Materials and Methods

Study area

Nanda Devi Biosphere Reserve (30°05' to 30°02'N Lat, 79°12' to 80°19'E Long) is located in the Western Himalaya. It has two core zones i.e., Nanda Devi National Park (625 km^2) and the Valley of Flowers National Park (88 km^2); both are listed as World Natural Heritage sites due to their exceptionally high biodiversity. The reserve is spread across ca. 2236.74 km^2 and has an elevational range from 1800-7817m above mean sea level (amsl). A total of 817 species of vascular plants have been recorded from the reserve [29,30]. The present study was conducted in the cold-arid region of NDBR covering Upper Dhauli Valley (UDV, *ca.* 727.71 km^2) in Uttarakhand, the 'Herbal state of India' (Figure 1). UDV is named after the river Dhauli Ganga that forms one of the major catchments of river Alaknanda. The elevation ranges from 3000 to > 6000m amsl. The valley, situated in the rain-shadow zone of NDBR, harbours a total of 460 vascular plants [31]. The entire area remains snow bound for more than 6 months in a year. Summer is very short and lasts from mid-May to late August. The region receives low amount of precipitation and remains dry and dusty. There are seven villages in the study area, viz; Mahargaon, Kailashpur, Gurgutti, Pharkia, Bampa, Gamsali and Niti inhabited by Tolcha and Marcha, the clans of Bhotiya ethnic community of Indo-Mongoloid origin. Niti is the last village in the valley that borders to China. The total number of households in the area is 292 with a total population of 864 people (47.5% males and 52.5% females [32]) and the average family size was 4-5 persons. Prior to 1962, residents of this valley carried cross-border trade with Tibet, primarily in salt and wool which was their main source of income. In recent decades, livestock (sheep and goat) rearing and weaving of woolen items such as pankhi (shawl), chutka or gudma (mattress), dann or kalin (carpet), topi (cap), fatuli (vascot) and baniyan (sweater) has been a more reliable source of income for locals, though at present it is restricted to a few families. The inhabitants have two dwellings; one in UDV i.e. cold-arid region, between 3000 to 3600m amsl, where they stay during the summer and the other in the lesser Himalaya, between 1000-1500m amsl, which is the permanent dwelling. They depend on natural resources from the adjacent forests and alpine pastures for their livelihood and the area continues to be used for transhumant Pastoralism [33]. The Bhotiyas have their own customs, folklore and religious beliefs. Additionally, this community has its own perspective on conservation which manifests itself through local archetypes [34]. An account on ethnobotanical use by locals reporting 86 and 50 species has been madein the entire Dhauli Ganga catchment of Alaknanda [35,36].

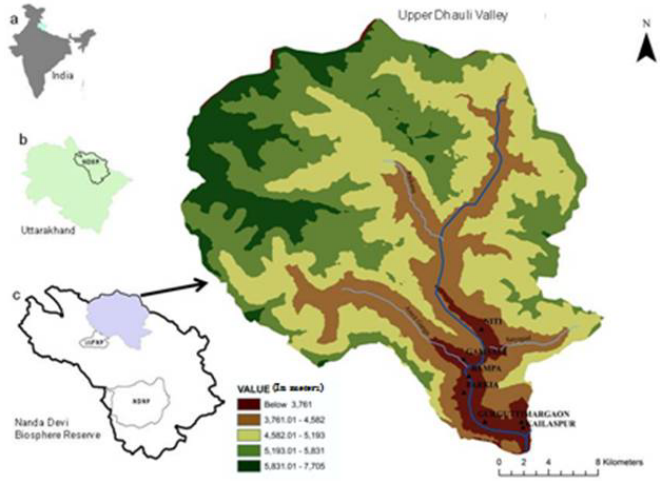

Figure 1: Map showing study area i.e. Upper Dhauli Valley, a part of Nanda Devi Biosphere Reserve.

Data collection

This study is based on an ethno-medicinal survey conducted within the Bhotiya community of seven villages of UDV during the snow-free period from July to September in the years 2011 and 2012. In order to document the state of traditional knowledge, semi-structured questionnaire surveys having open-ended and close-ended questions, in-depth interviews and focus group discussions were conducted following [37] to collect information primarily on medicinal plants and their uses. The respondents were selected and interviewed randomly at various locations such as agricultural fields, house, forest, alpine meadows etc. To generate the information a considerable amount of time was spent with every respondent (gender-wise). In order to assess the traditional knowledge among various age groups, respondents were categorized into four age-classes i.e. 18-30 years (young generation), 31-50 years (adult), 51-70 years (middle aged) and above 70 years (veterans). The demographic information of inhabitants and information regarding local names, plant parts used, and aliments for which a particular plant is being used were recorded following [24,38]. Participatory resource surveys, i.e. field visits to the high alpine areas with the locals were organized and plant specimens of medicinal plants were also brought back to village, so as to ascertain the identity of plants and also to obtain first-hand information regarding their use.

Data analysis

A total of 98 respondents, respresenting 30-35% households from each village were surveyed. Among the total respondents interviewed, 42.5% were male and 57.5% female. The percent distribution of interviewed respondents in 18-30 years was 20%, 31-50 years 31%, 51-70 years 35% and above 70 years 14%. The richness of knowledge with respect to MPs was evaluated by knowledge richness index (KRI) following [39,40]. The KRI values range from 0 to infinity; lower KRI value corresponds to the greater knowledge of the informants and vice-versa. The relationship between age and number of species known to the informant's was analysed using Pearson coefficient (PC).

Results and Discussion

Ethno-medicinal knowledge

The study revealed that the respondents were aware of medicinal

uses of 38 species (24 families and 32 genera), locally used to cure 24 different human ailments (Table 1). The maximum species (14) were used for the treatment of cold and cough followed by fever (11), stomachache (10), rheumatism (8), cuts and wounds (7) and headache (6) as shown in Figure 2. The inhabitants reported 32 species to have more than one therapeutic use, while 6 species were used only for single human ailment. Cold and cough, fever, stomachache, rheumatism, cuts and wounds, headache, diarrhea, toothache, asthma and skin disease were recorded as ten major human ailments to be cured by these MPs (Figure 2). Polygonaceae (6 species), Asteraceae (5 species) and Apiaceae (4 species) represented the families with maximum number of species. *Juniperus indica, Hippophae salicifolia* and *Ephedera gerardiana* were known for medicinal use among the shrub species; while *Betula utilis* and *Prunus armeniaca* were among the tree species (Table 1). Nearly 91% of the locals do not use medicinal plants for treatment of day-to-day ailments. About, 42% of the surveyed population was unacquainted about the use of these plants. Only 1%

Species	Local name	Parts used	Medicinal uses	Status [41]
**Aconitum balfourii* Stapf	Meetha jari	Rt	Fever, rheumatism	VU
Aconitum violaceum Jacq.	Atis	Rt	Rheumatism, stomachache, cold and cough	VU
Aconogonum tortuosum (D. Don) Hara	Nyalo	Rt, Sh	Leucorrhoea	-
Allium carolianum DC.	Doom	Wp	Headache, joint pain, cold and cough, diarrhea	-
***Allium stracheyi* Baker	Faran	Wp	Digestive power, cold and cough, jaundice	VU
Angelica archangelica L.	Choru	Rt, Fr	Body ache, fever, headache	-
Angelica glauca Edgew.	Choru	Rt	Stomachache, cold and cough	EN
Arctium lappa L.	Jangli Kuth	Rt	Stomachache, rheumatism, fever	-
Arnebia benthamii (Don) John.	Laljari	Rt, Lv	Baldness, fever, cuts and wounds	CR
Artemisia gmelinii Webb. ex Steckin	Purchu	Lv, Fr	Cold and cough	-
Artemisia maritima L.	Purchu	Lv, Fr	Stomachache, rheumatism	NT
Bergenia stracheyi Hk.f. & Th.) Engler	Silfore	Rt	Kidney stone	NT
Betula utilis D. Don	Bhuj	Bk	Rheumatism, asthma, cold and cough	NT
Carum carvii L.	Jangli zeera	Sd, Lv	Stomachache, fever, headache, diarrhea	-
Chenopodium foliolosum (Monech) Aschers.	Bethua	Lv	Indigestion, cold and cough	-
Dactylorhiza hatagirea (D.Don) Soó	Salam panja	Rt	Fever, diarrhea, cuts and wounds	CR
Ephedra gerardiana Wall.	Somlata	Rt, Sh	Asthma, rheumatism, headache	EN
Fagopyrum esculentum (L.) Moench.	Phaphar	Rt, Lv	Rheumatism, lung diseases, fever	-
Fagopyrum tataricum Gaertn.	Phaphar	Rt, Lv	Toothache, fever, headache	-
Gaultheria trichophylla Royle	Jheri	Fr, Lv	Wound, cold and cough	-
Geranium wallichianum D. Don ex Sw.	-	Rt	Toothache, skin disease	-
Hippophae salicifolia D.Don	Ames	Fr, Bk	Cold and cough, cuts and wounds	NT
Hyoscyamus niger L.	Phagun	Wp	Toothache, cold and cough	VU
Juniperus indica Bertol	Bitaru	Lv, Fr	Fever, cold and cough	-
Morchella esculenta L.	Gucchi	Wp	Cold and cough	-
Phytolacca acinosa Roxb.	Jagra	Wp	Asthma	-
Picrorhiza kurroa Benth.	Kutki	Rt, Wp	Cold and cough, fever, diabetes, jaundice	CR
Pleurospermum brunonis Benth. ex C.B. Clarke	Chippi	Wp	Stomachache, fever	-
Podophyllum hexandrum Royle	Ban kakri	Fr, Rt	Stomachache, fever, skin diseases	EN
Polygonatum verticillatum (L.) All.	Salam-misri	Rt	Stomachache, tuberculosis (Kshay rog)	VU
Polygonum plebejum R. Br.	Tanka ghas	Rt	Boils	-
Prunus armeniaca L.	Chuli	Fr	Bodyache, diarrhea	-
Rheum moorcroftianum Royle	Dholu	Rt	Cold and cough, cuts and wounds	NT
Rheum webbianum Royle	Tatri	Rt, Lv	Cuts and wounds, boils	VU
Saussurea obvallata (DC.) Edgew.	Brahma Kamal	Wp	Rheumatism, cuts and wounds, boils	EN
Taraxacum officinale Weber	Karan phool	Rt	Fever, headache	-
Thymus linearis Benth.	Marcha Ghas	Wp	Stomachache, cuts and wounds	-
Valeriana hardwickii Wall.	Tagger	Wp	Skin diseases, stomachache	-

Abbreviations: CR: Critically Endangered; EN: Endangered; VU: Vulnerable; NT: Near Threatened; Rt: Root; Wp: Whole plant; Lv: Leaf; Fr: Fruit; Sd: Seed; Sh: Shoot; Bk: Bark; *Indeterminate, **Vulnerable as per [42] red list of threatened plants.

Table 1: List of medicinal plants reported to be known by the interviewed respondents.

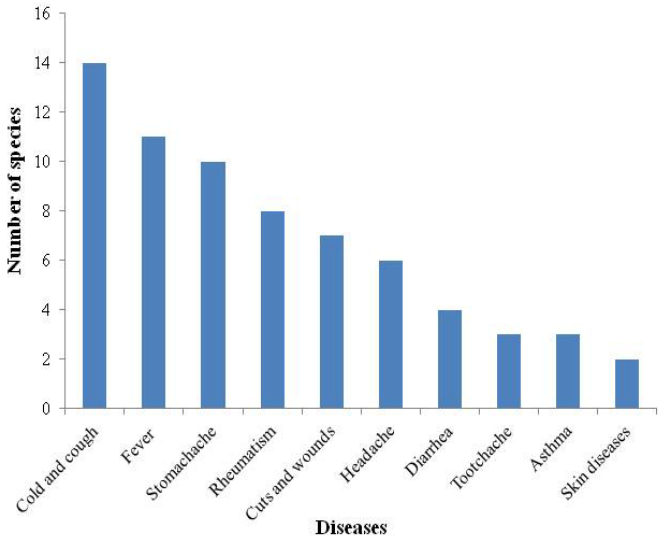

Figure 2: Medicinal plants used for different ailments by *Bhotiyas* in Upper Dhauli Valley.

of the surveyed population practiced TK to cure human ailments. Most of the respondents (95%) mentioned about the availability of modern medical facilities as reason for the depletion of TK of MPs, whereas 34% of the respondents pointed out the unavailability of medicinal plants in nearby forested zone.

Plant parts used

Commonly used plant part were roots (52% species), followed by whole plant and leaves (26% each) for curing different human ailments (Figure 3). Most of the MPs reported by locals were harvested from the wild (78% species), while 16% were cultivated and 6% were both cultivated as well as harvested from the wild. More than one plant part was reported to be used for 15 species, while 23 species were used only for single plant part.

Richness of knowledge about medicinal plants

Among respondents, the younger age class respondents mentioned that they know very few MPs (3-4), 31-50 years age class 6-7, 51-70 yeras age class 9-10, while maximum by >71 yeras age class 19-20 MPs. The KRI values was highest (0.93) for 18-30 years age class and lowest (0.25) for >70 years age class. However, the overall KRI value is 0.52 ± 0.30 for the interviewed respondents of the study area. A negative trend (y=-0.225 x + 1.075; R^2=0.91; P<0.001) is observed between the knowledge about MPs among young generation as compared to middle aged and veterans (Figure 4). The KRI values for male and female shown in Figure 5 shows similar pattern among interviewed respondents, suggests that there is as such no difference among male and female informants for knowledge of MPs.

Ethno-botanical knowledge

Apart from MPs, the use of other plants showed no decline in practice. Till date, certain plants such as *Allium stracheyi* (Jambufaran), *Allium carolianum* (Doom) and *Carum carvi* (Kala zeera) serve as condiments. *Juniperus indica* (Bitaru), *Pleurospermum brunonis* (Chippi), *Hyssopus officinalis* (Dhoop), *Artemisia gmelinii* (Purchu), *Valeriana hardwickii* (Tagger) and *Thymus linearis* (Marcha ghas) are used to make *dhoop* (traditional insence sticks). *Thymus linearis,*

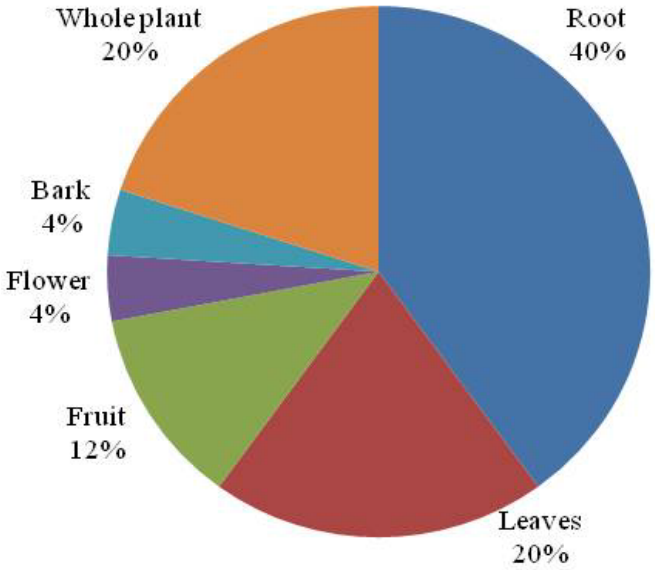

Figure 3: Plant parts used in curing different human ailments by the *Bhotiyas*.

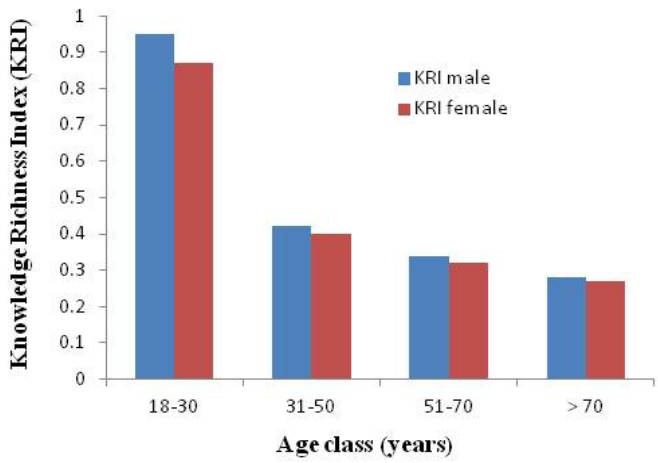

Figure 4: Knowledge Richness Index (KRI) for each age-class of male and female respondents.

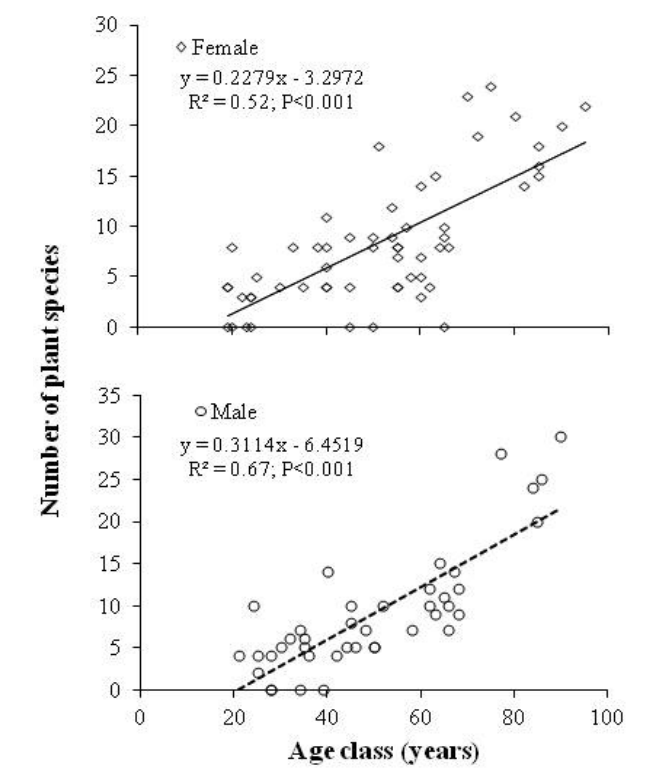

Figure 5: Relationship between age-class and the number of species known to the respondent.

Artemisia gmelinii, Artemisia maritima, Anaphalis royleana, A. nubigena, A. nepalensis, Bistorta affinis, Pleurospermum brunonis, Saussurea obvallata, Betula utilis, Juniperus indica and *Valeriana hardwickii* are used in religious ceremonies. *Ribes alpestre* (Lepcha) is used for making pickle, *Prunus armeniaca* (Khumani) is used for making jam as well as pickle, and the leaves of *Chenopodium foliolosum* and *Carum carvi* are eaten as green leafy vegetables. The species like *Kala zeera* is cultivated in kitchen gardens, while *Jambu faran* and *doom* are collected from the wild as well as grown in kitchen gardens.

Threatened taxa

Of the total 23 threatened species reported in the area [31], which fall under various threat categories as per ref. [41], 18 MPs (78%) were known to locals for their medicinal use (Table 1). Among these threatened species 34, 27, 22 and 17% were Vulernable, Near Threatened, Endangered and Critically Endangered, respectively. Additionally, two of the species viz., *Aconitum balfourii* and *Allium stracheyi* have been reported as Indeterminate and Vulnerable as per ref. [42] red list of threatened plants. The respondents reported that the populations of species such as *Aconitum balfourii, A. violaceum, Angelica glauca, Arnebia benthamii, Bergenia stracheyi, Dactylorhiza hatagirea, Ephedra gerardiana, Picrorhiza kurroa, Rheum moorcroftianum, Rheum webbianum* and *Sausurrea obvallata* have declined in the wild in recent decades. This might be due to degradation of habitat and unregulated extraction of MPs in the past. However, the authors have also verified the similar trend while conducting the floristic surveys during this study. Despite the presence of suitable habitats, the authors didn't find any individuals of *Datcylorhiza hatagirea* from the valley. However, locals mentioned its presence in the valley, though the identity of this plant is mostly confused with *Gymnadenia orchidis*.

Traditional knowleddge and locals' perception across age, gender and education

The study revealed that only 58% of the population possess traditional knowledge, mostly above the age of 50 years. About 96% of total respondents among young generation (18-30 years) mentioned that they do not have any interest in using herbal medicines, due to painstaking to find in the nature, preparation of medicine and use of such medicines. Based on surveyed population, 15, 27, 32 and 38 plant species for their medicinal values are known to Bhotiya community, respectively as per age-classes (18-30, 31-50, 51-70 and >71 years). The male respondents mentioned high number of plants used for medicinal purposes in all the age classes, except 51-70 years age class as compared to female respondents. Figure 5 show that the males know up to 32 species of MPs, while females up to 30 only. The relationship between the informant's age and number of species being known as medicinal value showed a positive correlation ($y=0.2306x - 3.6727$; $R^2=0.57$). This indicates that the older people (>50 years) have the knowledge of MPs, which is not being transfered to the youger generation. Due to migration, the informantion is not being transfred to the next generation and at the same time the older people do not want to share the knowleddge with other people of the area, except their own relatives, which is also one of the major reasons of its depletion in the study area. Of the total interviewed respondents, 44% of the respondants did not have a formal school education, 24% were having primary education (class 5^{th}) and 18% higher secondary education (10+2) and 14% higher studies (graduation and above). An assessment of knowledge with respect to education revealed that TK of MPs was more in uneducated respondants, followed by respondants having primary education. This implies that due to socio-economic transformations, the knowledge of MPs has declined in educated inhabitants. Due to less income, 90% of the inhabitants want their generations to be in other professions, mostly in government jobs.

Factors influencing the Ethno-medicinal wisdom

The study revealed that the inhabitants were knowledgeable about MPs but they seldom use this knowledge in their daily lives. Though, till the late 1990's traditional plant derived medicines were used for curing common ailments such as cold and cough, fever, stomachache, headache and cuts and wounds (personal communication to knowledgeable inhabitants about MPs viz., A.S. Chauhan and M.S. Chauhan). Recently, due to the availability of modern medicine provided at Gamshali and Burans, Indo-Tibetan Border Police (ITBP) camps and also special health drives or camps by the State of Uttarakhand, the use of plant derived traditional medicines has seen a sharp decline. Due to the lack of primary schools, most of the families and the younger generation have migrated to nearby urban centers (mostly Gopeshwar, Rishikesh and Dehradun) for higher studies and employment. Hence, this clearly proves that introduction of modern medicine, lack of educational facilities and employment and socio-economic transformations are the major factors responsible for decline in TK of medicinal plants in the region.

Conclusion

The present study revealed that inspite of rich diversity of plants in the region, only 8% were known to the locals for their medicinal values. Due to the lack of education facilities and employment, the transfer of indigenous knowledge to younger generations has been hindered. Moreover, in recent decades, due to modernization vis-a-vis socio-economic transformations in the region, the TK has eroded. The present documentation on indigenous knowledge of MPs will provide recognition to this indigenous source of information of this ethnic community from the Biosphere Reserve. The management authorities of NDBR need to recognize and preserve the ethno-medicinal wisdom of the local community, alongwith their role in the conservation and management of biodiversity as stated in the 'Target 18 under Strategic goal-E' of Aichi Biodiversity Targets into the implementation of CBD. Moreover, facilitating education facilitiy and developing people's or community biodiversity register in the region could act as fundamental cornerstone in this reform.

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