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DISTRIBUTION AND STRUCTURE OF CONIFERS WITH SPECIAL EMPHASIS ON *TAXUS BACCATA* IN MOIST TEMPERATE FORESTS OF KASHMIR HIMALAYAS

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Abstract

Coniferous forests play important role in sustaining biodiversity and providing ecological services. Present study was conducted in Pir Panjal range, Western Himalayas to assess the present status of the conifers, in particular *Taxus baccata* population. Field data was obtained systematically using quadrate method. Environmental data including coordinates, altitude, slope gradient, aspect and intensity of anthropogenic disturbance was recorded by field survey method. The quantity of fuel wood consumption was measured using weight survey method. Three conifer species viz., *Abies pindrow*, *Pinus wallichiana* and *Taxus baccata* were found in 5 communities at different aspects in 1800 to 3000 m altitudinal range. Conifer stands showed an average tree density of 306 trees/ha with a regeneration value of 76 seedlings and saplings/ha and deforestation intensity of 82 stumps/ha respectively. *T. baccata* showed zero regeneration having no seedling or sapling in the whole study area. The stem to stump value was calculated as 4.08. *A. pindrow* was dominant in all the 5 communities with an Importance value percentage of 72.8% followed by *P. wallichiana* (19.5%). *T. baccata* was recorded sporadically throughout the altitudinal range having an IVI value of 7.9%. The *T. baccata* tree density was 26/ha whereas dead tree and stumps density was 27/ha with a stem/stump value of 0.98.The average fuel wood consumption recorded for the area was 4.08kg/capita/day. Pressure is increasing on conifers due to high level of fuel wood consumption as well as overgrazing due to limited available grazing area. The conifer species, especially *T. baccata,* demand immediate attention of forest management and policy makers for the conservation of these under pressure species.

Key words: Conifer species, *Taxus baccata*, conservation, Himalayas.

Introduction

Himalayan forests are considered to be globe's most depleted forests (Shaheen *et al.*, 2011), de-graded due to nomadic activities, overgrazing and tree cutting (Ahmed *et al.*, 1990, 2012). High elevation ecosystems of Himalayan region are the most vulnerable geographic regions to climate change, considered as the most serious threat to mountain forests (Cavaliere, 2009; Glatzel, 2009). Deforestation is a crucial cause of biotic extinctions in the tropics and temperate forests. Trends of deforestation in the Indo-Pak Himalaya project the likely consequential extinctions of endemic taxa by 2100 A.D. across a broad range. With present levels of deforestation, almost a quarter of the endemic species could be wiped out, including 366 endemic vascular plant taxa (Pandit *et al*., 2007; Schickoff, 1993; Knudsen, 1994).

Coniferous forests are important natural resources to sustain life in the Kashmir Himalayas. The role of these forests lies in the maintenance of biodiversity, watershed protection as well as supplying timber, non-wood forest products, grazing land and habitat for threatened taxa (Ahmed *et al.*, 2006, 2010). These temperate coniferous forests are dominated by *A. pindrow* and *P. wallichiana* forming distinct communities at lower altitudes (1500-2000m). Sporadically *T. baccata* is present in whole altitudinal range (Bhatt *et al*., 1994). *T. baccata* is native to Himalayas, occurring in mixed fir and pine forests at 1800-3400m (Farjon, 2001; Xu *et al*., 2009). *Taxus* species have become threatened due to their small population size, poor regeneration, slow propagation, narrow distribution area, habitat specificity, destructive harvesting, over grazing, high value of utilization, climate change and habitat loss (Samant, 1999). Current information on the size and status of *Taxus* populations is largely unavailable (Anon., 2004). *T. baccata* is listed as endangered in China (Wu & Raven 1999); and as vulnerable (VU D2) by the IUCN (Anon., 2007, 2009). *T. baccata* in various parts of the Himalaya is listed as an endangered native species (Samant *et al*., 1998). The present study was conducted in Pir Panjal range, South Western Himalayas with the aim to assess the present status of the conifers, in particular *T. baccata* population, and analyze the population structure.

Materials and methods

Study area: Toli Pir is located in the Western Himalayan foothills of Pir Panjal sub range, between $33^0$55-15-56 North' latitude and $73^0$58-19-95' East longitude (Fig. 1). The study was conducted in 5 coniferous communities within 1,800m to 2,800m altitudinal range. The topography of the study site is uneven, characterized by steep mountain slopes varying from 20^0 up to 75^0. The climate of the study area is temperate to sub alpine with four distinct seasons with relatively long winters from October to March (Shaheen *et al*., 2011b). Summers are cool, with average temperatures from 9 to 12C^o, whereas winters are severe and below freezing down to -10 C^o. The area studied remains under snow cover from December to March (Anon., 2012).

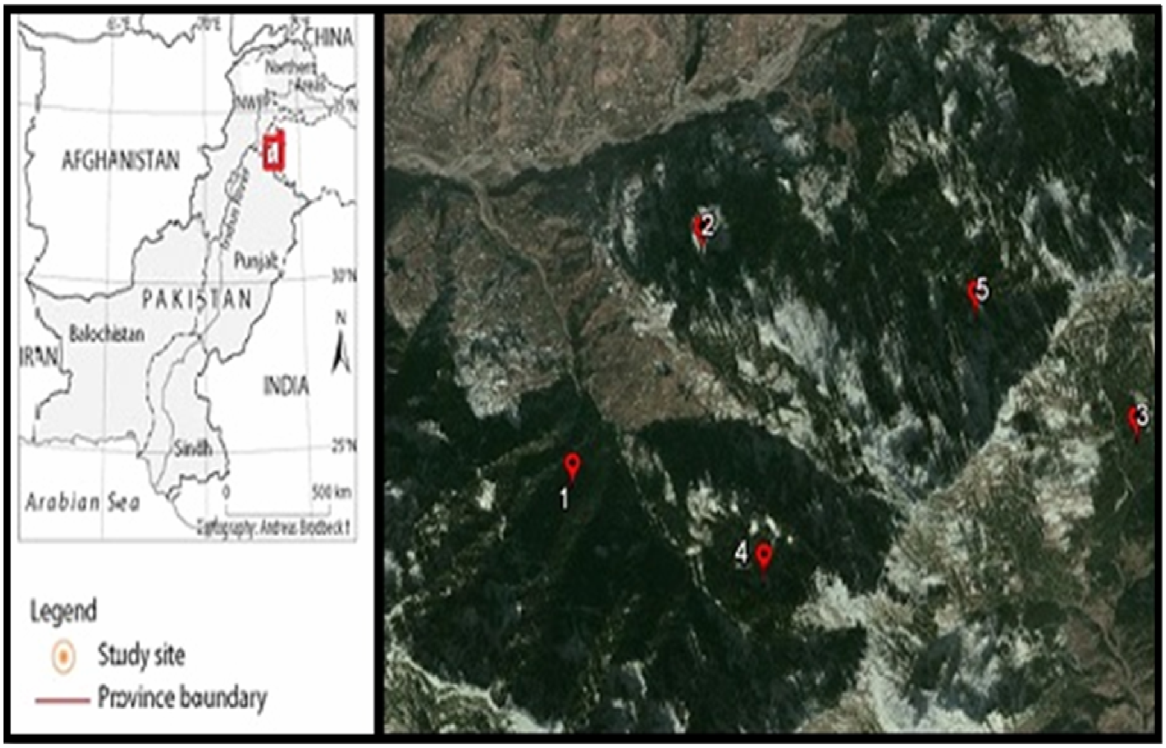

Fig. 1. Map of study area and location of studied forest communities.

The field survey was conducted during May-June 2013. Five forest stands were selected to study conifer species of the area. In each forest stand two transects were laid from 1800m extending up to 2800m. In each transect, five plots with the dimension of 20m x 20m at an interval of 200 meters were laid down. All conifers individuals were identified, and their Diameters at Breast Height (DBH) was recorded with their coordinates. All seedlings (height < 137cm), saplings, stumps and dead trees were also recorded. The quantity of fuel wood consumption was measured over a period of 24 h using a weight survey method (Shaheen *et al*., 2011a). The data about land holding, cattle rearing, crop production, grazing area/grazing unit was obtained through field survey questionnaire method. A total of 180 questionnaires (30 /site) were asked. Considering the importance of *T. baccata*, complete and in-depth quantitative field survey was conducted on population estimation in different localities. The coordinates, altitude, aspect, slope gradient, slope position and disturbance agents both anthropogenic and natural such as soil erosion, tracks, grazing pressure, presence or absence of animal drops were recorded. The field data was used to calculate density, frequency, canopy cover, importance value and stem/ stump ratio of conifer species.

Results

The coniferous species composition in the study area was composed of two species of pinaceae family, *A. pindrow* and *P. wallichiana*, and one species, *T. baccata* belonging to family taxaceae. Five conifer communities were identified in the study area with *A. pindrow* was the dominant comprising 72.7% of total IVI values, followed by *P. wallichiana* and *T. baccata* with IVI values of 19.4 and 7.82 respectively (Table 1). The average tree density was 102/ha in the area with *Abies* density of 226/ha and *Pinus* with 54/ha. *Taxus* showed lowest density value of 26/ha (Table 2). Average seedlings and saplings density was 26/ha with *P. wallichiana* having highest values of 61/ha followed by *A. pindrow* (14/ha). *T. baccata* showed zero regeneration having no seedling and sapling in the studies sites (Table 2). The stem/stump value was calculated to be 3.51 for the studied forest stands indicating intense anthropogenic disturbances. Average values of stump and dead trees density were 98/ha and 65ha respectively. Presence of tracks, cattle dung and hoof marks indicate high grazing pressure at all the sites. The results of Principal Component Analyses were significant explaining 90% variance in data. PCA biplot separated Community 1 on X-axis showing strong correlation with *A. pindrow* (Fig. 3). This fact is validated by 81% IVI share in community 1 by *A. pindrow* (Table 1). The community 2 and 3 are closely placed at lower right Y-axis showing close affinity with *T. baccata* (Fig. 3) having maximum IVI values (Table 1). The communities 4 and 5 are placed at upper right Y-axis along with *P. wallichiana* (Fig. 3). This placement is justified by highest IVI of *P. wallichiana* (20.1, 23.1) in the said communities (Table 1). This trend is also verified by single linkage dendrogram constructed on the basis of Euclidean distance showing three distinct groups of Community 1, communities 2, 3 and communities 4, 5 respectively (Fig. 4).

Table 1. Importance values of conifers at different communities.

Sr No.	Species	Community 1	2	3	4	5	Average
1	*Abies pindrow*	80.2	71.7	71.7	72.1	67.9	72.8
2	*Pinus wallichiana*	14.2	19.8	19.8	20.1	23.1	19.5
3	*Taxus baccata*	5.5	8.3	8.3	8.1	8.9	7.9
	∑	99.9	99.9	99.9	99.9	99.9	99.99

Table 2. Tree density, regeneration and deforestation values (/ha) at the studied sites.

Communities	Abies pindrow		Pinus wallichiana		Taxus baccata		Stump density	Stem to stump value
	Density	Seedlings	Density	Seedlings	Density	Seedlings		
1 North East	223	37	12	32	35	0	110	2.45
2 South West	243	0	17	22	32	0	82	3.56
3 South East	227	35	73	95	22	0	98	3.28
4 North	227	0	73	95	20	0	70	4.57
5 North	210	0	97	65	20	0	50	6.54
Average	226	15	54	61	26	0	82	4.08

Table 3. Socioeconomic descriptors of the village populations surrounding study area.

Village name	Family size	Herd size	Land holding	Grazing area	Fuel-wood consumption Kg/capita/day	Cultivated Land Acres/Household	Grain Production kg/Acre
Tohli	08	04	1.5	0.375	4.8219	.075	240
Swanj	09	05	2.5	0.5	4.1301	1.25	400
Ali Sojal	7.5	03	03	1.0006	3.7078	1.5	480
Bun Khori	06	04	02	0.5	4.2789	01	320
Lohar Bela	06	06	2.375	0.3957	4.04011	1.1875	380
Bun Behk	5.5	02	2.5	1.25	3.6159	2.5	400
Average	07	04	2.3125	1.0053	4.0991	1.2520	370

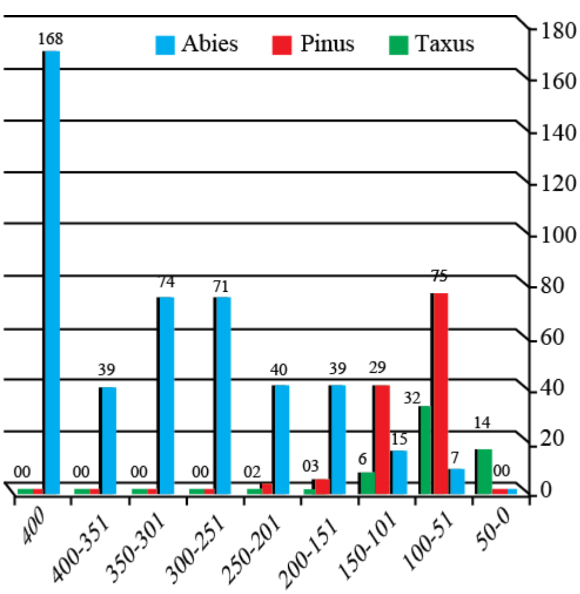

Fig. 2. Diameter class distribution of the conifers in studied communities.

Community 1 was identified at an elevation of 1800-2800m with 50-55° slope and moderate litter content at a distance of 500m from human settlement. The highest I.V.I percentage was for *Abies* (80.2) followed by *Pinus* (14.3) and *Taxus* (5.51) respectively (Table 1). Average stem density was 270/ha (*Abies* 222, *Taxus* 35 and *Pinus* 12/ha). Average stump density was 110/ha; dead trees density was 60/ha; seedling and sapling density was 70/ha where as Stem/stump value was 2.45 (Table 2). The highest number of individuals (26) was recorded for biggest DBH class (≥ 400 cm) whereas lower DBH classes harbored least number (2) of individuals (Fig. 2).

Community 2 was found at an elevation of 2500m, South West facing with 50-55° slope, moderate litter content at a distance of 1km from human settlements. Average stem density was 292 stems/ha, (*Abies* 243, *Taxus* 32 and *Pinus*17and living trees/ha) (Table 2). The highest I.V.I percentage recorded for *Abies* was (80.4), followed by *Pinus* (13.5) and *Taxus* (5.9) respectively (Table 1). Average stump density was and 82/ha; dead trees density 45/ha whereas seedlings density was 22/ha (*Pinus*09, *Abies* and *Taxus*0). Stem/stump ratio was found as 3.54 (Table 2).

Community 3 was located at an elevation of 2500m, South East facing with 40-50° slope and moderate litter content at a distance of 2 km from human settlements. Average stem density/ha was 322 (*Abies*, 227, *Pinus* 73 and *Taxus* 22 stems/ha (Table 2). The highest I.V.I percentage was recorded for *Abies* followed by *Pinus*, (19.8) and *Taxus* (8.3) respectively (Table 1). Average stump density/ha was 98; dead trees density/ha was 65; seedlings density/ha 130where as Stem/ stump ratio was 3.28 (Table 2). Total 126 gymnosperm trees (*Abies* 94, *Pinus* 23 and *Taxus* 09) were recorded with no seedlings and saplings for *Taxus*.

Community 4 was embraced at an elevation of 2500 m, north facing, having 55-60° slope at 2.5 km distance from human settlement. Average stem density/ha was 320 (*Abies* 227, *Pinus* 73 and *Taxus* 20 stems/ha). The highest IVI percentage was recorded for *Abies* (72.1) followed by *Pinus* (20.1) and *Taxus* (8.1) respectively. Average stump density/ha was 70; dead trees density/ha 35; seedlings density/ha 85 whereas stem/stump value was 4.51 (Table 2).

Community 5 was encompassed at an elevation of 2500 m, north facing, having average 50-55° slope at a distance of 2.5 km from human settlements. Average stem density/ha was 327 (*Abies*, 210, *Pinus*, 97 and *Taxus* 20 trees/ ha). The highest IVI percentage was recorded for *Abies* (67.9) followed by *Pinus* (23.1) and *Taxus* (8.9). Average stump density/ha was 90; stump density/ha 50; seedlings density/ha 65 where as Stem/stump ratio was as 6.59 (Tables 1, 2).

Anthropogenic pressure and socioeconomic parameters: The per capita/day fuel wood consumption level was found to be 4.09 with a maximum of 4.8 at Tohli whereas minimum of 3.61 at Bun Behk. Firewood consumption was influenced by climate and season of the year, on average 2.0-3.0 - folds higher in winter. Average land holding/family was estimated to be 2.31 acres, with a maximum of 03 acres in Ali Sojal and minimum of 1.5 acres in Tolli. Average family size was found to be 07 with whereas herd size was 04. The average available grazing area was 1.01 acres/unit. Average cultivated land/household was 1.25 acres. Cultivated crops included wheat and maize with an average yield of 370 kg/acres in the study area (Table 3).

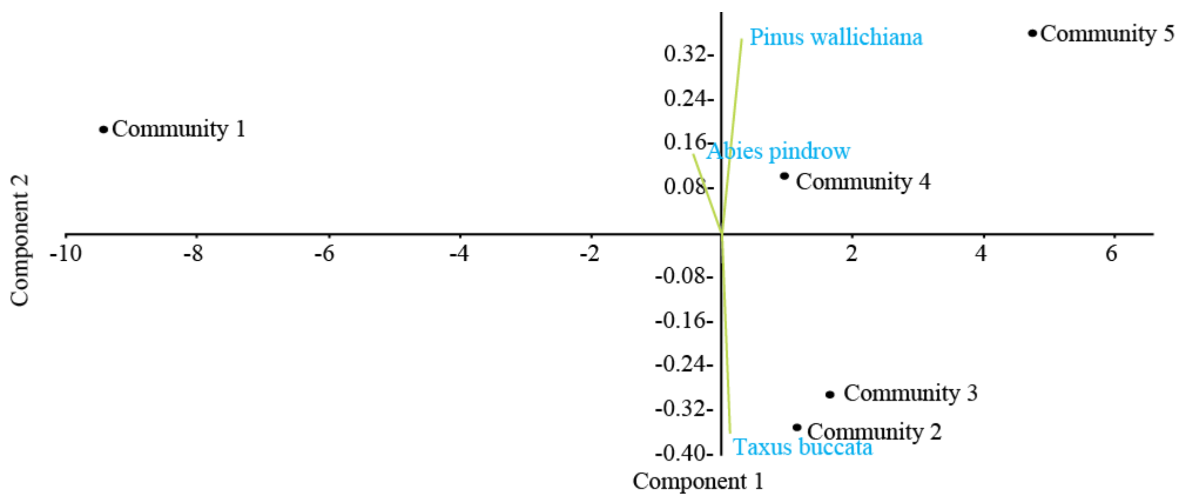

Fig. 3. Principal component analyses biplot.

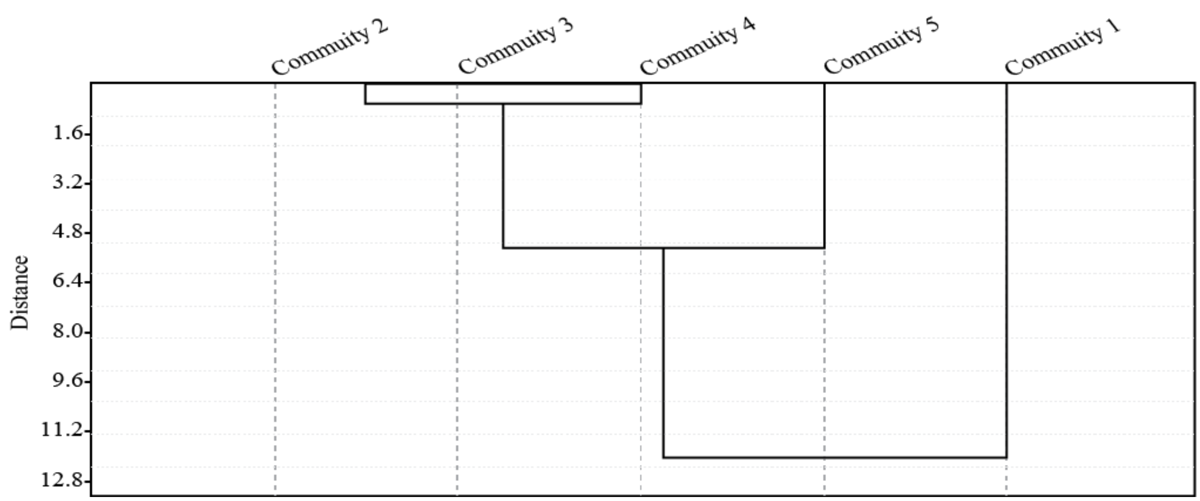

Fig. 4. Single linage cluster analyses dendrogram based on Euclidean distance.

Discussion

Interactions of various biological and physical factors determine the distribution of tree populations in an area. Physiographic characteristics of specific landforms such as slope, aspect, parent materials and soils are used for characterizing vegetation over the space (Barnes *et al*., 1997). Natural population of conifers increases exponentially in suitable conditions when resources are freely available (Watkinson, 1997). Individual species have different resource requirements or tolerance, making effective competitors able to exist in different sites (Glatzel, 2009).

Altitudinal range of the tree species: The altitudinal limit resulting from various combinations of physical and biological factors determines the species distribution pattern. Conifer distribution studies across the various mountain systems show elevation and aspect related variations in floristic composition and structure (Lovett, 1996). Present study revealed *A. pindrow* dominated forests in studied communities along the whole altitudinal range (1800-2800m). *P. wallichiana* and *T. baccata* showed complete disappearance after 2500 m altitude in 1st and 2nd community where as Sporadic occurrence was shown in 3rd, 4th and 5th community. Sparsely dispersed populations were the result of selective cutting. *P. wallichiana* is considered as a disturbance driven and pioneer species in early succession on disturbed areas (Ahmad *et al.,* 2012).

Structural characteristics of conifers: Forest structure is an expression of past stand history and human inferences based on several attributes such as DBH, height, volume, leaf area, age, tree crown (Veblen, 1992). *A. pindrow* was steadily present in each quadrate in all 5 communities. The DBH distribution smoothly increased with numbers of individuals progressively increasing up to 74 in 301-350 cm class, then suddenly decreasing to 39 individuals in 351-400 cm class. A sharp increase with 168 individuals in ≥400 cm class indicates that these trees are standing there for centuries (Fig. 2). *P. wallichiana* occurred sporadically in the whole altitudinal range. The DBH distribution revealed that minimum individuals were in the lowest (0-50 cm DBH) as well as highest (>100) DBH classes. Most of the individuals (75%) were observed in middle 51-100 cm DBH class (Fig. 2). This pattern might be correlated to disturbance and selective cutting of this species. *T. baccata* stands were recognized as priority habitats for biodiversity conservation. The occurrence of *Taxus* was inconsistent in the forest stands with irregular presence at 1,800-2,800 m along transect 1 in first 2 communities whereas in transect 2 it was totally absent. The DBH distribution varied from 14, 32 and 06 individuals in first three classes respectively. Since it is a shade tolerant slow growing species and cannot have large DBH, it peaked around 51-100 cm DBH class (Fig. 2). Its productivity is better in shady micro sites at undisturbed locations. More than 5 times stumps and dead trees as compared to live stems indicated the impact of destructive cutting on *Taxus*. Browsing negatively affects its regeneration and spatial distribution (Farris & Filigheddu, 2008).

Regeneration: Study area is under immense grazing and anthropogenic pressure, and this might explain the extreme impact on the seedling numbers (Gratzer *et al*., 1999). *P. wallichiana* requires high illumination by sunlight for both terminal as well as radial growth (Pant & Samant, 2008). Its regeneration was somewhat good and higher seedling counts were observed at south east and north east facing sites. The regeneration pattern of *T. baccata* in the present study was static as no seedlings were observed. The main reasons for the decline of *Taxus* populations are widespread deforestation, selective felling and grazing (Jahn, 1991; Bugala, 1978). *T. baccata* (locally known as *Thunni*) is now not available singly or in pure stand within 5 to 10 km radius from villages (Shaheen *et al.,* 2011b; Tittensor, 1980).

The present study revealed a fuel wood consumption of 04 kg/capita/day. Firewood consumption differs according to family size; large families having more consumption (Bhatt & Sachan, 2004). The increased levels of fuel wood extraction causes a proportional change in forest size, structure and composition. Decline of large old trees results in forest fragmentation and susceptibility to invasion by ephemerals inhibiting the seedlings regeneration (Ruger *et al.*, 2007). The disappearance of *T. baccata* from many areas has been attributed primarily to anthropogenic factors rather than climatic change or reduced ecological fitness (Thomas & Polwart, 2003). It is the need of hour that *T. baccata* stands should be preserved. Any further delay may cause complete extinction of *T. baccata* from this area.

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