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Registered Office: 3A2 Varadarajulu Nagar, FCI Road, Ganapathy, Coimbatore, Tamil Nadu 641006, India
Ph: +91 9385339863 | www.threatenedtaxa.org
Email: sanjay@threatenedtaxa.org

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Cover: A bag worm with its beautiful heap of junk. Acrylics on 300 GSM paper by Dupati Poojitha based on a picture by Sanjay Molur.

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COMMUNICATION

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Population status, threats, and conservation of *Trachycarpus takil*: an endemic and threatened plant species in western Himalaya, India

Himani Tiwari [1], Dhani Arya [2] & K. Chandra Sekar [3]

[1] G.B. Pant National Institute of Himalayan Environment, Kosi-Katarmal, Almora, Uttarakhand 263643, India.
[1,2] Department of Botany, Soban Singh Jeena University, Almora, Uttarakhand 263601, India.
[3] Garhwal Regional Centre, G.B. Pant National Institute of Himalayan Environment (NIHE), Srinagar, Garhwal, Uttarakhand 246174, India.
[1] himanitiwaribotany@gmail.com, [2] dhaniarya@gmail.com, [3] kcsekar1312@rediffmail.com (corresponding author)

Abstract: Population status and endemism are important concepts in biogeography and conservation biology. Given the dataset's importance and limited availability, we studied the population status and distribution pattern as per the IUCN Red List categories and criteria for *Trachycarpus takil* in Uttarakhand. The study aimed to identify the targeted species' location-specific population status, distribution, area of occupancy (AOO), extent of occurrence (EOO), and resource use patterns. An intensive field visit was conducted in remote areas of Pithoragarh District, Uttarakhand, to identify location-specific information on *T. takil* in the wild. The AOO was recorded at 28 km^2 and the EOO was 2,078.80 km^2. *T. takil* is used by locals to prepare ropes, brooms, and seeds from the wild, which are collected for trade. The study suggests that, as per the IUCN Red List categories and criteria, the species can be included under the 'Endangered' category [B1ab(iii,v) and B2ab(iii,v)] and requires immediate conservation actions to save the wild population.

Keywords: Area of occupancy, conservation, distribution, diversity, extent of occurrence, Indian Himalayan region, native, thakil palm, threatened palm, Uttarakhand.

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Author details: Ms. Himani Tiwari is a senior research fellow, Centre for Biodiversity Conservation and Management, G.B. Pant National Institute of Himalayan Environment, Almora and she specializes in endemic plant diversity, ecology and conservation of higher plants of Indian Himalayan region. Dr. Dhani Arya is an associate professor & head, Department of Botany, Soban Singh Jeena University, Almora, Uttarakhand, with specialization of ecology and plant diversity in Western Himalaya. Dr. K. Chandra Sekar is scientist F & head, Garhwal Regional Centre, G.B. Pant National Institute of Himalayan Environment, Srinagar Garhwal, with specialization of plant taxonomy, ecology and conservation of high-altitude vascular plants of Himalaya.

Author contributions: HT—conceptualization, data collection and preparation of initial draft, DA and KCS—data validation, editing and preparing the final version of the manuscript.

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INTRODUCTION

Diversity of endemic plants is one of the prime criteria for determining the global biodiversity hotspot. The Himalaya, one of the 36 global biodiversity hotspots, is well known for its unique repository of biodiversity and unique & rich endemic plants (MAPs) (Singh et al. 2021; Tiwari et al. 2024). Indian Himalayan Region (IHR) covers the major part of Himalaya Biodiversity Hotspot and is represented by 11,743 native plant species including 11,695 angiosperms, 48 gymnosperms (Wani et al. 2024). Among these, 1,466 trees (Bhatt et al. 2021), 1,748 medicinal (Samant et al. 1998; Mehta et al. 2023), 456 threatened (Mehta et al. 2020), and 1,076 endemic plants (Tiwari et al. 2024) have been reported from IHR. Himalayan endemic plants are confined to highly fragile ecosystems and will almost certainly be the first to be hit by extinction processes. Hence, they require proper assessment and effective conservation plan for restoration. Among the reported endemic plants of IHR, the conservation related studies conducted only around 7% of total endemic plants and highlights the requirement for more conservation efforts (Tiwari et al. 2024).

Trachycarpus takil is one of the threatened and endemic palm species of IHR belonging to the family Arecaceae. The species has been reported from only three locations in Kumaun Himalaya at 2,000–2,500 m altitude growing as undergrowth in the mixed forest of *Quercus* spp. (Khan 2016; Kholia 2009; Husain & Garg 2004). Earlier reports revealed that two small populations with less than 500 individuals are found in the Pithoragarh District (Thal Kedar Hills, Kalamuni Ridge) and third population is found in the Almora District of Kumaon Hills and is nearly on the verge of extinction due to forest fire (Lorek 2007; Gibbons & Spanner 2009; Khan 2016). As per the literature (Kholia 2009; POWO 2024), the species also recorded from Nepal, although we could not find the valid specimen records. So, the distribution of *T. takil* in Nepal is doubtful. As per the IUCN, the population trend is also unknown (www.iucnredlist.org/species/236274959/236274961). Efforts have been made to study the species' flowering phenology, pollination, and breeding behaviour (Kholia 2009). However very little information on the ecology, and population status is available for threat assessment of the species. Therefore, the present study aimed to assess the population, location-specific diversity, distribution, area of occupancy (AOO), extent of occurrence (EOO), resource use patterns, and threats in the wild habitat of *T. takil* in Uttarakhand.

MATERIAL AND METHOD

Species Description

Trachycarpus takil is a medium-sized, evergreen, rare, and endemic palm species of Indian Himalayan Region, commonly known as '*Thakil'.* The species grows as undergrowth in mixed forests of *Quercus* spp., up to an elevation of 2,500 m (Gibbons & Spanner 2009; Kholia 2009). It is a solitary palm of about 9–12 m height and flowering starts from April–May and fruits from September–October (Kholia 2009). Flowers are yellow, small trimerous cyclic, stalked or subsessile, and polygamously monoecio-dioecious (Kholia 2009). The leaves are fan shaped, persistent, 1.2 m long, and are arranged as a crown on the top of the trunk. The palm is distinguished by a network of fibres that cover the trunk up to the base and whorl of persistent dry leaves below the crown of fresh ones.

Vegetation sampling

The occurrence data about species presence was obtained from the existing literature (Kulkarni & Mulani 2004; Gibbons et al. 2008; Kholia 2009, 2010; Gibbons & Spanner 2009; Khan 2016), herbarium records and online datasets (GBIF 2024; POWO 2024). All the identified places (i.e., Thal Kedar, Baravey, Kalamuni, Ratapani, Giniband) were surveyed extensively during September 2022–October 2023 for diversity and distribution pattern (Figure 1). Information about indigenous resource utilization, emerging threats were documented by direct field-based observation and questionnaire survey methods (Malik et al. 2014). A handheld GPS (Garmin eTrex 30x) was used to record the geo-coordinates and altitude of each site. As the species is recorded as endemic to Kumaun Himalaya (Gibbons & Spanner 2009; POWO 2024), efforts are made to assess the population as per the IUCN Red List categories and criteria (Keith et al. 2024). The flowering individuals are only considered as mature individuals and recorded accordingly.

Area of Occupancy (AOO) & Extent of Occurrence (EOO)

To calculate the AOO and EOO of species, geo-coordinates were collected during field visits and also supplemented through secondary literatures (Gibbons & Spanner 2009; Kholia 2009, 2010). Further, the extent of occurrence for *T. takil* is measured by delimiting a polygon that encompassed all the known localities of a taxa (known as minimum convex polygon or convex hull) using Geospatial Conservation Assessment Tool (GeoCAT) and QGIS version 3.32 (Tali et al. 2015). Area of

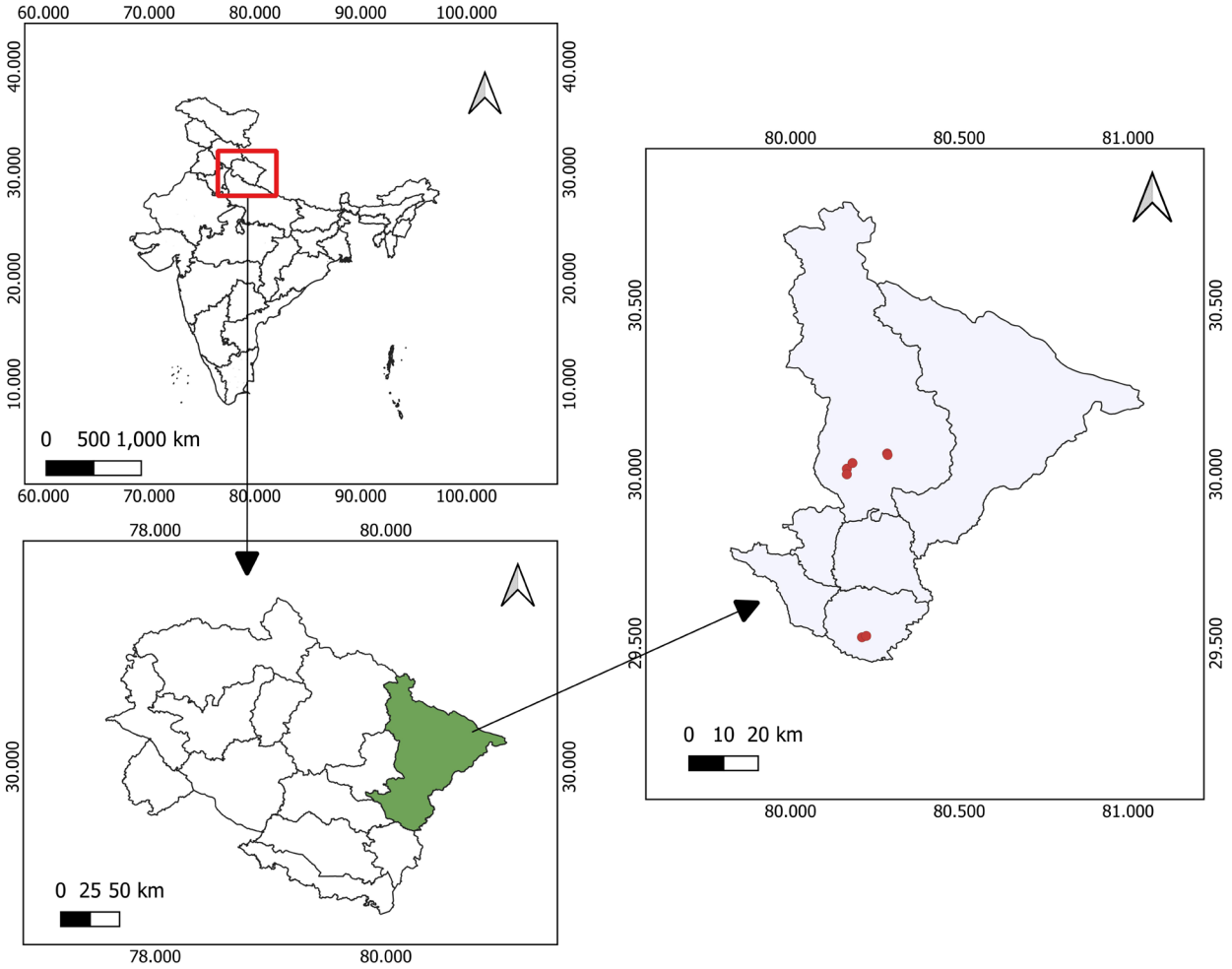

Figure 1. Map of study area for field survey.

occupancy of the species was calculated by overlaying a uniform grid over the entire range of the taxon and then tallying the number of all the grids occupying species' presence. Grid size of 2*2 km^2 size was used to calculate the AOO of *T. takil* (Tali et al. 2015; IUCN 2024) using the below provided formulae:

Area of occupancy = No. of occupied cells × area of individual cell.

RESULTS

Distribution of the species

The population of *Trachycarpus takil* recorded between 1,900 m and 2,500 m elevation in the rocky and moist, shady habitat as undergrowth of mixed oak forest. Total mature individuals of the species are varying significantly in different location. Presently, the species recorded in Almora (Bhatkot) and Pithoragarh (Thal Kedar, Baravey, Kalamuni) districts, Uttarakhand, India. Currently, the mature individuals have recorded only in three places, namely, Kalamuni, Thal Kedar, and Baravey, whereas, no mature individuals are found in Bhatkot area. The Kalamuni- Ratapani recorded 243 mature individuals (adult trees in flowering stage), while the Thal Kedar recorded five mature individuals. The Gini band-Samkot recorded 49 mature individuals, and the Baravey had eight mature individuals. *T. takil* is growing in association with *Buxus wallichiana*, *Cupressus torulosa*, *Quercus semecarpifolia*, and *Taxus wallichiana* at Kalamuni, Ratapani, and Gini band-Samkot. At Thal Kedar, the species is mainly associated with *Arundinaria falcata, Quercus floribunda*, and *Quercus leucotricophora* (Table 1).

Resource use pattern and threats

Traditionally, the locals of the nearby villages use the fibres and leaves of *T. takil* to prepare ropes and brooms,

Table 1. Site characteristics and threats on mature individuals of *Trachycarpus takil*.

	Sites	Altitude (m)	Geo-coordinates	Habitat type	Associated species	Threats
1	Thal Kedar	2,430	N 29.518, E 80.211 N 29.526, E 80.196 N 29.521, E 80.203	Mixed Oak Forest	*Quercus floribunda, Q. leucotricophora, Arundinaria falcata*	Lopping
2	Baravey	1,910	N 29.522, E 80.224	Along barren grazing land	*Quercus leucotricophora*	Lopping
3	Kalamuni-Ratapani	2,220–2,320	N 30.016, E 80.166 N 30.033, E 80.183 N 30.020, E 80.180 N 30.036, E 80.191	Moist rock slopes, under dense canopy of mixed forest	*Q. semecarpifolia, Cupressus torulosa, Taxus wallichiana*	Lopping, seed collection
4	Gini band- way to Samkot	2,259	N 30.017, E 80.167 N 30.000, E 80.167	Moist rocky slopes, under dense canopy of mixed forest	*Q. semecarpifolia, Taxus wallichiana, Buxus wallichiana, Abies pindrow*	Lopping, seed collection

for which they cut down the tree at the base, posing a serious threat to the species in the wild. The paste of flowers with young flowers of *Bombax ceiba* are being used as a medicine to cure gonorrhoea and vaginal infections. *T. takil* is also cultivated for ornamental purposes, therefore, the seeds are collected and sold at the village level (Rs. 500–1000 /kg). Ripe seeds are edible and also consumed by the local people. The destructive methods used by locals to collect the leaves, fibres, and seeds of the species and forest fire occurrences are major threats to the wild population.

Extent of occurrence & Area of occupancy

In Uttarakhand State, *T. takil* was found distributed between 30.06611–30.09250° N and 80.38861–80.42805° E along an altitudinal range of 1,900–2,500 m. The total extent of occurrence (EOO) of *T. takil* is 2,078.80 km^2. The AOO of the species is 28 km^2. The EOO of *T. takil* encompasses only 3.95% area of Uttarakhand and 29.29% area of Pithoragarh District (Figure 2,3).

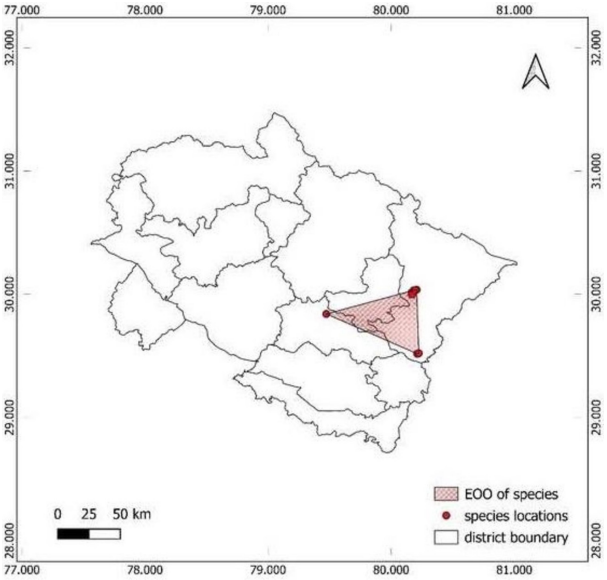

Figure 2. Extent of occurrence of *Trachycarpus takil*.

Threat Assessment of *Trachycarpus takil*

As per the IUCN Red List categories and criteria, the *Trachycarpus takil* has been assessed. The EOO of the species recorded 2,078.80 km^2, which is less than the threshold value (<5000 km^2) and aligns with criterion 'B1' for 'Endangered category'. The AOO of the species was estimated 28 km^2, which meets again criterion 'B2'. Data collected from secondary sources and field visits indicates that the species is restricted to only four places (Thal Kedar, Baravey, Kalamuni, Bhatkot) in Uttarakhand, aligning with sub-criterion 'a'. The multiple threats across its distribution range are leading to continuous decline in the habitat of the species. In Bhatkot and Thal Kedar, forest fire causes degradation in its habitat and direct collection of seeds from natural population also affects the regeneration of the species aligning with the sub-criterion 'b(iii)' (continuous decline in area, extent, and/or quality of habitat). A continuous decline in the number of mature individuals is also recorded from these locations due to forest fire and anthropogenic pressure, qualifying the species for sub-criterion 'b(v)' (decline in number of mature individuals).

Keeping the above, the endemic *Trachycarpus takil,* recorded in restricted number of location, limited AOO, EOO, declining in habitat quality and mature individuals justify its IUCN Red List assessment as 'Endangered' under B1ab(iii,v) & B2ab(iii,v) (Table 2).

DISCUSSION

The population assessment is essential to quantifying the threat status, especially for endemic and threatened elements. In absence of quantifiable datasets, we were not able to analyse the population threat and distribution

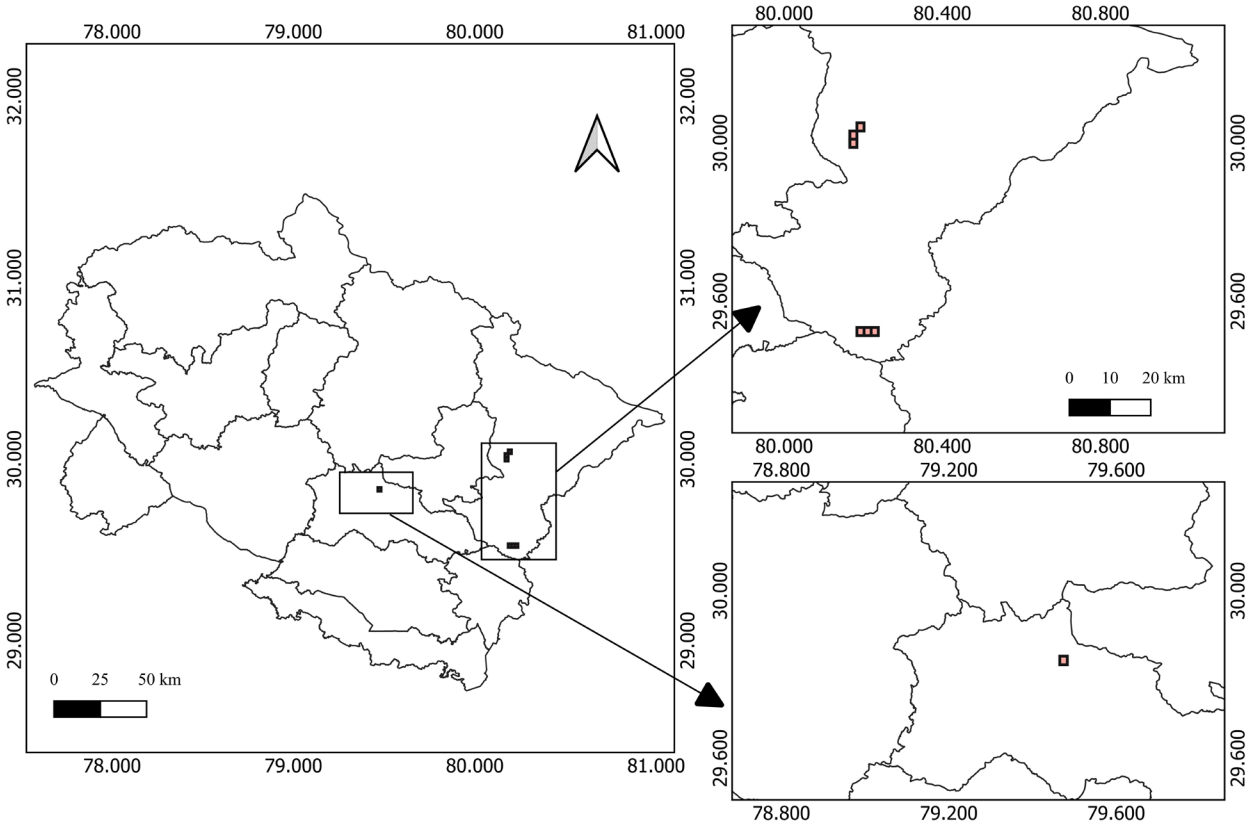

Figure 3. Area of occupancy (2 km²) of *Trachycarpus takil*.

Table 2. Threat categorization of *Trachycarpus takil*.

Criteria	IUCN categories	*T. takil* values	Status / reference	IUCN Red List proposed
B. Geographic range	**1. Extent of occurrence (**<5000 km²)	2,078.80 km² EOO, recorded in 04 location only, habitat degradation due to forest fire, decline of mature individuals (from approx. 500–305)	Present study; Kholia (2009), Kholia (2010), Gibbons & Spanner (2009)	Endangered (EN) EN B1ab(iii,v)
	a. Known to exist at no more than five locations			
	b. Continuing decline, observed, inferred iii. area, extent and/or quality of habitat v. number of mature individuals			
	2. Area of occupancy (<500 km²)	28 km² AOO, recorded in 04 locations only, habitat degradation due to forest fire, decline of mature individuals (from approx. 500–305)	Present study; Kholia (2009), Kholia (2010), Gibbons & Spanner (2009)	EN B2ab(iii,v)
	a. Known to exist at no more than five locations			
	b. Continuing decline, observed, inferred iii. area, extent and/or quality of habitat v. number of mature individuals			

pattern. *T. takil* is one among the species having limited/quantitative datasets to conclude the population trend and distribution range (Tali et al. 2015). To strengthen the quantification of the dataset, we surveyed all the places where the species recorded in Uttarakhand State, India. Extensive survey revealed a total of four areas, namely, Kalamuni, Thal Kedar, Baravey, Bhatkot (Almora and Pithoragarh districts, Uttarakhand, India), we recorded the presence of *T. takil* in natural condition. The Kalamuni region recorded highest number of individuals (243) and the interior population of Samkot (49) is reported first time in the present study. Due to forest fire and presence of few juveniles (<10), the population of Bhatkot is having higher threat (Kholia 2009). Further,

Image 1. *Trachycarpus takil*: a—Habitat | b—Sapling | c—Seedling | d—Lopping of leaves | e—Brooms prepared by locals | f—Fibre used for ropes | g—Ligules.

the present study could not able to consider the *T. takil* recorded in China, due to non-availability of quantitative dataset on population, area of occupancy, distribution range (Ding et al. 2022). Currently, the *T. takil* is very restricted distribution in India (Uttarakhand) and placed in the 'Rare' category of Red Data Book of India (Nayar & Sastri 1988). The larger population recorded in Kalamuni and Ratapani may be due to lesser accessibility in the hill region. During the survey, a good number of seedlings (>50) were observed in the Thal Kedar forest showing

good regeneration potential. But due to continuous extraction of leaves and seeds, and occurrences of forest fires, the survival of these saplings is questionable (Kholia 2010). Therefore, there is a need to develop effective propagation protocols along with *in situ* conservation efforts. However, present study reported good number of mature individuals at Kalamuni area as compared to the previous studies (Kholia 2009), but due to increasing demand of seeds, continuous leaf extraction and forest fires, this species is under severe threat. *T. takil* is native, endemic to Indian Himalayan Region, and having only four populations, thus requires immediate attention and conservation measures, before vanishing from the natural forest area.

CONCLUSION

Threatened and endemic species are confined to restricted range and certainly be the first to be hit by extinction processes therefore such species require effective conservation strategies. *Trachycarpus takil* is an endemic and threatened palm of western Himalaya, India. The species is reported from four locations of Uttarakhand. The locals use the species as medicine, for making ropes, brooms, and curd churners. Destructive harvesting and forest fires are posing serious threats to the species. The AOO and EOO of the species is calculated and finds 28 km^2 and 2,078.80 km^2, respectively. On the basis of restricted distribution, number of locations, individuals and threats, the study recommends inclusion of *T. takil* in IUCN Red List threat categories, under 'Endangered', and inclusion of the identified locations into the protected area network to ensure the effective *in-situ* conservation of the species.

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