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RESEARCH PAPER

Assessment of Shrinkage, Exploitation and Threats to *Taxus wallichiana* in North-western Himalayas

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ABSTRACT

Taxus wallichiana is a species of high demand due to its utility in extraction of taxol, which is present in its bark, needles, and seeds. Moreover, Himalayan yew wood is used locally for construction and building purposes. Due to overexploitation and illicit felling of *T. wallichiana* and the anthropogenic pressure over the plant for earning their livelihood, Himalayan yew is under severe threat and is on verge of extinction in Himalaya. As a slow-growing species, this species has a low regeneration capacity due to low seed production and late germination (1.5–2 years). The objective of the case study was to quantify and report the causes (natural as well as anthropogenic) which are threatening the species. State of Uttarakhand in western Himalaya was selected for the case study of Himalayan yew. A Questionnaire review was supervised with 200 key respondents belonging to the region regarding the potential threats linked with the species. Results revealed that over-exploitation (stripping bark, mowing branches, etc.), and slow growth were major reasons resulting to shrinkage of the species. Other causes for the decline of the species include a variety of pressures exerted by human beings. Examples can be overgrazing, agricultural utility, roof construction, fuel wood, medicinal use, etc. The study indicated an immediate need for the protection of *T. wallichiana*. There is a need of the hour to organize awareness programs for local community regarding the significance of the species. Moreover large-scale reforestation efforts are required along with participation of native people. In nutshell immediate in-situ and ex-situ supplemented with biotechnologically tools are required for conservation and management of Himalayan yew in its natural habitat.

HIGHLIGHTS

- Principle anthropogenic factors contributing to the reduction of the Himalayan yew population are mismanagement, over-harvesting, and overgrazing.
- *In-situ* and ex-situ conservation and management coupled with local community involvement is prerequisite for large-scale reforestation efforts.

Keywords: Himalayan yew, Taxol, Over-exploitation, Slow- growing, *In-Vitro*, awareness-creation

The Himalayan yew, *Taxus wallichiana* Zucc., belongs to the family Taxaceae and is one of the most important medicinal plants in the world (Samant *et al*. 1998). This species is widely exploited for

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synthesis and yield of Taxol. Its leaves bark and roots contain baccatin, Taxol, which is a compelling anti-cancer drug, possesses property of inspecting the growth of carcinogenic cells. It is known to be effective in retarding cancer cells multiplication and slowing cancer effect in the body. Taxol initial screening started with Californian Yew *Taxus orevifolia,* since then multiple species were screened for Taxol. It is also mentioned in CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) Appendix II. (http://www.cites.org/eng/app/appendices.shtml#10).

(a) Taxonomy and naming

Kingdom:	Plantae
***Clade*:**	Tracheophytes
Unranked:	Gymnosperms
Division:	Pinophyta
Class:	Pinopsida
Order:	Pinales
Family:	Taxaceae
Genus:	*Taxus*
Species:	*wallichiana*

(b) Distribution and Habitat

Global distribution of *Taxus* is confined to Europe, N. America, Morocco, Philippines, Algeria and India (Tittensor 1980). *Taxus wallichiana is* a temperate forest species found in Asia, ranging from Afghanistan passing the Himalayas and to the Philippines at a height of 1500-3500 meter above sea level. It is a drought susceptible species. The growth of Himalayan yew is abundant in cold temperate montane and sub-montane climate regimes which is favored by abundant rainfall (Thomas and Lianming 2013). It is slow growing and reaches maturity at age of 70 years and lives up to 1000 years.

(c) Community structure

T. wallichiana is a diecious gymnosperms ranging in size from an understory shrub to a tree height of 32.5 m. It is a small to medium-sized tree; stem is short thick and is covered by reddish- brown bark that peels off easily, which is valuable for Taxol extraction (Phillips *et al*. 1998).

(d) Morphology

The bark of *T. wallichiana* is thin, brownish in colour, scaly, and falls off in little chips aligned with the stem. The leaves are usually flat, dark green, 1-4 cm long, 2-3 mm wide, and spirally arranged on the stem, but with the leaf bases twisted to align the leaves in two flat rows on either side of the stem, except on upright leading shoots where the spiral arrangement is more visible. Its foliage resembles the fir (*Abies*) and hemlock (*Tsuga*), When Yew is not in the fruiting stage. But it can be differentiated by field characters of other two such as massive trunks and a tall trunk.

In this work, we hypothesized that the present distribution of *T. wallichiana* may show shrinkage drastically due to mounting anthropogenic pressure. The foremost goal was to quantify and recognize the anthropogenic and natural threats in the Himalayan region. With this broad objective, our study aimed:

(i) To survey the rage of distribution and conduct survey from local's respondents near *Taxus wallichiana* forest.

(ii) To quantify and recognize the anthropogenic and natural Threats to *Taxus wallichiana*.

(iii) To assess the impacts of use and overexploitation of Taxol on habitats of *Taxus wallichiana.*

In this context, we tried to assess and prepare a baseline data to address following objectives. The present study provides scientific evidence for policy making on the impact of while advocating mitigation measures. Overall, this work contributes towards the protection, conservation and habitat restoration of *T. wallichiana* in the Himalayas.

MATERIALS AND METHODS

(a) Study area

The study area is located in Uttarakhand state of North India, which is recognized for its diverse physiography and biodiversity. Uttarakhand commonly known by "*Dev Bhoomi*" is one of the India's 12 Himalayan states, located between the coordinates E 77°34'–81°03'; N 28°43'–31°28' and occupies a total area of 53,483 km^2. The state encompasses a cross-section of the northwestern Himalayan region, which can be further classified into the following sub-domains based on geological evolutionary history: Trans-Himalaya, the Greater Himalaya or Himadri, the Lesser Himalaya, the

Shivalik Ranges, the Foothills, the Terai, and the Plains are all parts of the Himalayas. (https://sbb.uk.gov.in). The first two zones i.e., Trans and Greater Himalayas represent to alpine and temperate climatic conditions, respectively, while the Lesser Himalaya and Shivalik correspond to subtropical and sub temperate regions, respectively, and the last three zones incorporate the tropical ecological climate niche (FSI 2019). However, there are five climate zones in Uttarakhand based on altitude: mild temperate (900-1800 m), cold temperate (1800-2400 m), cold zones (2400-3000 m), alpine zone (3000-4000 m), glacier zone (4000-4800 m), and continuously frozen zone (above 4800 m). (Uttarakhand Forest Statistics 2012–2013). Typically, the mean annual temperature of Uttarakhand ranged from -4.7 ˚C (lowest) to 40.7 ˚C (highest), while the mean annual rainfall has been reported to be >1600 mm in the recent year 2018-19 interval (Uttarakhand at a Glance 2018–2019).

(b) Collection of Data

Review of literature was extensively done and places were identified which could be targeted for collection of the plant. The following maps were examined to determine the species' distribution status: Forest Survey of India (FSI, 2015), state forest department working plans (Uttarakhand, India). Species occurrence data were also gathered by analyzing herbarium specimens at the Forest Research Institute (FRI), the Wildlife Institute of India (WII), and the northwestern Botanical Survey of India (BSI), all of which are located in Dehradun. Literature obtained from the FRI's National Forest Library Information Centre (NFLIC) in Dehradun. Many places near Himalayan ranges were identified which were found more appropriate and offered advantages like availability of tourist vehicles at reasonable rates, local guides and support from the locals. The study was conducted during 2017–2021 in Dehradun, Pauri, Chamoli, Pithoragarh, Tehri, Bageshwar and Uttarkashi districts of Uttarakhand. To identify significant informants, an average of five informal talks with valley residents was conducted. Through community participation and talks with key informants and interviewers, the primary threats to Himalayan yew were identified. Data for these in-person interviews were gathered using expert-reviewed questionnaires. Five informal meetings were held before to the survey in order to identify interviewees. A total of 225 interviews

Table 1

Sl. No.	Location	District	Latitude	Longitude	Altitude
1	Kanchula Kharg	Chamoli	N 30^{0}27′11.5″	E 79^{0}14′29.9″	2577 m
2	Chopta	Chamoli	N 30^{0}28′51.9″	E 79^{0}11′52.3″	2937 m
3	Deoban	Dehradun	N 30^{0}44′52.4″	E 77^{0}51′58.3″	2818 m
4	Bhujkoti	Dehradun	N 30^{0}47′14.2″	E 77^{0}55′24.2″	2693 m
5	Mandal to Rudranath temple	Chamoli	N 30^{0}29′34″	E 79^{0}18′40.1″	3135 m
6	Auli, Joshimath	Chamoli	N 30^{0}31′9.5″	E 79^{0}33′54.3″	2933 m
7	Harshil	Uttarkashi	N 31^{0}01.319	E 78^{0}44.700	3139 m
8	Sukhitop	Uttarkashi	N 31^{0}00′9.7″	E 78^{0}41′42.5″	2795 m
9	Bhukkitop	Uttarkashi	N 31^{0}50′27.0″	E 78^{0}39′36.9″	
10	Dudatoli	Pauri	N 30^{0}03′17.86″	E 79^{0}06′51.57″	2320 m
11	Gheas	Chamoli	N 30^{0}07′29.46″	E 79^{0}42′43.82″	2286 m
12	Mudhal	Dehradun	N 30^{0}94′12.00″	E 77^{0}07′52.3″	2817 m
13	Motodhar	Dehradun	N 31^{0}05′79.00″	E 77^{0}09′50.4″	2735 m
14	Yamunotri	Uttarkashi	N 30^{0}58′49.0″	E 78^{0}26′56.2″	2932 m
15	Balganga	Tehri	N 30^{0}68′10.6″	E 78^{0}67′37.5″	2812 m
16	Karandam bugyal	Pithauragarh	N 30^{0}01′41.2″	E 80^{0}38′51.3″	2896 m
17	Narainasharam	Pithauragarh	N 29^{0}58′46.13″	E 80^{0}39′18.43″	2500 m
18	Dhakuri Pass, Dhakuri	Bageshwar	N 30^{0}03′46.12″	E 79^{0}55′18.42″	2775 m
19	Nagtibba, Nainbagh	Tehri	N 30^{0}35′08.20″	E 78^{0}08′29.49″	2648 m
20	Badanital, Jhakholi	Rudraprayag	N 30^{0}29′40.89″	E 78^{0}56′47.01″	2459

Table 2: Reasons for threats and uses of *Taxus wallichiana* in the Uttarakhand

Sl. No.	Threats	Reasons/Uses
1	Over-exploitation/ Deforestation	lopping of branches, Peeling bark, etc. Used in Slabs (tabai), coffin (taabut) in the graveyard.
2	Slow Growing	Due to its long seed dormancy period i.e. 1.5 to 2 years
3	Over-grazing	Its leaves used as fodder for animals (sheep and goats).
4	Firewood	Used for cooking purposes by local people and also used for keeping themselves warm in cold weather by burning its wood.
5	Lack of awareness	Local people not have adequate knowledge about the importance of the species
6	Construction	Furniture, roofs, and eaves

were done, with 25 conducted in each of the selected valleys (Table 1). Field observations were carried out using a checklist of Himalayan yew morphological traits and habitat.

3. RESULTS

Taxus ecological habitats have been under serious threats due to livelihood, profitability and survival of local inhabitants. On the basis of our survey six factors (listed in descending order of significance) which were identified as being most dangerous to *T. wallichiana* and some examples of their uses in Uttarakhand (Table 2). Threats are arranged according to descending order in table 2. Overexploitation and deforestation are an important reason of shrinkage. Respondents to our study suggested that the slow growing nature (seed ripen after long period of 1.5 to 2 years due to seed dormancy) of this species is another factor which supplements habitat loss of this species. Locals peel bark and branches lopping, to meet the towering demand of Taxol. Traditionally, locals utilize the bark for preparation of tea and for curing coughs and colds. Bark paste is also used and externally applied for curing headaches. Yew wood is also used for making furniture due to its extremely hard nature and durability.). Respondents thought that over-grazing is also one of the reasons for the decline. Leaves of Himalayan yew contain dietary minerals for cattle, goat, sheep and other livestock are a preferred forage source of their diet. In addition, our study concluded that firewood collection, lack of awareness and construction activities were the key reasons for the depleting condition of the species. The wood of Himalayan yew is widely preferred as construction material for eaves, roofs, and furniture due to its hard nature and has a beautiful color.

DISCUSSION

Taxus' ecological habitat has been altered owing to human intervention for reasons such as livelihood, profitability, and human survival, yet efforts such as *ex-situ* and *in-situ* conservation are essential to keep this plant alive in the future (Mohamed and Vidaver 1990; De Klerk *et al.* 1997; Larsen and Olsen 2007; Nimachow *et al.* 2010; Aslam 2016). It is utilised to make anticancer drugs, as well as in Ayurvedic and Tibetan medicine. *Taxus wallichiana* was added to CITES Appendix II in 1995 (Schippmann 2001). Our result suggests that overexploitation and deforestation are important reasons for its decline. Even so, the prospect of the species may be at high-risk, as its global population has dropped at an alarming rate over the last 25 years, owing to overexploitation of natural resources and deforestation (Lanker *et al*. 2010; Paul *et al*. 2013; Sahai and Sinha 2020). International Union for Conservation of Nature (IUCN) estimates a 90% drop in its population in India's Himalayan regions (Thomas and Farjon 2011). **The present study** results were consistent with some of earlier case studies conducted by (Lanker *et al*. 2010; Sahai and Sinha 2020) in western Himalayas. Growing gymnosperms in the Himalayan highlands is always a difficult undertaking due to less success rate and long seed dormancy. Previously workers have attempted rhizogenesis, tissue culture, auxin supplementation etc for growing these plants in lab like conditions (Pilet and Saugy 1987; Kevers *et al.* 1997; Fogaca and Fett-Neto 2005; Chauhan *et al.* 2014; Shah *et al.* 2008; Kumar *et al.* 2017).

CONCLUSION

The results of the present work indicates the effect of anthropogenic (related to human activities) and

natural factors on the survival of *T. wallichiana*, the impacts of climate change on Himalayan yew is not comprehensively explored yet. The main anthropogenic factors contributing to the reduction of the Himalayan yew population are mismanagement, over-harvesting, and over-grazing. Slow development and seed dormant for long periods are natural factors that contribute to this species' decline. As a result, awareness campaigns should be conducted for the citizens so that they are made aware of the significance and the need for proper management of medicinal plants and so that the knowledge can be passed down to future generations. Scientific management plans must be developed and *in-vitro* (labs) must be established and *in-situ* (nurseries) conservation programs must be conducted for vegetative propagation and seed production for reforestation.

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