Postprint: Ethnobotanical Survey of Weisang Plants in Tibet

Authors: Zhang Xiong, Feng Haowen, Wang Jin, Lin Lei, Wang Yuhua

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Abstract

Incense burning (Wei Sang) is a folk activity with distinctive ethnic cultural characteristics on the Tibetan Plateau, holding an important position in the daily life of Tibetans. The Tibetan Plateau possesses abundant incense-burning plant resources and related cultural knowledge. To investigate, document, and study Tibetan incense-burning plants and associated traditional knowledge, the research team conducted four ethnobotanical surveys on incense-burning plants in Tibet, interviewing 459 informants from 23 townships, and recorded 83 species of incense-burning plants from 19 families and 36 genera, along with related traditional knowledge. The results indicate: (1) People from different regions, age groups, and genders generally possess rich knowledge of incense-burning plants; (2) Highland barley (Hordeum vulgare var. coeleste), Juniperus indica, and Rhododendron anthopogon have relatively high Cultural Value (CV) indices and are three highly important plants in incense-burning activities; (3) The utilization of incense-burning plants exhibits characteristics of regionality and substitutability, demonstrating local people's practical experience in scientific management and sustainable harvesting of incense-burning plant resources. This study will contribute to the inheritance of incense-burning culture as well as the conservation of biodiversity and sustainable utilization of incense-burning plant resources.

Full Text

Preamble

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Title: Ethnobotanical Survey and Research on Bsang Plants in Xizang Autonomous Region

Authors: ZHANG Xiong[1,2], FENG Haowen[1,3], WANG Jin[1,3], LIN Lei[1,3], WANG Yuhua[1]*

Affiliations: 1. Yunnan Key Laboratory for Wild Plant Resources, Kunming Institute of Botany, Chinese Academy of Sciences, Kunming 650201, China 2. College of Life Sciences, Shaanxi Normal University, Xi'an 710119, China 3. University of Chinese Academy of Sciences, Beijing 101408, China

Abstract: Bsang is a folk activity with unique ethnic cultural characteristics on the Qinghai-Tibet Plateau (QTP), occupying an important position in the daily life of Tibetan people. The QTP is rich in bsang plant resources and related cultural knowledge. To investigate, document, and research Tibetan bsang plants and associated traditional knowledge, our research team conducted four ethnobotanical surveys on bsang plants in Xizang, interviewing 459 informants from 23 townships and documenting 83 species of bsang plants belonging to 36 genera across 19 families, along with related traditional knowledge. The results show: (1) People from different regions, age groups, and genders possess extensive knowledge of bsang plants; (2) Hordeum vulgare var. coeleste, Juniperus indica, and Rhododendron anthopogon have high cultural value (CV) indices, making them three particularly important plants in bsang activities; (3) The utilization of bsang plants demonstrates regional and substitutive characteristics, reflecting local practices of scientific management and sustainable harvesting of bsang plant resources. This study contributes to the inheritance of bsang culture and the biodiversity conservation and sustainable utilization of bsang plant resources.

Keywords: Xizang, bsang plants, ethnobotany, resource management, sustainable utilization

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Corresponding Author: WANG Yuhua, PhD, Researcher, Ethnobotany, Email: wangyuhua@mail.kib.ac.cn

Introduction

The Qinghai-Tibet Plateau, located in central Asia, is a globally unique and complex geographical entity characterized by high altitude, cold climate, thin oxygen, diverse ecosystems, and rich biodiversity (He et al., 2007; Shimono et al., 2010). The harsh and fragile environment of the plateau shaped the knowledge system of Tibetan ancestors as they initially understood, perceived, and communicated with nature, giving rise to a belief system that venerates nature and values that respect life. As a Tibetan cultural practice, bsang holds an important position in the daily lives of Tibetan people (Li and Xu, 2007). Families and tribes conduct bsang rituals numerous times throughout the year (Zhong, 2011). Various sacrificial activities held in monasteries or among the public, as well as traditional folk festivals such as Tibetan New Year, Wangguo Festival, Shoton Festival, and Linka Festival, all involve bsang. Some families

even light sang smoke every morning (Zhong, 2011; Wang, 2015). Bsang is a purification ritual (Chabai and Dawa, 1989; Wandaiji, 2009; Qiongda, 2020) used to dispel various forms of "impurity" that Tibetans believe include filthiness and pollution of health (Wang, 2015; Qiongda, 2020). This custom has a history of at least several thousand years (Chabai and Dawa, 1989).

Bsang has two meanings: purification and offering (Anxiamaocao, 2017; Dou, 2013). First, Tibetan ancestors used the "rolling smoke" produced by burning cypress branches and leaves along with other fragrant plant materials to "drive away foul air" and achieve "purification." The use of aromatic plants and the burning of volatile substances with strong odors for sterilization, environmental purification, and dispelling evil is a common custom throughout China (Wang, 2015; Zhang et al., 2018). The active substances in plant materials can produce many healthcare effects when absorbed through the skin or respiratory system via incense burning (Zhang et al., 2018). Second, bsang is a sacrificial ritual reflecting the profound beliefs of Tibetan people (Wandaiji, 2009; Wang, 2015). The "sang smoke" produced by burning plants during bsang ceremonies is also a special offering dedicated to deities (Wandaiji, 2009; Dou, 2013; Anxiamaocao, 2017). Reciting bsang scriptures along with the smoke can make wishes come true (Zhang, 2013). Plants used in bsang ceremonies that produce fragrant white smoke when burned are called bsang plants (Wang, 2015; Li and Xu, 2007).

International research on bsang plants has primarily focused on India, Nepal, Sikkim, and other countries. Reports indicate that approximately 90 species of coniferous plants are used for incense burning in the Himalayas, with various Juniperus species being the most important and commonly used (Pennacchio et al., 2010). In India, Dorjey et al. (2021) conducted ethnobotanical research on Cupressaceae plants in the Himalayan cold desert environment of Ladakh, finding that locals are renowned for using Juniperus formosana leaves and branches to create enchanting aromatic smoke, mixing "Shukpa" with several other plant products locally called "Khampa." In Nepal, Nardostachys jatamansi is a very popular bsang plant whose smoke has numerous medicinal effects, but the plant faces extinction risk due to extensive use (Shah, 2023). Manandhar (2004) reported 31 plant species with bsang value in Nepal, belonging to 11 families and 24 genera. Chhetri et al. (2020) found that residents of the Darjeeling and Sikkim Himalayas burn certain plants in the morning and evening, walking through their houses with the smoke to purify the surrounding environment, with six such plants identified.

Domestically, Malaisse et al. (2012) conducted ethnobotanical research in southern Tibet, finding that many families burn aromatic plants in the morning, including species from Pinaceae, Cupressaceae, Ericaceae, and Artemisia. Li and Xu (2007) investigated bsang plants in two communities of Diqing Tibetan Autonomous Prefecture in Yunnan Province, documenting and comparing local bsang customs, finding that plant selection in Tibetan areas of Yunnan follows functional principles and is closely related to daily life. Additionally, the eth-

nobotany team at Kunming Institute of Botany, Chinese Academy of Sciences, has conducted extensive surveys in Tibet, cataloging some bsang plants, though without systematic in-depth thematic research (Ding et al., 2022; Guo et al., 2022).

Ethnobotany aims to deeply study the interrelationship between human society and the plant world (Smith and Martin, 1995). Tibetans on the Qinghai-Tibet Plateau have integrated plant resources into their culture, life, and traditional practices. As a widespread cultural phenomenon of plant utilization among Tibetans on the plateau, bsang is an essential part of local life, involving numerous aromatic plants. Based on years of accumulated experience, locals have even explored medicinal uses for bsang plants. Ethnobotanical research on this topic is an important means of understanding the close relationship between local residents and these plants, helping us understand how humans use plants to adapt to the plateau and contributing to biodiversity conservation (Liu et al., 2002), while also facilitating the development and utilization of aromatic plants for human health. Therefore, this study investigated and documented the plants and traditional knowledge used by Tibetans in Xizang during bsang ceremonies to explore biodiversity conservation and sustainable utilization within bsang culture.

1. Materials and Methods

1.1 Study Area

This study was conducted in seven prefecture-level administrative regions of Xizang: Ngari Prefecture, Qamdo City, Lhasa City, Nyingchi City, Nagqu Prefecture, Xigaze City, and Shannan Prefecture (Table 1 and Figure 1). We selected 1-3 townships in each prefecture-level city, and 2-3 villages in each township, totaling 45 villages across 22 townships. In each village, we selected more than 10 informants with traditional bsang knowledge for interviews, totaling 459 respondents (246 males and 213 females) aged 18-95 years, all of Tibetan ethnicity.

Table 1 Study sites

City (Prefecture)	County (District)	Township (Town)	Elevation (m)
Qamdo City	Markam County	Mcotrten Township	
	Karub District	Ritung Township	
Nyingchi City	Bomi County	Yitvong Township	
	Bayi County	Smanyul Township	
	Gyaca County	Logling Township	
Shannan Prefecture	Nedong District	Rtobobrang Township	
Lhasa City	Maizhokunggar County	Bobrang Township	
	Nyemo County	Rgyatmar Township	

City (Prefecture)	County (District)	Township (Town)	Elevation (m)
Xigaze City	Namling County	Mgarru Township	
	Sangzhuzi District	Dunpa Town	
	Tingri County	Rtoskor Township	
	Yadong County	Tangga Township	
Nagqu Prefecture	Sog County	Ronggongsstokhs Township	
Ngari Prefecture	Burang County	Ringcengangs Township	
	Zanda County	Gangsgsum Township	
		Sarzima Town	
		Bagri Town	
		Gyirong Town	
		Rongbu Town	
		Burang Town	
		Mtsolunggsumcags Township	
		Vstiyag Township	
		Sarang Township	

Figure 1 [Figure 1: see original paper] Geographical distribution map of survey points

1.2 Field Research and Data Collection

In accordance with the Law of the People's Republic of China on Intangible Cultural Heritage (2018) and Access and Benefit-Sharing (ABS) regulations (Zheng, 2019), and with informed consent from local governments and participants, we used the snowball sampling method to identify key informants with specialized knowledge, such as monks and Tibetan medicine practitioners. After interviewing these informants, we asked them to provide additional survey subjects from the target population. The survey employed semi-structured interviews and free listing. Since many local people in the study areas could not speak Mandarin fluently, fieldwork was conducted with the assistance of local guides hired with the help of community leaders. All interviews were conducted in Tibetan, translated into Mandarin by local guides, and plant local names were recorded in pinyin based on Tibetan pronunciation. Since most computer systems cannot correctly input and display Tibetan text without special language packs, local names are recorded in Latin transliteration of Tibetan in this paper. The spelling rules for Tibetan Latin can be found on the relevant website at omniglot.com (https://www.omniglot). All procedures were conducted with informed consent from informants. Based on the commonly used 5W+1H principle (What, Where, When, Who, Why, How) in ethnobotany, this study designed the following semi-structured interview questions:

1. Can you list some bsang plants you have used?
2. Where do you collect these plants?
3. When do you collect this plant? How do you utilize it?

4. Why do you use this species?
5. Which parts of the plant are used—roots, stems, leaves, or other parts?
6. Can you tell us myths, legends, and customary stories related to bsang?

1.3 Plant Voucher Specimen Collection and Identification

Plant voucher specimens were collected under the guidance of key informants and identified with reference to *Flora of China*. Plant family and species classification boundaries follow the APG IV system (APG IV, 2016). Specimens collected from various locations were identified according to *Flora of China* (https://www.iplant.cn), and plant species nomenclature standards refer to *World Flora Online* (www.worldfloraonline.org).

1.4 Quantitative Analysis

All local utilization knowledge information was organized into "use-report (UR)" lists (Tardío and Pardo-de-Santayana, 2008) for quantitative analysis. A use-report (UR) was counted each time an informant mentioned the use of a species for a taxonomic use type.

1.5 Frequency of Citation (FC) and Relative Frequency of Citation (RFC)

The relative frequency of citation (RFC) was proposed by Spanish ethnobotanists Tardío and Pardo-de-Santayana (2008) to represent the value and importance of a species in the corresponding region.

$$RFC_s = \frac{FC_s}{N}$$

Where: FC_s is the number of informants who mentioned that species s is useful (also called frequency of citation, FC), which is the sum of all UR records for that species during interviews (a UR is formed by the combination of three variables: informant i, use type u, and useful species s). N is the total number of informants surveyed. A higher RFC value for a species indicates that it is frequently used in the study area and utilized by a high proportion of informants.

1.6 Cultural Importance Index

The Cultural Importance Index (CI) was proposed by Heinrich et al. (1998) to reflect the prevalence and diversity of use of each ethnospecies. The CI value is the sum of the proportions of informants mentioning each use category for a particular ethnospecies (Tardío and Pardo-de-Santayana, 2008). The CI is defined by the following formula:

$$CI_s = \sum_{u=1}^{NC} \frac{UR_{ui}}{N}$$

Where: UR_{ui} is the total number of use-reports for a species in each utilization category; N is the total number of informants; NC is the total number of utilization categories.

1.7 Cultural Value Index

The Cultural Value Index (CV) was proposed by Reyes-Garcia et al. (2006) as the product of three factors. The calculation formula is:

$$CV_s = \left(\frac{NUs}{NC}\right) \times RFC_s \times CI_s$$

Factor 1: The number of use categories (NUs) for an ethnospecies divided by the total number of use categories (NC). Factor 2: The relative frequency of citation (RFC) for the given ethnospecies. Factor 3: The sum of the relative reported frequency for each use type of a species (CI). CV values range from 0 to FC. Higher CV values mean that most informants consider the ethnospecies to be more preferable for use.

1.8 Use Value

Use Value (UV) was proposed by Prance, defined as the sum of primary and secondary utilization values of a species within a particular culture (Prance, 1987). The calculation formula is:

$$UV_s = \frac{\sum_{i=1}^{n} u_i}{n}$$

Where: u_i is the number of times an informant mentioned the utilization of a plant; n is the total number of informants.

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2. Results

2.1 Community and Informant Characteristics

Ethnobotanical surveys were conducted in 22 townships across Xizang, with a total of 459 informants interviewed (246 males and 213 females), all of Tibetan ethnicity. A total of 3,317 use-reports (UR) were recorded. Informants ranged in age from 18 to 95 years, with an average age of 50 years (50 years for males and 51 years for females). The middle-aged group (40-59 years) provided the most reports on plant use (39.8%) (Figure 2). The selection of informants was random, and both men and women possessed rich bsang knowledge. There was no significant difference in knowledge mastery among informants of different age groups; everyone had relatively extensive knowledge.

Figure 2 [Figure 2: see original paper] Distribution of knowledge among informants. The line represents the average number of URs provided by local people in each age group.

2.2 Plant Diversity

This study recorded 83 plant taxa, with 75 identified to species level and 8 difficult taxa identified to genus level, totaling 19 families and 36 genera. Asteraceae had the most species with 25 (30.1%), followed by Cupressaceae with 13 species (15.7%) and Ericaceae with 13 species (15.7%). Among plant genera, Artemisia had the most species with 19 (22.9%), followed by Rhododendron with 13 species (15.7%) and Juniperus with 10 species (12.0%). Of these 83 species, 30 were trees (36.1%), 33 were herbs (39.8%), and 20 were shrubs (24.1%). The most commonly used parts were leaves (39.4%), branches (23.5%), and flowers (15.3%) (Table 2). According to the International Union for Conservation of Nature (IUCN) Red List, 11 species are listed as threatened: 1 species as Critically Endangered (CR)—Nardostachys jatamansi; 1 species as Endangered (EN)—Taxus wallichiana; and 3 species as Vulnerable (VU)—Abies squamata, Juniperus tibetica, and Santalum album (Table 2).

Table 2 List of bsang plants in Xizang

Specimen code	Species	Family name	Local name	Life form	Usage	Area of use	Endangered level	Cultural value index	Use value index
QDX-QDC-5	Abies spectabilis	Pinaceae	dang-seng	Tree	Branch leaf	Homo wood			
QDX-QDC-6	Abies squamata	Pinaceae	dang-seng	Tree	Branch leaf	Homo wood	VU		
DGX-CC-6	Ajania tenuifolia	Asteraceae	ngan-pa/ya-bsa	Herb	Flower	Offering			
Pulan-2	Allardia glabra	Asteraceae	ngan-pa	Herb	Aerial part	Fragrant medicine			
YGX-ZGC-1	Artemisia annua	Asteraceae	spang-mo	Herb	Aerial part	Fragrant medicine			
Jilong-1	A. calophylla	Asteraceae	spang-mo	Herb	Aerial part	Fragrant medicine			
Pulan-1	A. demissa	Asteraceae	ngan-pa	Herb	Aerial part	Fragrant medicine			

Specimen code	Species	Family name	Local name	Life form	Usage	Area of use	Endangered level	Cultural value index	Use value index
Pulan-3	A. deserto-rum	Asteraceae	sa-mo	Herb	Aerial part	Fragrant medicine			
Pulan-4	A. gmelinii	Asteraceae	ngan-pa	Herb	Aerial part	Fragrant medicine			
YGX-BYC-4	A. hedinii	Asteraceae	ngan-pa	Herb	Aerial part	Fragrant medicine			
Jilong-6	A. japonica	Asteraceae	ngan-pa	Herb	Aerial part	Fragrant medicine			
Pulan-5	A. roxburghiana	Asteraceae	ngan-pa	Herb	Aerial part	Fragrant medicine			
YGX-ZGC-4	A. sieversiana	Asteraceae	ngan-pa	Herb	Aerial part	Fragrant medicine			
MEX-SGLC-6	Artemisia sp.	Asteraceae	bsang-mgan-pa	Herb	Aerial part	Fragrant medicine			
DPZX-BMC-10	Artemisia sp.	Asteraceae	sa-ma	Herb	Aerial part	Fragrant medicine			
RXX-CMJC-7	Artemisia sp.	Asteraceae	hu-mu	Herb	Aerial part	Fragrant medicine			
RXX-CTC-9	Artemisia sp.	Asteraceae		Herb	Aerial part	Fragrant medicine			
BRZ-PRDC-5	Aster semipros-tratus	Asteraceae	ha-lu	Herb	Aerial part	Fragrant medicine			
RBZ-GDC-2	Betula platy-phylla	Betulaceae	sta-ba	Tree	Branch, leaf	Homo wood			

Specimen code	Species	Family name	Local name	Life form	Usage	Area of use	Endangered level	Cultural value index	Use value index
Pulan-6	B. utilis	Betulaceae	sta-ba	Tree	Branch leaf	Homo wood			
Pulan-7	Brassica juncea	Brassicaceae	ske-tshe-skyi	Herb	Fruit, leaf	Offering			
Zhada-1	Camellia sp.	Theaceae	shukh-pa	Shrub	Flower	Offering			
RXX-CMJC-11	Cupressus torulosa	Cupressaceae	ske	Tree	Aerial part	Offering			
Zhada-2	Ephedra saxatilis	Ephedraceae	rkang-ma	Shrub	Branch, leaf	Fragrant medicine			
RXX-DCC-3	Fragaria nubicola	Rosaceae	lbras	Herb	Fruit	Offering			
Jilong-5	Hordeum vulgare var. coeleste	Poaceae	nas	Herb	Seed	Offering			
LZ-BMX-2	Hypecoum erectum	Papaveraceae	jaeae khu-po	Herb	Aerial part	Fragrant medicine			
YGX-SMC-6	Hypochaeris ciliata	Asteraceae	mong-mu	Herb	Flower	Fragrant medicine			
QDX-DBC-4	Inula helenium	Asteraceae	rgan-pa	Herb	Flower	Fragrant medicine			
QTP-LBL-001	Juglans regia	Juglandaceae	stag-ka	Tree	Fruit, leaf	Offering			
Jilong-9	Juniperus chinensis	Cupressaceae	shug-pa	Tree	Branch leaf	Homo wood			

Specimen code	Species	Family name	Local name	Life form	Usage	Area of use	Endangered level	Cultural value index	Use value index
QDX-QDC-7	J. convallium	Cupressaceae	sprama	Shrub	Branch, leaf	Fragrant medicine			
QTB-SJX-13	J. indica	Cupressaceae	shukpa	Shrub	Branch, leaf	Fragrant medicine, homo wood			
QTB-PL-9	Juniperus sp.	Cupressaceae	sprenga	Shrub	Branch, leaf	Homo wood			
QTP-DY-055	J. pingii var. wilsonii	Cupressaceae	sprama	Shrub	Branch, leaf	Homo wood			
QTB-JL-5	J. pingii	Cupressaceae	rdzwa-sheng	Shrub	Branch, leaf	Homo wood			
RTX-XDC-1	J. recurva	Cupressaceae	rdzwa-po-sheng	Shrub	Branch, leaf	Homo wood			
Artemisia sp.	Cupressaceae	shukpa		Shrub	Branch, leaf	Fragrant medicine, homo wood			
J. saltuaria	Cupressaceae	shukpa		Shrub	Branch, leaf	Homo wood			
J. squamata	Cupressaceae	srongseng-shin		Shrub	Branch, leaf	Fragrant medicine			
J. tibetica	Cupressaceae	sranbu		Tree	Branch, leaf	Homo wood	VU		
Larix potaninii var. australis	Pinaceae	spang-spos		Tree	Branch, leaf	Offering			
Myricaria elegans	Tamaricaceae	lchags		Shrub	Branch, leaf	Fragrant medicine			
Nardostachys jatamansi	Caprifoliaceae	dangthkar		Herb	Branch, leaf	Fragrant medicine	GR		

Specimen code	Species	Family name	Local name	Life form	Usage	Area of use	Endangered level	Cultural value index	Use value index
Oryza sativa	Poaceae	dang-shing	Herb	Seed	Offering				
Picea likiangensis var. linzhiensis	Pinaceae	dang-shing	Tree	Branch, leaf	Homo wood				
Pinus armandii	Pinaceae	skhron-me-shing	Tree	Branch, leaf	Homo wood				
P. densata	Pinaceae	shukh-pa	Tree	Branch, leaf	Homo wood				
P. gerardiana	Pinaceae	gam-bu	Tree	Branch, leaf	Homo wood				
Platycladus orientalis	Cupressaceae	sra-la-me-tokh	Tree	Branch, leaf	Fragrant medicine				
Prunus mira	Rosaceae	gla-ma	Shrub	Fruit	Offering				
P. persica	Rosaceae	gla-ma	Shrub	Fruit	Offering				
Quercus aquifolioides	Fagaceae	he-lu	Tree	Branch, leaf	Homo wood				
Q. lanata	Fagaceae	he-lu	Tree	Branch, leaf	Homo wood				
Q. semecarpifolia	Fagaceae	he-lu	Tree	Branch, leaf	Homo wood				
Rhododendron anthopogon	Ericaceae	stakh-ma-me-to	Shrub	Branch, flower	Fragrant medicine				
R. anthopogonoides	Ericaceae	he-lu	Shrub	Branch, leaf	Fragrant medicine				

Specimen code	Species	Family name	Local name	Life form	Usage	Area of use	Endangered level	Cultural value index	Use value index
R. cephalanthum	Ericaceae	se-lu	Shrub	Branch, leaf	Fragrant medicine				
Rhododendron sp.	Ericaceae	se-lu	Shrub	Branch, leaf	Fragrant medicine				
Rhododendron sp.	Ericaceae	se-thkar	Shrub	Branch, leaf	Fragrant medicine				
R. laudandum	Ericaceae	se-lu	Shrub	Branch, leaf	Fragrant medicine				
R. lepidotum	Ericaceae	se-thkar	Shrub	Branch, leaf	Fragrant medicine				
R. mainlingense	Ericaceae	se-lu	Shrub	Branch, leaf	Fragrant medicine				
R. nivale	Ericaceae	se-thkar	Shrub	Branch, leaf	Fragrant medicine				
R. nyingchiense	Ericaceae	se-lu	Shrub	Branch, leaf	Fragrant medicine				
R. primuliflorum	Ericaceae	se-thkar	Shrub	Flower	Fragrant medicine				
R. setosum	Ericaceae	se-lu	Shrub	Branch, leaf	Fragrant medicine				
R. tomentosum	Ericaceae	gam-bu	Shrub	Branch, leaf	Fragrant medicine				
Rosa macrophylla	Rosaceae	se-la-me-tokh	Shrub	Flower	Offering				
Salix babylonica	Salicaceae	gha-ma	Tree	Branch, leaf	Homo wood				
S. takasagoalpina	Salicaceae	gha-ma	Shrub	Branch, leaf	Homo wood				
S. trichocarpa	Salicaceae	sro-shing	Shrub	Branch, leaf	Homo wood				

Specimen code	Species	Family name	Local name	Life form	Usage	Area of use	Endangered level	Cultural value index	Use value index
Santalum album	Santalaceae	spa-ma	Tree	Trunk	Fragrant medicine	WU			
Saussurea aster	Asteraceae	bal-u	Herb	Whole plant	Fragrant medicine				
Taxus wallichiana	Taxaceae	gam-bu	Tree	Branch, leaf	Homo wood	EN			
Thymus mongolicus	Lamiaceae	gang-lha-me-tokh	Shrub	Stem, leaf, flower	Fragrant medicine				
Triticum aestivum	Poaceae	a-rmos-lo-tokh	Herb	Seed	Offering				
Zea mays	Poaceae	srong-shing	Herb	Seed	Offering				

Note: 1. Ngari Prefecture; 2. Qamdo City; 3. Lhasa City; 4. Nyingchi City; 5. Nagqu Prefecture; 6. Xigaze City; 7. Shannan Prefecture.

2.3 Use and Indigenous Knowledge Diversity

The uses or functions of bsang plants were divided into three categories: offering, fragrant medicine, and homo wood. Fifty-one plant species were used for fragrant medicine, 26 for homo wood, and 19 for offering. Eight species had dual uses (fragrant medicine and homo wood), and three species had dual uses (fragrant medicine and offering) (Figure 3 [Figure 3: see original paper]).

Offering, fragrant medicine, and homo wood are all important items in bsang culture. Offering (Tibetan “mchoth-rtsas”) refers to plant materials with cultural and religious significance that are burned to produce smoke for worshipping various deities. Fragrant medicine (Tibetan “sman-sang”) refers to plant materials whose burning smoke has a “purifying” effect and also possesses certain medicinal value. Homo wood (Tibetan “buth-shing”) refers to culturally significant fuel used for ignition and producing smoke in bsang ceremonies. Homo wood serves to ignite and kindle the fire, fragrant medicine produces smoke with various effects, and offering serves a sacrificial function. Although they have different roles and uses, all are closely related to religious beliefs and nature worship, representing Tibetans’ reverence and respect for their faith and nature.

In terms of plant parts used (Table 2), the utilized parts included leaves (47 species), branches (39 species), aerial parts (20 species), flowers (6 species), seeds (6 species), stems (2 species), fruits (3 species), trunk (1 species), bark (2 species), and whole plant (1 species).

Figure 3 [Figure 3: see original paper] Materials used in bsang activities. a. Offering; b. Fragrant medicine; c. Homo wood.

2.4 Popular Bsang Plants

The Cultural Value Index (CV) integrates CI, RFC, and NU/NC values. Calculating CV for local bsang plants based on three use types (offering, fragrant medicine, homo wood) shows that Hordeum vulgare var. coeleste, Juniperus indica, and Rhododendron anthopogon rank relatively high, indicating that Tibetans are familiar with the different uses and applications of these plants and that these species occupy important positions in Tibetan bsang culture. Among them, Hordeum vulgare var. coeleste has the highest CV value (0.129) because it has the widest application range and is used by the most people, being used as a ritual plant throughout almost the entire Tibetan region. Barley is often roasted, ground into flour, mixed with sugar and milk, stir-fried and dried to make tsampa, or the barley seeds can be directly thrown into the sang burner. Juniperus indica (CV=0.070) and Rhododendron anthopogon (CV=0.060) are both small shrubs with very special fragrances that are deeply loved by Tibetan people. In addition to daily bsang use by residents in the species distribution area, their fragrant leaves are collected, dried, ground into powder, and processed into bsang powder for sale to various regions. Moreover, besides bsang use, these two plants have medicinal effects for treating diseases: in some areas, Tibetans use Rhododendron anthopogon flowers soaked in water to treat lung diseases and chew leaves to prevent colds; they use smoke from Juniperus indica to fumigate eyes to treat eye diseases and inhale smoke to treat heart and body pain, with some informants mentioning that smoke from these two plants has calming and sleep-aiding effects.

The Use Value index (UV) is used to determine the most important species according to a particular group. The top 10 bsang plants are Rhododendron anthopogon, Hordeum vulgare var. coeleste, Artemisia sieversiana, Cupressus torulosa, Juniperus indica, Juniperus tibetica, Nardostachys jatamansi, Triticum aestivum, Oryza sativa, and Rhododendron tomentosum. Among them, Hordeum vulgare var. coeleste, Triticum aestivum, and Oryza sativa, as food crops, are the most commonly used offerings in bsang ceremonies across almost all regions because they are the most easily obtained. Rhododendron anthopogon and Rhododendron tomentosum, both Ericaceae species, produce unique fragrances when burned, with Rhododendron anthopogon being the most used; in areas where Rhododendron anthopogon is not distributed, Rhododendron tomentosum is used for bsang instead. Cupressus torulosa, Juniperus indica, and Juniperus tibetica all have unique cypress fragrances, and their usage is related to local distribution, with residents typically choosing

whichever species is locally available. According to our survey, Artemisia sieversiana is a very commonly used bsang plant in Lhasa and other areas. In addition to bsang use, it can be used for bathing and treating colds by brewing in hot water, and its processed bsang product "Gandian Vanilla" is sold throughout Tibetan regions. Nardostachys jatamansi is very popular among people in all regions, but its resources are scarce, so not everyone collects and uses it; however, the unique odor produced after burning is deeply loved by local residents, thus it is used in many areas.

This study systematically investigated and compared bsang plant usage across seven regions of Xizang (Ngari Prefecture, Qamdo City, Lhasa City, Nyingchi City, Nagqu Prefecture, Xigaze City, and Shannan Prefecture), finding that these regions share a common material foundation in bsang culture while also demonstrating their own regional characteristics. All seven regions commonly used three plants in bsang activities: Artemisia sieversiana, Juniperus indica, and Hordeum vulgare var. coeleste. Additionally, bsang plant species showed diversity and regional characteristics across different regions. Unique bsang plants in Ngari Prefecture included Thymus mongolicus, Aster semiprostratus, Ephedra saxatilis, Artemisia wellbyi, Salix babylonica, Rosa macrophylla, Artemisia stracheyi, Rhododendron tomentosum, Salix takasagoalpina, Artemisia roxburghiana, Hypecoum erectum, Hypochaeris ciliata, Artemisia desertorum, Prunus persica, Inula helenium, Pinus gerardiana, Allardia glabra, Artemisia stechmanniana, Artemisia demissa, Myrtama elegans, and Saussurea aster. Unique bsang plants in Qamdo City included Abies squamata, Oryza sativa, Picea likiangensis var. linzhiensis, Quercus lanata, Abies spectabilis, and Juniperus chinensis. Unique bsang plants in Nyingchi City included Artemisia hedinii, Juniperus recurva, Juniperus saltuaria, Quercus semecarpifolia, Brassica juncea, Rhododendron nyingchiense, Rhododendron laudandum, Rhododendron mainlingense, Larix potaninii var. australis, Taxus wallichiana, Triticum aestivum, and Zea mays. Rhododendron nivale was unique to Nagqu Prefecture. Unique bsang plants in Xigaze City included Betula platyphylla, Betula utilis, Rhododendron setosum, Pinus densata, Juglans regia, Salix trichocarpa, Artemisia calophylla, Artemisia japonica, and Fragaria nubicola. Unique plants in Shannan Prefecture included Juniperus pingii, Juniperus sp., Prunus mira, and Rhododendron anthopogonoides. No unique bsang plants were found in Lhasa City (Table 3).

Table 3 Common and unique bsang plants in different regions of Xizang

Region	Commonly used bsang plants across regions	Endemic bsang plants in each region
Ngari Prefecture	Artemisia sieversiana, Juniperus indica, Hordeum vulgare var. coeleste	Thymus mongolicus, Aster semiprostratus, Ephedra saxatilis, Artemisia wellbyi, Salix babylonica, Rosa macrophylla, Artemisia stracheyi, Rhododendron tomentosum, Salix takasagoalpina, Artemisia roxburghiana, Hypecoum erectum, Hypochaeris ciliata, Artemisia desertorum, Prunus persica, Inula helenium, Pinus gerardiana, Allardia glabra, Artemisia stechmanniana, Artemisia demissa, Myrtama elegans, Saussurea aster
Qamdo City		Abies squamata, Oryza sativa, Picea likiangensis var. linzhiensis, Quercus lanata, Abies spectabilis, Juniperus chinensis
Nyingchi City		Artemisia hedinii, Juniperus recurva, Juniperus saltuaria, Quercus semecarpifolia, Brassica juncea, Rhododendron nyingchiense, Rhododendron laudandum, Rhododendron mainlingense, Larix potaninii var. australis, Taxus wallichiana, Triticum aestivum, Zea mays
Nagqu Prefecture		Rhododendron nivale
Xigaze City		Betula platyphylla, Betula utilis, Rhododendron setosum, Pinus densata, Juglans regia, Salix trichocarpa, Artemisia calophylla, Artemisia japonica, Fragaria nubicola

Region	Commonly used bsang plants across regions	Endemic bsang plants in each region
Shannan Prefecture		Juniperus pingii, Juniperus sp., Prunus mira, Rhododendron anthopogonoides
Lhasa City		None identified

3. Discussion

3.1 Bsang and Biodiversity Conservation

In bsang culture, rare and endemic plants such as Juniperus and Rhododendron species have special significance in bsang ceremonies due to their unique fragrances and medicinal values. However, resources of these plants are often very limited and cannot meet large demands. When demand for bsang plants is high, other plants with similar characteristics must be used as substitutes. For example, Juniperus tibetica is a widely used bsang plant in Tibetan areas (UV = 0.327), but its conservation status is Vulnerable. Therefore, in actual practice, people do not limit themselves to this single species but choose other easily accessible junipers as substitutes based on local resource availability, such as Juniperus squamata, Juniperus recurva, and Juniperus saltuaria, all of which can be used for bsang. However, not all juniper species can be used for bsang—only those with similar characteristics are suitable.

Some bsang plants, such as Rhododendron anthopogon, although not endangered, are distributed at high altitudes (4,000 m) on mountains, making them difficult to collect. In the harsh alpine environment, plants grow slowly, and if damaged, they recover with difficulty. According to our survey, for small-leaf rhododendrons, Rhododendron anthopogon and Rhododendron anthopogonoides are used in most areas, while in regions lacking these two species, other small-leaf rhododendrons are used as substitutes, such as Rhododendron laudandum, Rhododendron mainlingense, Rhododendron nivale, and Rhododendron primuliflorum. Due to different plant species distributions and resource quantities across regions, plant use shows strong regional characteristics, with locals typically selecting locally abundant species for bsang. If local production is high, they may even be sold to other regions.

During the collection of bsang plants, special attention must be paid to protecting plant buds, which are critical for plant growth. Damage to buds affects normal plant growth and development. Therefore, locals employ the following measures when collecting bsang plants: when collecting rhododendrons, they select mature branches and leaves while avoiding damage to buds, and only

pick a few leaves from each plant to ensure its growth and development. When collecting junipers, they normally only pick up fallen branches while herding, and only conduct large-scale collection for major bsang activities.

In summary, locals have good substitution applications for rare and endemic bsang plants and possess scientific, rational, and sustainable knowledge and measures in collection management. This effectively protects these precious natural resources while meeting the needs of bsang culture inheritance and development.

3.2 Comparison of Bsang Plants Across Regions

This study systematically compared bsang plant usage across seven different regions of Xizang. The results show that although each region exhibits different bsang plant characteristics due to geographical, climatic, and ecological environment differences, Artemisia sieversiana, Juniperus indica, and Hordeum vulgare var. coeleste are commonly used bsang plants in most regions. This finding reveals the important position of these plants in Tibetan bsang culture and provides new perspectives for further understanding Xizang's ecological environment, cultural inheritance, and regional development.

Artemisia sieversiana, as an aromatic plant widely distributed across Xizang, plays an irreplaceable role in bsang activities. Its unique fragrance can purify the air and repel mosquitoes, and its smoke carries people's prayers and blessings, serving as a medium for communication between humans and nature and between humans and deities. Juniperus indica is highly valued among the public for its fragrance, flammability, and medicinal value, and is commonly used to treat common diseases. Its widespread application in bsang culture highlights both its practicality and deep cultural identity and emotional attachment. Hordeum vulgare var. coeleste, as a unique food crop in Xizang, is revered as an offering in bsang activities, symbolizing the local people's spirit of struggling against nature and pursuing a better life. These bsang plants are widely recognized in bsang cultures across regions and are relatively abundant in Xizang. Rational resource management and development of these three plants could be promoted for use across Xizang regions, thereby protecting other less common bsang plant resources from damage.

Additionally, the selection of bsang plants in each region has its own characteristics: Ngari Prefecture uses Thymus mongolicus, Pinus gerardiana, Rosa macrophylla, etc.; Qamdo City commonly uses Abies spectabilis, Abies squamata, Juniperus chinensis, etc.; Nyingchi City selects Brassica juncea, Zea mays, Triticum aestivum as offerings, and uses local endemic Rhododendron species such as Rhododendron laudandum and Rhododendron mainlingense as fragrant medicine; Nagqu Prefecture uses the locally endemic Rhododendron nivale as fragrant medicine; Xigaze City tends to use Betula platyphylla, Betula utilis, and Salix trichocarpa as homo wood; while Shannan Prefecture uses endemic plants such as Juniperus pingii and Prunus mira. Notably, this study found no

unique bsang plants in Lhasa City, perhaps because as the cultural, political, and economic center of Xizang, Lhasa's bsang culture is more diverse and incorporates plant resources from surrounding areas. The unique bsang plants in each region enrich the diversity of bsang culture and alleviate the problem of insufficient local bsang plant resources caused by species distribution patterns.

In summary, Artemisia sieversiana, Juniperus indica, and Hordeum vulgare var. coeleste, as bsang plants commonly used across seven different regions of Xizang, not only have important practical value and cultural significance but also provide valuable clues and insights for further understanding and inheriting Xizang's bsang culture. Future research could continue to focus on the inheritance and development of these plants in Xizang's bsang culture to provide more scientific and comprehensive support for protecting and utilizing these unique plant resources.

3.3 Bsang and Human Health

Plant volatile oils are widely applied in food safety, skincare, and even the pharmaceutical industry, possessing various pharmacological effects including analgesic, anti-inflammatory, antioxidant, antispasmodic, insecticidal, antibacterial, and antiviral activities (Xiao et al., 2023). Bsang plants are rich in volatile components that are released into the air during bsang and can be contacted or even absorbed by the human body. Pan (2009) demonstrated that aromas can trigger positive emotions and reduce anxiety and stress. The aromas produced by bsang plants may have significant effects on human emotions and feelings. In cultural and religious rituals, this aroma helps create a peaceful and comfortable atmosphere, reminding people of reverence and respect for nature, and achieving physical and mental "purification."

Extracts from the aerial parts of Artemisia sieversiana contain absinthin, sesamin, fargesin, crysoeriol, achillin, and diayangambin, which have good anti-inflammatory activity. Artemisia sieversiana also contains sieversinin, beta-sitosterol, and epiashantin, which have antibacterial effects. Suleimenov et al. (2009) found that tricin from Artemisia sieversiana has good anti-influenza virus effects (Liu, 2017). Additionally, volatile components from most bsang plants have antibacterial effects, such as essential oil components from Rhododendron anthopogon, Juniperus indica, Juniperus tibetica, and Cupressus torulosa (Duan, 2008; Innocenti et al., 2010). Furthermore, volatile oil extracted from Nardostachys jatamansi roots has anti-inflammatory and antioxidant effects (Li et al., 2023), and essential oil from Rhododendron tomentosum also has anti-inflammatory, antitussive, and expectorant effects (Jiang, 2012). These activities may form the basis for Tibetans using bsang plants to eliminate impurity and for local people using bsang plants to treat diseases. Further phytochemical and biological research is needed to reveal the specific mechanisms of action of active ingredients.

According to our survey, people generally believe that bsang plants and the

smoke they produce have no harmful effects. However, literature research indicates that some chemical components may pose potential health risks. Grayanotoxins in rhododendrons and volatile substances such as thujone and camphor in Artemisia species (Hai et al., 2022; Chen et al., 2023) all have certain neurotoxicity, and their potential effects on humans require further safety and toxicological evaluation.

Additionally, bsang smoke itself may pose some potential health risks. The particulate matter and chemical substances in bsang smoke may irritate the respiratory tract, especially for those with existing respiratory problems or allergies. Long-term exposure to incense smoke may lead to respiratory problems and other health issues. Therefore, caution is needed when using bsang plants, especially indoors, ensuring good ventilation and avoiding excessive use.

3.4 Sustainable Development of Bsang Culture

This study documented 3,317 use-reports (UR) from 459 informants (246 males and 213 females), all of Tibetan ethnicity. We found that knowledge distribution was relatively uniform among both genders and all age groups, with everyone possessing rich traditional knowledge about bsang. This differs from knowledge distribution in some medicinal and edible plant surveys (Guo et al., 2022), where knowledge distribution typically shows male dominance (as men are mainly responsible for external affairs and livelihood while women handle domestic affairs) (Zang et al., 2013), and where knowledge of these medicinal and edible plants gradually disappears with social development. However, as a very common and important cultural activity, bsang does not show obvious knowledge loss, demonstrating the importance of culture for knowledge preservation.

The scientific management of plant resources, regional selection, and substitution strategies in bsang culture contribute to biodiversity conservation. The protection of plant buds during collection demonstrates sustainable harvesting practices. In the inheritance process of bsang culture, scientific management and sustainable collection should continue to be promoted, encouraging local community participation and establishing closer cooperative relationships to ensure the sustainable development of cultural traditions and ecological balance. Although local selection and substitution strategies help sustainable utilization of local resources, large-scale demand and commercialization may lead to overexploitation. Stricter management policies should be formulated during bsang plant collection to ensure that commercial utilization of bsang plants does not affect natural balance.

This study conducted ethnobotanical surveys on bsang plants in 23 townships across Xizang, documenting 83 species of bsang plants belonging to 36 genera across 19 families, along with related traditional knowledge. The survey shows that bsang, as a very common and important cultural activity, is associated with rich knowledge across different regions, ages, and populations, without signifi-

cant differences. The use of bsang plants demonstrates regional and substitutive characteristics, with people selecting different plants for bsang based on local resource distribution to meet large demands. The collection process of bsang plants demonstrates practices of scientific management and sustainable harvesting, including protecting plant buds, using substitute plants, and conducting careful collection during large-scale demand, all reflecting local awareness of biodiversity conservation in bsang activities. However, bsang may also be affected by commercial demand, potentially leading to overexploitation. Therefore, it is recommended to formulate stricter management policies during collection to ensure sustainable utilization of bsang plants.

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Note: Figure translations are in progress. See original paper for figures.