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Resource Assessment of *Oroxylum indicum* in Northern Indian States of Uttarakhand, Uttar Pradesh, Punjab and Haryana

B. P. Tamta*, Sushmita Uniyal and Rajarshi Ghosh

Non-Timber Forest Products Discipline, Silviculture and Forest Management Division, ICFRE-Forest Research Institute, P.O. New Forest, Dehradun, Uttarakhand (248 006), India

Corresponding Author

B. P. Tamta
e-mail: tamtabp@icfre.org

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Abstract

This study was undertaken from April, 2016 to March, 2018 in different forest divisions of Uttarakhand, Uttar Pradesh, Haryana and Punjab to assess and map the distribution and population status of *Oroxylum indicum* that can be developed into a readily accessible database for further conservation efforts, either in-situ or ex-situ, given that the species is gradually depleting from its natural habitat due to unscientific collection practices, exploitation by uprooting of entire trees to meet the high demand for its raw materials in pharmaceuticals, perfumery, and incense industries. An extensive survey was conducted in different forest divisions of these four Northern Indian states for estimating the distribution and quantifying population of *O. indicum.* Data on different parameters like frequency, density, abundance, location, altitude, habitat, along with brief identifying features, were noted as per Curtis and McIntosh (1950) after laying down quadrats and transects randomly. Subsequently, geo-referenced maps were prepared showing the surveyed areas that were studied. Results of the study indicate occurrence of the species in 51 locations across 15 forest divisions of Uttarakhand, 13 locations across 02 forest divisionsof Haryana, 12 locations in 04 forest divisions of Punjab, and 17 locations across 9 forest divisions of Uttar Pradesh. This information will assist formulation of conservation plans and aid sustainable management of this valuable medicinal tree in these Northern Indian states.

Keywords: *Oroxylum indicum*, medicinal plant, resource assessment, conservation, distribution

1. Introduction

Oroxylum indicum is a medicinal plant, of family Bignoniaceae. In *Ayurvedic* literature, it is referred to as *Shyonak* and forms an important part of the *Dashmula* group (Kapoor, 1990). It is a small deciduous tree, branched at top, bark light brown, with large pinnate, bipinnate, or tripinnate ovate or elliptic leaves with purple tubular flower (Rai et al., 2022). This species is native to the Indian sub-continent, found in the Himalayan foothills extending to Nepal, Bhutan, Myanmar, and southern China (Fujian, Guangdong, Guangxi, Guizhou, Sichuan, Taiwan, Yunnan), in Indochina (Laos, Cambodia, Vietnam), in Thailand, Malaysia, Philippines, Indonesia (Java, Sumatra) (Lawania et al., 2010; Maciuk et al., 2000). It is also reported in Sri Lanka (Ceylon) (Theobald, 1981). It is distributed up to an altitude of 1200 m mainly in ravines, damp regions, and moist places in the forests (Chauhan, 2006).

In India, it is distributed in the Himalayan foothills, Eastern and Western Ghats and North-East India (Jayaram and Prasad, 2008). In North-eastern India, its occurrence is in foothills of Papumpare, East Siang, West Siang, East Kameng, West Kameng, Changlang, Tirap, Lohit and Lower Dibang Valley, everywhere in Assam, Tripura, entire Garo hill in East Khasi, West Garo, East Garo and South Garo districts of Meghalaya, areas of Assam bordering Mokokchung in Nagaland. Population distribution is found restricted to very limited areas in most of Northeastern India (Shankar and Tripathi, 2015).

All parts of this plant possess medicinal value, specifically the roots of this tree are used in the preparation of several *Ayurvedic* formulations like *Chyavanprash, Dashmularishta, Brahat Panchamulyadi Kwath, Syonaka Putapaka, Syonak Siddhaghrita,* etc (Rajasekharan et al., 2017). It is traditionally used to treat asthma, biliousness, bronchitis, diarrhea, dysentery, fevers, vomiting, inflammation, leukoderma, rheumatoid arthritis, and deworming intestine (Jagetia, 2021). Root bark shows marked cardio-protective activity, due to the presence of the antioxidant compounds (Menon et al., 2019). The phytochemical investigations gave an approximate

estimation of 111 phytochemical compounds extracted from different parts of the plant. Flavonoids like chrysin, oroxylin, and baicalein as active principal components (Dinda et.al., 2015).

Due to rapidly increasing domestic and global demand of medicinal plants, there is tremendous pressure on the supply base. According to a National Medicinal Plant Board report, demand is 100 MT/ year and supply much less. To meet this huge gap the population has reached a crisis point. The indiscriminate collection, over exploitation has depleted its natural population (Singh et al., 2014). This valuable tree has become vulnerable in Karnataka, Andhra Pradesh, and endangered in Kerala, Maharashtra, M.P. and Chhattisgarh (Darshan and Ved, 2003). Habitat destruction, over grazing, deforestation and forest fire have also contributed to the decline in the population (Mishra and Kotwal, 2010). Although the species is distributed throughout India, it is listed amongst endangered species in many areas in the country (Najar and Agnihotri, 2012). It possesses high genetic diversity among its population and fragmented distribution is a serious concern for the conservation (Rajasekharan et al., 2017).

Increased anthropogenic activity is leading to rapid decline in nature making it endangered, vulnerable, possibly facing extinction soon (Samatha and Swamy, 2020). Being an important medicinal tree, conservation of this species is urgent (Preety and Sharma, 2016). Sustainable measures need to be taken to conserve this important medicinal plant to protect its population in the wild (Kumar et al., 2021). Potential habitat identification is necessary for conservation and restoration of this species (Bushi et al., 2023). Therefore, population assessment in nature is required which the present study attempted conducting field surveys in different forest divisions of four north Indian states (Uttarakhand, Uttar Pradesh, Haryana, and Punjab) for population assessment.

2. Materials and Methods

An extensive survey was conducted in different forest divisions (Table 1) of four north Indian states from April, 2016 to March, 2018 (2 years). Survey was conducted from 176 to 1463 msl in Uttarakhand, 171 msl to 1140 msl in Haryana, 250 msl to 724 msl in Punjab, and 62 to 660 msl in Uttar Pradesh, for estimating the distribution and quantification of population of *O. indicum.*

Frequency, density, and abundance, date, locality, habitat and brief identification features were noted. Valuable information on its uses was also obtained. Latitude, longitude, and altitude of the location were recorded using GPS. Transects and quadrats were laid randomly in different forest divisions depending upon the geographical coverage of the habitats. At every 100 m interval, a 10×10 m^2 plot was laid, resulting in 10 quadrats in 1 km of the transect.

The number of surveyed quadrats in each kilometer of the transect per forest division was counted, where every kilometer of the transect corresponds to a surveyed site. Thus, we calculated the total length of the transects covered. The total surveyed area was subsequently calculated, since 1 km of the transect has 10 quadrats of 100 sq. m each. Important quantitative metrics such as density, frequency and abundance of species were determined as per Curtis and McIntosh (1950).

3. Results and Discussion

The distribution mapping and population quantification of *O. indicum* was conducted in different forest divisions of Uttarakhand, Haryana, Punjab and Uttar Pradesh. During the survey it was found that the local people are using this tree owing to its medicinal properties, bark and leaves are utilized in the preparation of traditional medicine to treat respiratory conditions like colds and coughs. Decoctions of the leaves are taken orally to reduce body temperature. The bark, leaves and seeds of the tree are being used frequently to treat digestive issues like dysentery, diarrhea and indigestion.

In Uttarakhand, exploration covered 78 locations across 18 forest divisions, with *O. indicum* being found in 51 locations across 15 of them. Notably, no population was reported in Tons, Upper Yamuna and Uttarkashi Forest Divisions. Population density was varied, with the highest average population kilometer^{-1} in Rudraprayag Forest Division (5.43/ km) and the lowest in Ramnagar Forest Division (1.17/ km). Additionally, Rudraprayag Forest Division showed the maximum average population of the species (18% frequency, 0.63 m^2 density, 3.33 abundance), whereas Tehri Dam-I Forest Division showed the minimum average population (15% frequency, 0.2 m^2 density, 1.25 abundance) as depicted in Table 1.

In Haryana, 34 locations in 9 forest divisions were surveyed, revealing the presence of *O. indicum* in 13 locations across 2 forest divisions. No population was observed in 7 forest divisions. Morni-Pinjore Forest Division exhibited the highest average population kilometer^{-1} (5.33/km), while Yamunanagar Forest Division recorded the lowest (2.25/km). The Morni-Pinjore Forest Division also showed maximum average population of the species (17.5% frequency, 0.6 m^2 density, 3.01 abundance), while Yamunanagar Forest Division recorded the minimum (16% frequency, 0.36 m^2 density, 1.70 abundance) as depicted in Table 1.

In Punjab, the survey covered 32 locations across 6 forest divisions, with *O. indicum* observed in 12 locations in 4 forest divisions. Notably, no population was reported in Gurdaspur and Nawansher forest divisions. Pathankot Forest Division displayed the highest average population kilometer^{-1} (3.0/ km), while Roop Nagar Forest Division recorded the lowest (0.4/km). The Pathankot Forest Division also exhibited the maximum average population of the species (24% frequency, 0.42 m^2 density and 1.63 abundance), while Hoshiarpur Forest Division showed the minimum (10% frequency, 0.13 m^2 density and 1.0 abundance) as depicted in Table 1.

Table 1: Quantitative analysis of *O. indicum* in different forest divisions of Uttarakhand, Uttar Pradesh, Punjab and Haryana

State	Forest divisions	Total no. of individuals	Quadrate of occurrences	Frequency (%)	Density (ha^{-1})	Abundance	Average population (km^{-1})
Uttarakhand	Badrinath	6.33	2.00	20.00	0.63	3.17	3.17
	Chakrata	6.57	2.43	24.28	0.66	3.05	4.10
	Dehradun	2.60	1.20	12.00	0.26	2.40	2.60
	Haldwani	2.00	1.00	10.00	0.2	2.00	2.00
	Haridwar	3.67	2.00	20.00	0.37	1.89	3.67
	Kalsi	3.50	1.50	15.00	0.35	3.00	3.50
	Lansdowne	3.20	2.00	20.00	0.32	1.63	2.00
	Mussoorie	3.33	2.00	20.00	0.33	1.67	2.50
	Narendranagar	3.67	2.00	20.00	0.67	1.92	3.67
	Ramnagar	3.50	2.00	20.00	0.35	1.75	1.17
	Rudraprayag	6.33	1.83	18.33	0.63	3.33	5.43
	Tarai Central	3.33	1.33	13.33	0.33	2.83	2.00
	Tarai East	3.50	1.50	15.00	0.35	2.00	2.80
	Tehri	2.50	1.50	15.00	0.25	2.00	1.67
	Tehri Dam-I	2.00	1.50	15.00	0.2	1.25	1.33
Uttar Pradesh	Banda	3.50	1.00	10.00	0.35	3.50	3.50
	Behraich	21.50	3.50	35.00	0.35	4.83	8.60
	Chitrakoot	9.00	3.00	30.00	0.9	2.62	3.60
	Hameerpur	2.00	1.00	10.00	0.2	2.00	0.67
	Lakhimpur Khiri	7.00	2.00	20.00	0.7	3.00	3.50
	Mahoba	1.00	1.00	10.00	0.1	1.00	0.40
	Pilibhit	3.00	1.00	10.00	0.3	3.00	1.00
	Renukoot	2.67	1.33	13.33	0.27	1.83	1.00
	Shivalik	5.00	2.50	25.00	0.5	2.00	5.00
Punjab	Dasuya	2.67	2.00	20.00	0.27	1.33	1.14
	Hoshiarpur	1.30	1.00	10.00	0.13	1.00	0.67
	Pathankot	4.20	2.40	24.00	0.42	1.63	3.00
	Roopnagar	2.00	2.00	20.00	0.2	1.00	0.40
Haryana	Morni-Pinjore	6.00	1.75	17.50	0.6	3.01	5.33
	Yamunanagar	3.60	1.60	16.00	0.36	1.70	2.25

In Uttar Pradesh, exploration encompassed 46 locations in 10 forest divisions, with *O. indicum* found in 17 locations across 9 of them. Gonda Forest Division reported no population. Behraich Forest Division displayed the highest average population kilometer^{-1} (8.6/km), whereas Mahoba Forest Division recorded the lowest (0.40/km). Behraich Forest Division also showed the maximum average population of the species (35% frequency, 0.35 m² density and 4.83 abundance), while Mahoba Forest Division reported the minimum (10% frequency, 0.1 m² density and 1.0 abundance) as depicted in Table 1.

During surveys in different forest divisions of four selected states, latitude, longitude and altitude of the location were recorded by GPS device. The geo-referenced maps were prepared by Forest Informatics Division of Forest Research Institute, Dehradun showing the surveyed areas in Uttarakhand, Haryana, Punjab and Uttar Pradesh (Figure 1a-d).

O. indicum is found in different parts of India, spanning a wide range of ecological zones. It is often encountered in the Himalayan foothills, Western Ghats, Eastern Ghats and the central and northern plains. The species is adaptable to diverse habitats and is commonly found in deciduous and

Figure 1a: Survey sites in different forest divisions of Uttarakhand

Figure 1b: Survey sites in different forest divisions ofUttar Pradesh

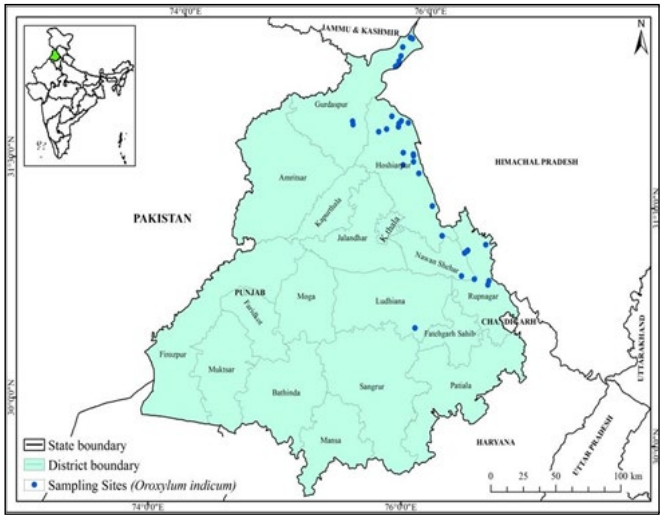

Figure 1c: Survey sites in different forest divisions ofPunjab

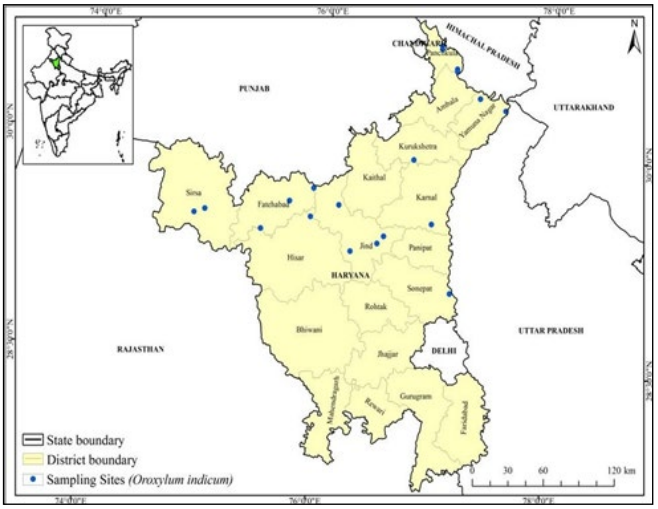

Figure 1d: Survey sites in different forest divisions of Haryana

semi-evergreen forests. It thrives in well-drained soils and is often seen along riverbanks and in disturbed areas.

Higher average population densities are observed in Uttarakhand and Haryana, wherein certain forest divisions make major contributions to the total population. Both Morni-Pinjore in Haryana and Rudraprayag in Uttarakhand stand out for having high population densities and abundance with the highest average populations kilometer^{-1} (Table 1). The overall population densities of Punjab and Uttar Pradesh are moderate, while there are higher concentrations in some forest divisions, such as Pathankot in Punjab and Behraich in Uttar Pradesh.

Nik et al. (2020) describes *Oroxylum indicum* as a versatile medicinal herb possessing a wide range of pharmacological activities and is widely distributed throughout Asia. Jagetia, (2021) reported distribution of this species throughout the Indian subcontinent except drier regions and in the foothills of Himalaya up to a height of 1000–1200 m including Bhutan and Nepal. The study of Shankar and Tripathi's in 2015, focuses on the Northeastern region, revealed a limited population of *O. indicum* concentrated in specific areas. The study reported varying population densities per unit linear transect in different states, such as 1.65 in Arunachal Pradesh, 2.3 in Mizoram, 3.4 in Meghalaya and 2.2 in Assam. Preety and Sharma's (2016) detailed review provided a comprehensive overview of the species, encompassing growth, propagation, taxonomy, phytochemical characteristics, medicinal applications and conservation needs.

However, concerns raised by Mishra (2011) regarding over-harvesting, habitat destruction, over-grazing, deforestation and fire, highlight the threats facing *O. indicum*. Similarly, Yasodha et al. (2004) emphasized the detrimental impact of destructive collection practices, low regeneration rates and habitat destruction, collectively posing a serious risk to the species (Singh et al., 2014; Bushi et al., 2023). *In vitro* propagation strategies have been proposed for this species

(Samatha and Swamy, 2020). Kumar et al. (2021) suggested the identification of the distributional and climatic ranges of suitable habitat for developing effective conservation strategies. These findings collectively underscore the importance of comprehensive conservation efforts to safeguard *O. indicum* and its ecological integrity in diverse regions across India.

4. Conclusion

Distribution and population dynamics of *Oroxylum indicum* in Uttarakhand, Haryana, Punjab and Uttar Pradesh. Diverse distribution patterns highlight ecological complexities, with varying population densities indicating adaptability to different conditions. Neglect has led to population declines, necessitating region-specific conservation strategies. Findings boost scientific understanding and urge targeted conservation efforts, addressing research gaps and refining strategies crucial for sustainable preservation and biodiversity maintenance. For long-term population health, focused conservation measures are vital, particularly in the identified high-density areas.

5. Further Research

Being an important medicinal plant *Oroxylum indicum* is heavily exploited, its population assessment in nature is required. Subsequently, superior germplasm maybe identified from the surveyed locations to aid in future conservation and germplasm restoration efforts, thus indirectly reducing the extraction from natural forest habits.

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