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Worthful Willows: Economic and Ethnomedicinal Uses of Genus *Salix* L. in the Kashmir and Ladakh Himalayas

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ABSTRACT

The genus *Salix* L. (commonly known as willow) has been one of the valuable groups of plants for humankind due to their multiple uses. In India, the Himalayan regions of Kashmir and Ladakh harbor maximum diversity of *Salix.* In this context, the present study documents multiple economic and ethno-medicinal uses of *Salix* in these Himalayan regions. The different species of *Salix* are used in plantation, landscaping, fuel wood, timber, livestock fodder, wickerwork, bat, fruit box and plywood industry; and also locally used for treatment of different human diseases. A total of 100 informants selected from representative age groups were interviewed in these Himalayan regions to collect the data on ethnomedicinal uses of these species. Hopefully, the results from the present study will guide the bio-prospection and commercial utilization of the worthful willow species in these two Himalayan regions.

Key words: *Willows; Salix; Economic uses; Ethno-medicine; Ecological services; Bio-prospection; Himalaya*

INTRODUCTION

The genus *Salix* L. (commonly known as willows) has been one of the valuable groups of plants for humankind due to their multiple uses. Historically, willows have economically contributed to the human societies (Sneader, 2000; Kuzovkina *et al*., 2008; Karp *et al.*, 2011). During the last century, *Salix* species have been grown notably for biomass production and bioremediation (Lindegaard and Baruer, 1997; Karp, *et al.,* 2011). Willows are easy to grow in moist habitats having adequate sunshine; and the easiest method of their propagation is by planting of cuttings. These species play an important role in riparian habitats and wetlands. Characterized by a high degree of genetic diversity, selected species are grown for a wide range of practical applications, including the power engineering industry, pharmaceutical sector, wicker production, landscaping, fodder, and for environmental management (Argus, 2007; Kuzovkina and Quigley, 2005; Sulima *et al*., 2006; Smart and Cameron, 2008; Forester *et al*., 2010). Owing to their huge economic importance, *Salix* species (e.g. *S. viminalis*, *S. triandra*) have been included in breeding programmes intended to produce hybrids/varieties with a high biomass production to harness energy (Przyborowski and Sulima, 2010).

Traditionally, people have been using *Salix* species growing in their surroundings for the treatment of various ailments (Malik *et al*., 2011). So far as the pharmaceutical industry is concerned; *S. alba* and *S. purpurea* are used in

the production of analgesic, antipyretic, anti-inflammatory and anti-rheumatic drugs. Increased salicylic glycoside content has been reported in hybrids of *S. alba* and *S. purpurea* (Sulima *et al*., 2009). Early records of using the willow tree, as a source of a medicine, dates back to about 6000 years ago (Mahdi, 2010). The historical perspective of the willow sheds light on the knowledge of native people and their healers which led to discovery of the wonderful drug, aspirin (Mahdi, 2010). The vast genetic variability in the genus is thus, one of the promising areas of production of new best genotypes. Willows are also an important resource for wildlife, particularly birds, insects and mammalian herbivores (Argus, 2010).

Taxonomically, *Salix* is distinguished from other genera of Salicaceae (e.g. *Populus*) in having buds consistently enveloped by a single scale, catkin scales entire, and its perianth being represented by one or more small glands (nectaries). The genus comprises of deciduous, dioecious trees and shrubs, rarely prostrate sub-shrubs. *Salix* has been classified into 3 sub-genera, namely *Salix, Vetrix* and *Chamaetia* (Meikle, 1984, 1992; Skvortsov, 1999). The subgenus *Salix* is characterized by trees, rarely shrubs, with bark furrowed, branchlets erect or pendulous, leaves mostly lanceolate and acuminate, specialized inflorescence as catkin and flowering coetaneous (i.e. vegetative and floral buds develop at the same time) or slightly precocious. *Salix* is the largest and widespread genus of the family Salicaceae with *ca*. 320 species world over (https://www.kew.org/science). In the Indian subcontinent, *ca*. 30 species of *Salix* are reported to occur (Hooker, 1888; Brandis, 1906). Stewart (1972) has reported 24 species, including 2 subspecies and 4 varieties from the West Pakistan and Kashmir. Javeid (1972) reported 15 species and 2 subspecies of *Salix* from different parts of the Kashmir valley. Recently, Malik *et al*., (2020) reported 18 species from the Himalayan regions of Jammu, Kashmir and Ladakh.

In Kashmir, *Salix* species are said to have been growing since times immemorial (Puttoo, 2010).Fossil plant studies have shown that species of *Salix* were growing in Kashmir even in the Pleistocene period (Rajoriya *et al.*, 2016; Bhat *et al*., 2017).The credit of their large scale plantation, however, goes to the Mr. MacDonnell first Head of the Forest Department and his associates, especially Mr. Red Cliffs, who started planting exotic species of *Salix* during 1916-29 around the wetlands of Kashmir and Ladakh (Puttoo, 2010). The plantation of willow species, being potential material for short rotation crop for renewable energy, was increased to supply firewood and timber to people to overcome the prolonged cold season and decrease pressure on the natural forests of the region (Rajoriya *et al*., 2016). The most recent statistics revealed that nearly 50 lac trees of *Salix* species are existing which comprise about 16% of the total broad-leaf tree plantations of Kashmir (Bhat *et al*., 2017; Masoodi *et al*., 2004). The English Willow (*S. alba*) was introduced from England during the British rule by an industrialist, Allah Bakh from Pakistan who established a subunit at Halmulla, Bijbehera in early 19th Century (Bhat *et al*., 2017). Since then, several other species, such as *S. fragilis, S. purpurea* and *S. babylonica* were introduced into Kashmir.

In this backdrop, the present study aims to investigate the economic and ethno-medicinal

uses of genus *Salix* in Kashmir and Ladakh Himalayas. We hope the results from the present study will guide the bio-prospection and commercial utilization of willow species in these two Himalayan regions.

MATERIAL AND METHODS

Study area

The Himalayan mountain range consists of the complex system of nearly parallel ranges of tertiary mountains, stretching over nearly 300 km, almost from the borders of Afghanistan in the west to the north of Myanmar in the east, approximately between 27º to 37º N latitudes and 72º to 91º E longitudes (Ohba, 1988). The Kashmir Himalaya, constituting a part of the Northwest Himalaya, represents a unique biospheric unit (Rodgers and Panwar, 1988). It is situated in the northern fringe of the Indian subcontinent between coordinates of 33º and 37º N latitudes and 72º and 80º E longitudes (Fig.1), at the north-western tip of the Himalayan biodiversity hotspot (Mittermeier *et al*., 2005). The temperature ranges from an average daily maximum of 31ºC and a minimum of 15 ºC during summer to an average daily maximum of 4 ºC and a minimum of -40 ºC during winter months. The region supports a rich and spectacular biodiversity of great scientific curiosity and promising economic benefits; chiefly owing to its topographic variations spanning from valley-floor through the terraced table-lands (*Karewas*) and dense forests, elevating upto snow-capped alpine peaks (Husain, 2001). On the other hand, Ladakh constitutes the easternmost Himalayan part bordering with Pakistan and China. The region is commonly known as cold desert because of harsh climate with an annual minimum temperature of 1.2 ºC and annual maximum temperature of 12.3ºC with annual precipitation 102 mm (Romshoo *et al*., 2020).The growing season is very short and vegetation is spare because of scanty precipitation. There are three main types of vegetation in the Ladakh Himalayas: alpine, desertic and oastic (Romshoo *et al*., 2020).

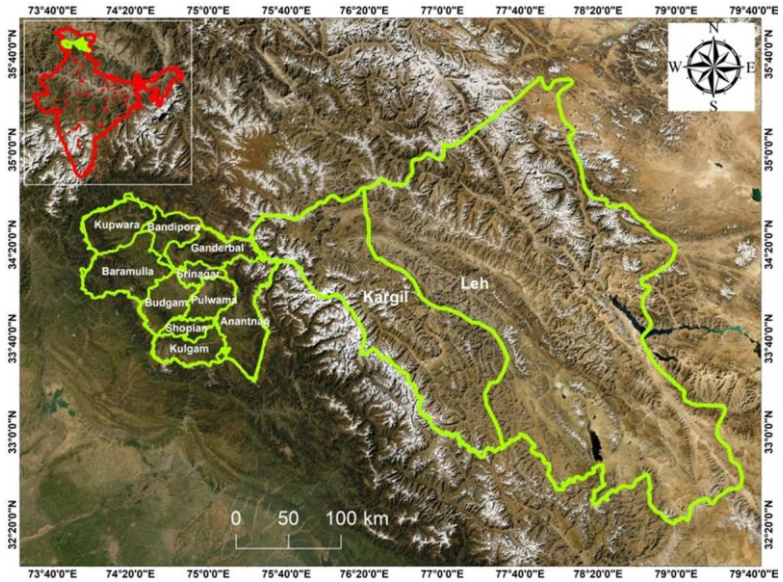

Fig.1. Map of the study area.

Methodology

The present study is based on the perusal of plant materials collected from the study area, supplemented with herbarium studies (Fig. 1). Specimens of the species of *Salix* present in the following herbaria were studied: KASH, DD, LWG, BSD, BSI, MH (Thiers, 2016). Various localities in the Kashmir and Ladakh Himalayas were thoroughly explored for collection of *Salix* specimens during the last ten years (i.e., 2008-2018). For collection purposes and taxonomic studies, the following tools were used: heavy duty polythene bags, shears, tags, rubber bands, cutter, altimeter, field camera, GPS, plant press, oldnewspapers, blotting papers, l0x hand lens, specimen collection bottles, formaldehyde hydrated solution, cello tape, and field notebook. Generally four to five, preferably young and catkin bearing, twigs of *Salix* growing in a particular locality were collected. They were kept separately in polythene bags of appropriate size, and all of them cut from the same tree/shrub at the same time were given a single collection number. Catkins, both male and female, were separately detached, collected in specimen bottles containing hydrated formaldehyde solution. All the specimens collected in polythene bags were tied airtight so as to prevent desiccation during carrying them to the base camp/laboratory. The collected specimens were pressed on the same day. The preserved specimens were identified in the laboratory using all the relevant available literature (Hooker, 1888; Argus, 1997; Skvortsov, 1999; Ali, 2001), and e-floras of China and Pakistan (www.efloras.org).

For collecting data on economic and ethno-medicinal uses, a total of 100 local elderly and experienced people, belonging to different age groups: 50 individuals in the age group of 65-80 years, 30 from 50-65 years, 20 from 35-50 years, It was ascertained that individual of every selected age group has some knowledge about ethnomedicinal uses of these species. 'Hakims' (local herbal healers) in the study area were consulted; and in the subalpine and alpine areas, the tribal people (Gujars, Bakerwals and Paharies) were also interviewed. The experienced persons were taken along to the natural habitats, or else complete specimens collected from the field were shown to them to know about the different uses of these plants, including information regarding the part used, dosage, method of preparation and uses. The additional information obtained on perusal of relevant literature and scrutiny of herbarium specimens of the concerned species was also appended. The methods employed during the present study were designed with the sole purpose of eliciting the precious wealth of information on the uses of *Salix* plants practiced by the indigenous people of the study area. To bring an element of accuracy, the information obtained from one locality was cross-checked with that from other localities.

RESULTS AND DISCUSSION

Economic uses

During the course of present study, economic uses of 18 species of *Salix* from the study area have been documented (Table 1). Phytogeorgraphicaly, the *Salix* species shows interesting distribution pattern in Kashmir and Ladakh Himalayas. Eight species of *Salix* are found exclusively in Kashmir Himalaya followed by 4 species which are restricted in Ladakh Himalaya, while 6 species are common in both these Himalayan regions (Fig. 2). These *Salix* species occur across a wide elevational gradient ranging from 1200-4000 m (Fig. 3), and grow in diverse habitats such as plains, forests, sub-alpine scrub and alpine meadows in the study area (Table 1).

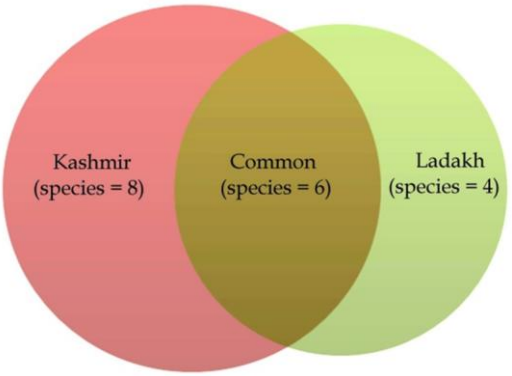

Fig. 2. Distribution of *Salix* species in Kashmir and Ladakh Himalayas.

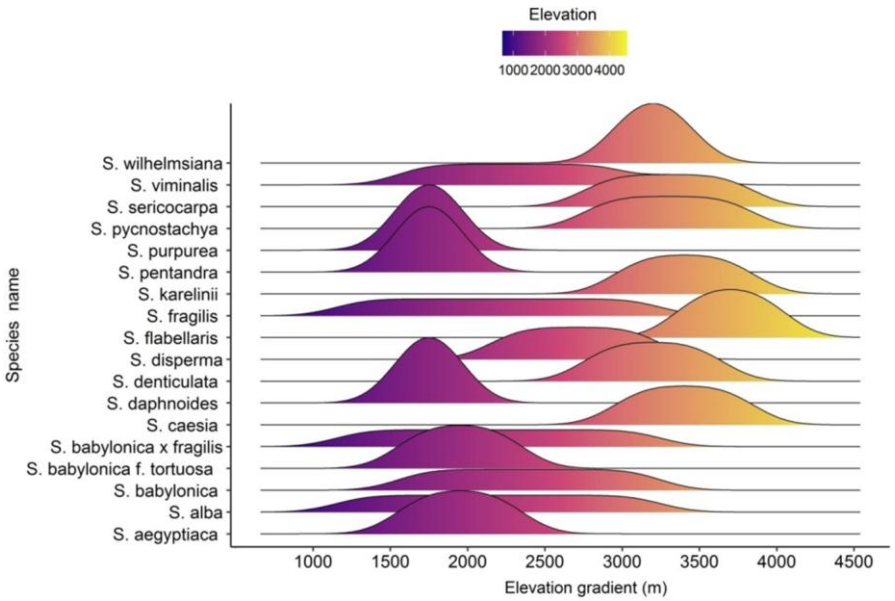

Fig. 3. Elevational distribution patterns of *Salix* species in Kashmir and Ladakh Himalayas.

Table 1. Economic uses of the *Salix* species of Kashmir and Ladakh Himalayas

S.No.	Scientific name	Vernacular name/ Voucher number, Herbarium	Habit/ Altitudinal range (m. amsl)	Economic uses
1	*Salix alba* L.	*Bota vir/ Akhtar 210, KASH	Tree/ 1200-3200	Wood used in making fruit boxes, furniture, plywood, footbridges and also as fuel. Leaves used as fodder to livestock. Trunk clefts used for making cricket bats and for construction of houses. Fiber obtained from stem used in paper making. The tender shoots and foliage are dried for used as livestock fodder for its use during winter months in Kashmir.
2	*Salix babylonica x Salix x fragilis* L.	*Teth vir/ Akhtar 211,KASH	Tree/ 1200-3200	Wood used as timber, for making fruit boxes and logs for fencing. The branches are lopped as fodder for cattle. The wood is suitable for making cricket bats. Soft twigs are used as clips for tightening grass bundles, fencing and poles.
3	*Salix fragilis* Forssk.	*Muth vir/ Akhtar 212,KASH	Tree/ 1200-3200	Wood used for bat making and is also chief source of fuel. It is also used for making artificial limbs, in match industry, for making charcoal, bows, arrows, tool handles, combs, toothpicks, agriculture tool handles, match boxes, in wooden-shoe making, sports goods. Dried leaves and branches are used for making charcoal. Foliage is used as fodder.
4	*Salix disperma* Roxb. ex D.Don (*S.wallichiana*)	*Dante vir/ Akhtar 213,KASH	Shrub/ 2200-3200	Foliage used as fodder during winter season. Fresh twigs are used in basket making by forest dwellers. Leaves and twigs are used as fuel. Stem used for making tracking sticks and agricultural tools.
5	*Salix purpurea* L.	*Kala vir / Akhtar 215,KASH	Shrub/ 1600-1900	Twigs are used in wicker industry for making baskets, chairs, sofa sets, fire pots, cages, stands, fancy items, and for art works. Foliage is used as fodder.

6	*Salix pentandra* L.	*Kaykas vir/ Akhtar 216,KASH	Shrub/ 1600-1900	The shiny branches are mostly used for making winnows, fire pots and in wicker works, after boiling them in water and peeling the bark.
7	*Salix babylonica* L.	*Vir/ Akhtar 217,KASH	Tree/ 1600-3200	Used chiefly as ornamental in gardens, parks and lawns. Wood used as fuel, timber, in bat making, boat construction, plywood, tables, and other furniture. Foliage is used as fodder.
8	*Salix viminalis* L.	*Lori vir / Akhtar 218,KASH	Tree/ 1600-3000	Tender branches are used in manufacturing of boxes, baskets, tables, and other fancy items; wood is used as fuel and for making agricultural implements. Foliage is used as cattle feed; twigs made into baskets, vessels; leaves and tender branches used as fodder.
9	*Salix flabellaris* Andersson	*Rangh vir / Akhtar 219,KASH	Dwarf shrub/ 3400-4000	Grows in high-altitude alpine pasture lands and is grazed by livestock of the nomadic pastoralists during summer season.
10	*Salix denticulata* Andersson	*Gujar vir / Akhtar 220,KASH	Shrub/ 2800-3800	Usually grows along and above treeline in mountains. Twigs are used as fuel by nomads and the foliage as fodder for cattle during summer months. Plant plays a pivotal role in reducing soil erosion.
11	*Salix karelinii* Turcz.ex Stschegl.	*Pahel vir / Akhtar 221,KASH	Shrub/ 3000-3800	Grows on alpine slopes in the Kashmir Himalaya, the plant is used as fuel wood and fodder.
12	*Salix babylonica* f. *tortuosa* Y.L.Chou (*Salix matsudana* Koidz.)	*Pache vir; Watalkani vir/ Akhtar 222,KASH	Tree/ 1600-2300	Commonly planted in gardens, parks and lawns as an ornamental, and along the roadsides for landscaping. Twigs are used in wicker-work for making baskets; while the leaves are used as fodder for livestock.
13	*Salix daphnoides* Vill.	*Jalama vir / Akhtar 223,KASH	Shrub/ 1600-1900	A twig used in wicker works, and also for making earthen fire pots ('Kangris').
14	*Salix caesia* Vill.	#Salchang/ Akhtar 224,KASH	Shrub/ 3000-3800	Foliage used as fodder and fuel in the cold desert region of Ladakh. A twig used in wicker works and fencing.
15	*Salix pycnostachya* Andersson	#Malchang/ Akhtar 225,KASH	Tree/ 2900-3800	Planted along river valleys in Ladakh.Used as shade tree, the

				branches along with leaves are stored for use as fodder in winter. Stem trunks are used in construction of houses, foot bridges, fencing and also for making agriculture implements. The stem and branches are used for thatching and making handles for doors and windows.
16	*Salix sericocarpa* Andersson	#Brookchung/ Akhtar 226,KASH	Tree/ 2800-3800	In Ladakh, planted along river sides, irrigation canals, roads, and in gardens. The leaves are highly valued in winter as food for cattles. Agricultural implements like winnows, ploughs and harrows are made out of them. The wooden piece, which is bored through the nostrils of bullocks that plough the land, is also made of *Salix*. Local people use snow boot made out of *Salix* twigs. The traditional handlooms or 'khaddis' are made from *Salix* wood. Stem trunks are used in construction of houses, foot bridges, fencing and also for making agriculture implements.
17	*Salix wilhelmsiana* M.Bieb.	# Brookchung /Akhtar 227,KASH	Shrub/ 3000-3400	Found in Nubra valley, Ladakh. Its foliage is used as fodder, and the twigs are reputed to be an excellent raw material for basketry, fencing and wicker work.
18	*Salix aegyptiaca* L.	*Bred mushk/ Akhtar 228,KASH	Tree/ 1600-2300	Used as avenue tree in lawns, parks and gardens. Fresh leaves used as fodder. Twigs used as fuel, for framing, sheeting and tea boxes. Essential oil of catkins is used in perfume industry along with roses.

Note:*= Kashmiri name; #= Ladakhi name

Ethnomedicinal uses

The present study has catalogued the ethnomedicinal uses of 12 species of *Salix* from the study area (Table 2). Out of 12 *Salix* species, 7 species were trees and 5 were shrubs. Different plant parts, such as the leaves, twigs, bark, roots and inflorescence are used. Leaves (35%) and twigs (27%) were used extensively followed by bark, roots and inflorescence (Fig. 4). These *Salix* species are being used to treat different ailments in humans such as fever, body pain, cleaning of

teeth, skin treatment, headache, respiratory infection, urinary tract infection, joint pain, typhoid, labour pain and as herbal tea (Fig. 5). This valuable information will guide the bio-prospection and commercial utilization of the worthful willow species in these two Himalayan regions.

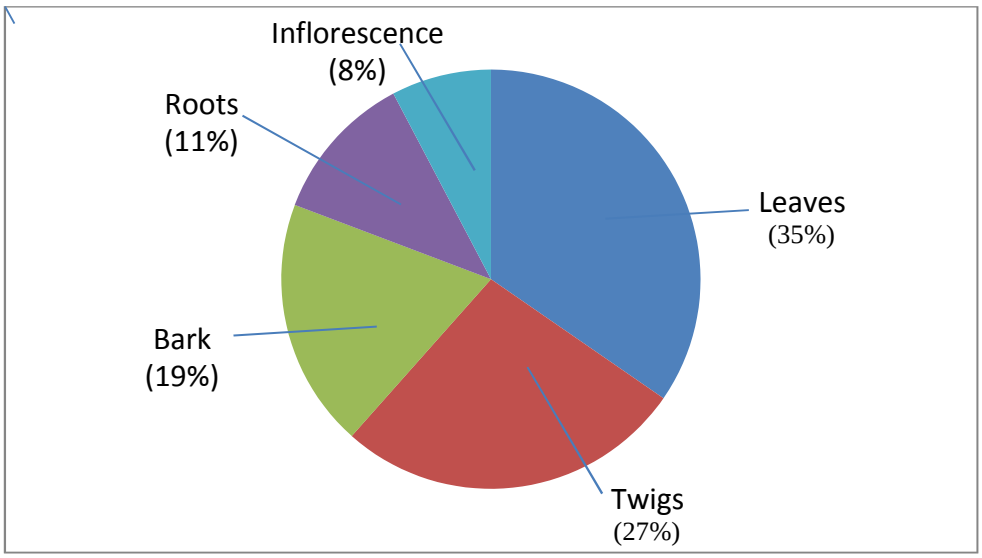

Fig. 4. Percentage use of plant parts in ethnomedicinal systems of Kashmir and Ladakh Himalayas

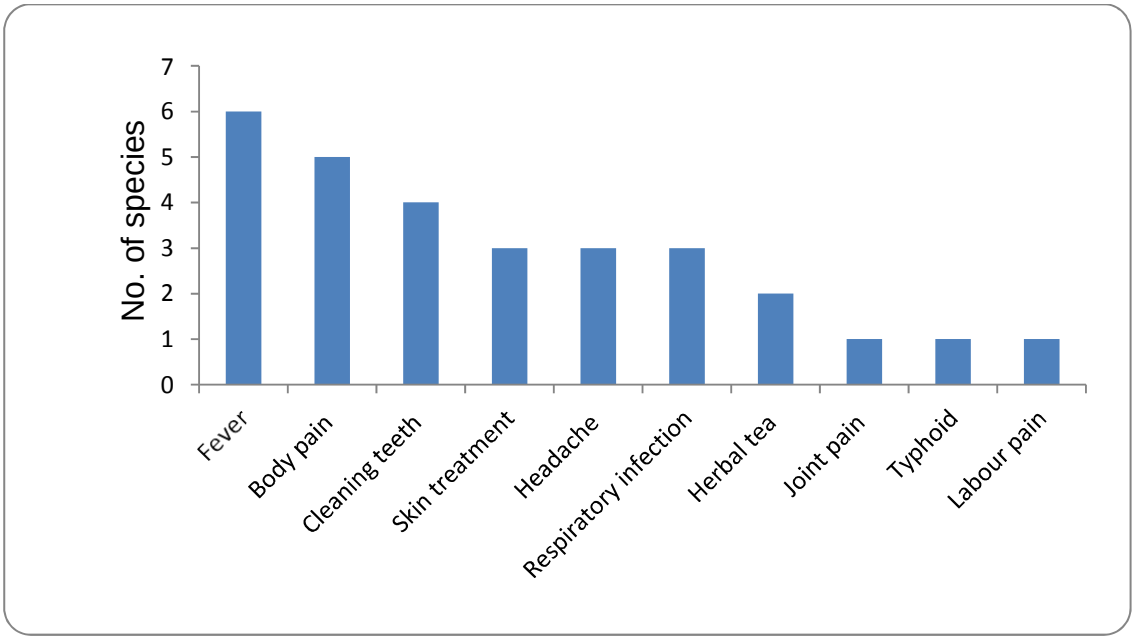

Fig. 5. Number of *Salix* species used to treat various human diseases.

Table 2: Ethnomedicinal uses of various species of *Salix* from the study area.

S. No.	Name of the species	Parts used	Ethnomedicinal uses
1	*Salix babylonica x S.x fragilis*	Bark, twigs	Bark extract used for curing insect bites. Twig is used as a local brush, commonly known as "Miswak' to clean teeth and as a mouth freshener. Twig sap is used to cure throat infection, skin rashes and aches.
2	*S. fragilis*	Leaves, bark	Leaves are boiled in water, with which the feet, legs and arms are washed to relieve tiredness and high blood pressure. Bark extract used to treat dandruff. Also used to relieve headache by taking decoction of its leaves boiled in water for 20 minutes.
3	*S. aegyptiaca*	Roots, leaves, bark, inflorescence	Fresh younger roots and leaves are used as tea. Catkins boiled in water, mixed with sugar and the decoction taken to treat respiratory tract infection and cough. Dried bark is used for treating diarrhoea and dysentery. Catkin is used in 'Sharbat' and 'Khambeer' formation.
4	*S. babylonica*	Inflorescence, twigs	Catkins and young twigs powdered and mixed with mustard oil are used for curing rheumatism and inflammation of joints.
5	*S. alba*	Twigs, leaves, bark, roots	The tender parts of twigs and leaves are consumed as food during the times of scarcity. Leaves are boiled in water and the decoction used for curing fever and body pain. Leaves also used as herbal tea, the tea are soothing and also used against head ache. Bark and root decoction are used against fever; and also used as tonic in convalescence, menstrual irregularities and diarrhoea.
6	*S. karelinii*	Leaves, twigs	Leaves are boiled in water and the decoction used to cure fever and body pain in some hilly areas of Kashmir. Twigs are used to treat toothache in some areas of Ladakh (Panikhar/Zanskar). In alpine areas of Kashmir, twig is used as a local brush, commonly known as "Miswak" to clean teeth and as a mouth freshener.
7	*S. wallichiana*	Twigs, leaves, roots	Young twigs are used for cleaning teeth and curing toothache. Twigs and leaves are boiled in water to treat typhoid. Roots are used in tea formation. Bark and leaves are boiled in water to cure labour pain, headache, fever and paralysis.

8	*S. wilhelmsiana*	Bark	Powder of dry bark is used for cleaning the scalp and skin by the nomadic people in Nubra valley of Ladakh.
9	*S. denticulata*	Leaves, inflorescence, bark	Leaves and catkins are used in a local preparation'Sharbat' to cure cough in children with the addition of sugar in it. Stem bark is boiled in water and is used in fever and headache.
10	*S. caesia*	Twigs, leaves	Twigs and leaves are boiled in water for two hours and the decoction is used for dressing wounds and also for blister treatment in some areas of Ladakh (Panikhar/Zanskar).
11	*S. pycnostachya*	Leaves, twigs	In Kargil, Zanskar and Nubra areas of Ladakh, leaves are boiled in water and the water bath is used to relieve body pain and fever. Twig is used as a local brush, commonly known as "Sootooth' to clean teeth.
12	*S. sericocarpa*	Leaves	In Suru valley of Kargil and Leh of Ladakh, leaves are crushed and 10-12 gm of its powder is boiled in water with addition of little sugar. The decoction is given to patients suffering from respiratory tract and urinary tract infections.

Other potential uses

The willows play an important role in preventing soil erosion, e. g. *S. alba*, *S. denticulata*, *S. fragilis*, *S. babylonica*, *S. pycnostachya, S. sericocarpa*. Some insects and birds feed on catkins (flowers) of different species of *Salix*. Some species also play a role as wind breaks, particularly those having tree-growth form, e.g. *S. babylonica, S. alba, S. fragilis* and *S. sericocarpa*. Some species, such as *S. alba, S. fragilis* and *S. vimnalis* are promising sources of biofuels. Willows have the property of heavy metal sequestration and, therefore, play important role in sequestration of heavy metals like Cd, Fe, Ni, and others leading to improvement of water quality (Kuzovkina and Quigley, 2005), thus help in phytoremedation. The fast growth feature has made the *Salix* species indispensable components of many farming systems in Kashmir (Bhat *et al*., 2017).

In recent times, increasing human and livestock population has put unprecedented demand on natural resources in Kashmir. Since the last 3 decades, the demand for timber has increased and the forests in the region are over-exploited at an enormous rate, causing extensive deforestation. Such deforested areas have not regenerated; instead the left-over young crop has been removed under local pressure for fulfilling fuel wood, fodder and timber needs. The rate of deforestation has reached 2.8% (Kawoosa, 2001). Considering the extent of the degraded forest area and wasteland, besides the marginal land under underproductive systems of cultivation, tremendous scope exists for multipurpose tree plantation programmes, particularly of *Salix* species.

The landscape of the Kashmir Himalaya is mostly dotted with different species of *Salix*, and therefore one of the flagship plantation materials in the Social Forestry Programmes. The willows not only serve the people by providing valuable by-products, but also support a rich biodiversity. Unfortunately, during the last 3 decades, willow plantations, especially on public lands, have been cut down at a large scale. The need of the hour is to protect all the private and social forestry willow plantations and make them flourish as the basis of sustainable industry in this region. Given the contribution of the willows in the economy of the region, the commercial aspects of their cultivation need to be studied in detail and their plantation should be encouraged. As true for the global level also, the expanding desertification in many semiarid regions of the world increases the need for plants that can cope with arid environments and meet peoples' requirements for food, fodder and fuel. In this regard, willows are the best model plant systems that can combat the runaway desertification and simultaneously provide multi-purposes benefits to the human societies.

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