Documenting potential ethnoveterinary knowledge from the indigenous communities of Cold Desert of Ladakh: A trans-Himalayan region of India

Zohra Batool, Kanwaljeet Singh and Sumeet Gairola

Correspondence

Zohra Batool[1,2], Kanwaljeet Singh[1], Sumeet Gairola[1,2*]

[1]Plant Sciences and Agrotechnology Division, CSIR- Indian Institute of Integrative Medicine Canal Road Jammu, 180001, Jammu and Kashmir, India
[2]Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, Uttar Pradesh, India

[*]Corresponding Author: sumeetgairola@iiim.res.in

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Research

Abstract

Background: The study was conducted in the cold-arid region of Ladakh to evaluate the important ethnoveterinary medical plants used by the indigenous inhabitants and to understand the traditional methods of herbal preparation used locally to treat livestock ailments**.**

Methods: Ethnobotanical survey was carried out in 15 villages of the Ladakh region. A total of 105 informants (83 men and 22 women) between the ages of 40-90 years were interviewed using semi-structured questionnaires in the ethnoveterinary survey. The ethnoveterinary data was analyzed using the use-value (UV) and informant consensus factor (ICF).

Results: A total of 25 plant species in 22 genera and 14 families were enlisted, which are used to treat various livestock ailments by Ladakh inhabitants. Fabaceae and Asteraceae were the most represented families with the highest number of species (5 each), followed by Lamiaceae (3 species) and Apiaceae (2 species). Based on taxonomic characteristics, 92% of the plants were herbs, and the whole plants (51%) were the most commonly used plant parts. The important locally used medicinal plants based on the higher use-value were *Thymus linearis* (UV=0.48), *Cicer microphyllum* (UV=0.31), *Corydalis govaniana* (UV=0.24). The highest informant consensus factor was recorded for respiratory, viral, and health-related disorders (ICF=1).

Conclusion: Livestock plays a significant role in enhancing the socio-economic status of the local inhabitants of the Ladakh region. Documentation of this traditional knowledge provides a more substantial chance to educate the younger generations and help in perseveration and future innovative research of these indigenous plants. Necessary initiatives should be taken at government and public levels to cultivate and preserve these endangered species.

Keywords: Medicinal plants, Traditional knowledge, Livestock diseases, Indigenous communities, Ladakh

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Background

Livestock constitutes an integral part of global ecological and food production systems (Herrero *et al.* 2009) and occupies 45% of the global surface areas (Reid *et al.* 2008). Approximately 10 billion dollars are lost annually because of livestock diseases worldwide (Sharma *et al.* 2012). Ethnoveterinary medicine covers people's knowledge, skill, methods, practices, and beliefs about the care of their animals (Shen *et al.* 2010). Ethnoveterinary drugs differ from one area to the next and from one community to another and are found effective in treating livestock diseases (Radha *et al.* 2022). Research into ethnoveterinary medicine is often undertaken as part of a community-based approach that improves animal health and provides essential veterinary services in rural areas (van der Merwe *et al.* 2001; McGaw & Eloff 2008).Furthermore, ethnoveterinary medicine is eco-friendly and sustainable as plant, and herbal formulations with known therapeutic properties are considerably more accessible to people in rural areas and small-scale farmers than modern medication (Gueye 1999).Easy availability and accessibility of medicinal flora and ethnoveterinary knowledge acquired by communities over many years through oral tradition (Ritter *et al.* 2012) provide cost-effective and socially compatible ethnoveterinary healthcare systems (Das & Tripathi 2009). However there is a concern that indigenous knowledge of traditional medicine will be lost over time due to a lack of interest among the younger generations and their tendency to migrate to urban areas in search of lucrative opportunities (Bhatia *et al.* 2014; Rao *et al.* 2015).

India has an old history of herbal medicine. Most livestock producers and tribals of rural India still rely on traditional herbal practices for the treatment of diseases, and this knowledge is considered a boon to society (Prasad *et al.* 2014). According to reports, the therapeutic systems of Ayurveda, Homeopathy, Siddha, Unani, and Tibet use up to 8000 plants (Pandey *et al.* 2013; Gairola *et al.* 2014). Indian Himalayan region is one of the world's wealthiest reservoirs of biological diversity and harbors 1748 medicinal plants (Khajuria *et al.* 2021). Plant-based ethnoveterinary medicine is widely practiced in the Himalayan region since livestock rearing is an integral part of the livelihoods (Lans *et al.* 2007).Furthermore, compared to modern allopathic medicines, traditional plant-based therapies are readily available; provide effective and affordable medicine (Ganesan *et al.* 2008).

The Union Territory (UT) of Ladakh is a cold-arid region situated in the northernmost part of Trans-Himalaya. The inhabitants of this deserted and hilly region are predominantly located in rural areas and depend on agriculture and livestock rearing. Extreme environmental conditions, persistent hypoxia, and limited grazing resources are major contributing factors in the causation of livestock diseases in the region (Gupta *et al.* 1996). Ladakh's rural and remote population, with limited accessibility and financial resources for modern veterinarian drugs, depends on local herbal remedies to treat and protect their domestic livestock (Shergojry *et al.* 2017). Ladakh has a rich heritage of over 397 medicinal plants used by indigenous communities for medicinal purposes (Gairola *et al.* 2014). Literature review reveals that only a few studies have been carried out on ethnoveterinary applications of the local herbs in the region, indicating a significant knowledge gap (Singh 1995; Chaurasia *et al.* 1999). Although studies are available on the indigenous ethnoveterinary practices in the western Himalayan region of India, the UT of Ladakh remains unexplored because of its remoteness, harsh climatic conditions, and rugged terrain.

Furthermore, the rapid migration of the younger generation to cities for higher education and career prospects is causing a loss of local traditional knowledge. In this context, the current study was designed to document the valuable ethnoveterinary knowledge from this unexplored area to fill the knowledge gap. The specific objectives of the present study include documenting the important ethnoveterinary applications of local plant species of the Kashmir region used to treat livestock ailments and disorders by the mountain populations of the area.

Material and Methods

Study area

The UT of Ladakh is a high-altitude region in the northernmost part of India (Fig. 1) and lies between 32°15'–36°N latitude and 75°15'–80°15'E longitude (Kala & Mathur 2002). It covers a geographical area of more than 59,417km^{2,} and the altitude varies between 1500-7680 meters above sea level (Gairola *et al.* 2014). The territory is divided into two Districts, i.e., Kargil and Leh. Kargil has a population of 140802 people and a literacy rate of 47.3% (Census 2011). The biggest ethnic group in Kargil is Muslims, followed by Buddhists. According to the Census (2011), Leh district had a population of 133487 and a literacy rate of 77.2%. Leh comprises the Indus, Shyok, and Nubra valleys, while Kargil includes the Suru, Dras, and Zanskar valleys. The biggest ethnic group is Buddhist, having 77.30% of the population, followed by Muslims at 13.78% and Hindus at 8.16%. The main ethnic groups of Ladakh include Balti, Beda, and Brokpa. Ladakhi is the most spoken language in the Union Territory. The main occupation engaging the working force is cultivation (37.92%), agriculture labor (4.28%), household industry (1.24%), and other works (56.56%). The flora of Ladakh is a rich source of aromatic and medicinal plants. The vegetation is sparsely distributed

in the region due to high aridity (Fig. 2) and is grouped into three broad classes—arid vegetation, alpine mesophytes, and oasitic or riparian vegetation (Kala & Mathur 2002). In winter, mercury drops to minus 48˚C at Drass (Kargil), the second coldest inhabited place after Siberia.

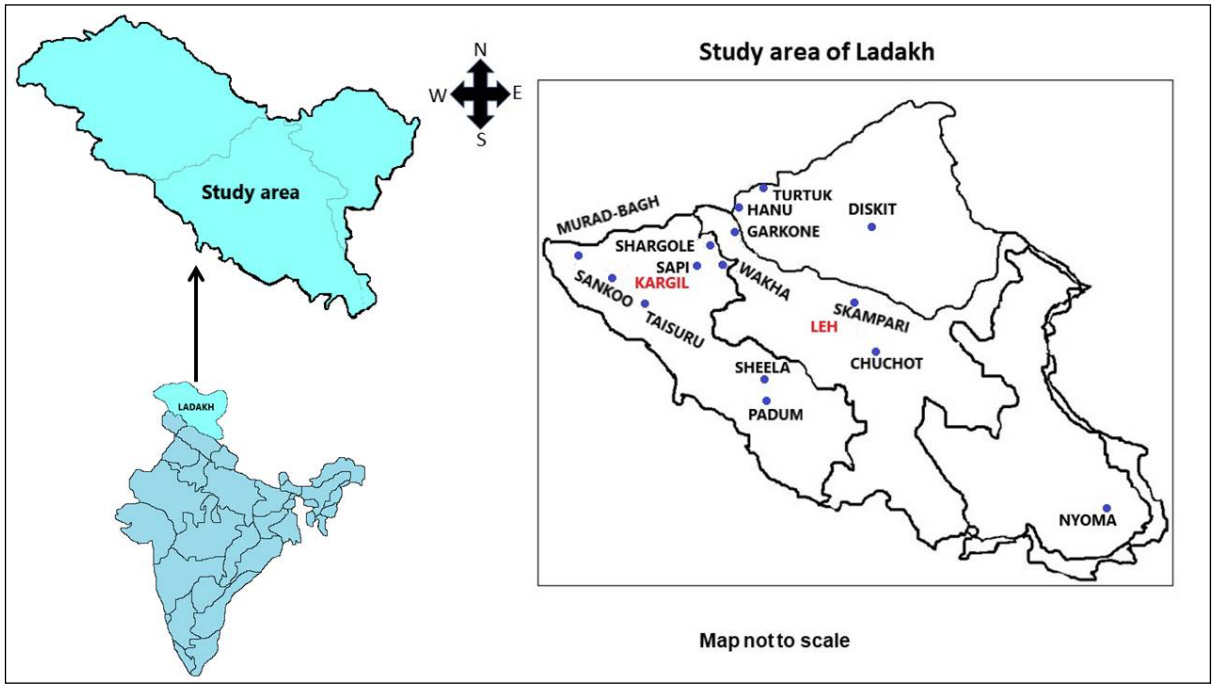

Figure 1. Map of the study area

Figure. 2 Sparse habitations in the study area.

The region receives meagre annual precipitation (22–36 mm), mainly in snowfall for 5-6 months and minimal rainfall for the rest of the year (Kachroo *et al.* 1977; Ballabh *et al.* 2008). The domesticated fauna of the region includes yaks, cows, sheep, goats, horses, ponies, donkeys, double-humped camels, and poultry.

Data collection

Field visits were conducted in several villages of the study area from 2019-2021. These include Sankoo, Tai Suru, Garkone, Hanu, Padum, Sheela, Wakha, Sapi, Shargole, Diskit, Turtuk, Nyoma, Skampari, Murad Bagh and Chuchot. As the first author is a resident of the study area, interviews were conducted in the local language, i.e., *Ladakhi*. Efficient communication and understanding of the local populace aided in collecting vital information. Prior Informed Consent was taken verbally from all the informants following the Convention on Biological Diversity (CBD) rules. We strictly followed the Code of Ethics for the present study established by the 'International Society of Ethnobiology' (2008).Field observations were carried out in the study region with the assistance of local guides and some local informants. Ethnoveterinary information was collected from 105 informants using semi-structured

questionnaires, participatory observations, and interviews. Informants having a wide range of information were visited multiple times to compare the findings reported by others. We consulted local veterinary practitioners *Amchis* for expert opinions to minimize misinformation (Fig 3). All the relevant information, including local names, parts used, and mode of herbal preparation, was recorded.

Figure 3. Collection of ethnoveterinary information from the informants.

The specimens collected during the field survey were processed and preserved according to the standard procedure (Jain & Rao 1977). Furthermore, identification and confirmation of collected samples were made with the help of regional floras (Polunin & Stainton 1984; Sharma & Jamwal 1988; Singh 2002; Shukla & Srivastava 2020) and the herbaria RRL, HBJU, and KASH (Thiers 2022). After identification, all the specimens were submitted to the Janaki Ammal Herbarium at CSIR-IIIM, Jammu. The valid botanical names and author citations of all the enlisted species were verified employing http://www.worldfloraonline.org. Photographs of some plant species are presented in (Fig. 4).

Data analysis

Data collected during the field survey from the local inhabitants and traditional healers of indigenous communities of Ladakh was initially organized in a Microsoft Excel sheet and later analyzed using Use-value (UV) and Informant consensus factor (ICF).

Use-value (UV)

The Use Value (UV) demonstrates the relative importance of plants known locally. It was calculated using the following formula (Vijayakumar *et al.* 2015)

$$UV = \Sigma Ui/N$$

Where UV is the use-value of a species, U is the number of use reports cited by each informant for a given plant species, and N is the total number of informants. UV is applied to determine the plants with the highest use in treating an ailment.

Informant consensus factor (ICF)

To calculate ICF, the diseases were divided into categories based on the information given by the informants. The following equation calculated this index:

$$ICF = N_{ur} - N_t/(N_{ur} - 1)$$

Where N_{ur} is the total number of use reports for each disease group, and N_t is the number of species used to treat various diseases in that particular group. This value determines the continuity and homogeneity of the exchange of information among the informants. A higher value of close to 1 indicates a sound exchange of information, and a lower value of close to 0 indicates a minimal or lesser exchange of information (Heinrich *et al.* 1998)

Figure 4. Photographs of some of the collected ethnoveterinary plants from Ladakh. A-*Physochlaina praealta*; B-*Rumex patientia*; C-*Cicer microphyllum*; D-*Heracleum pinnatum*; E-*Mentha longifolia*; F-*Iris lactea*; G-*Corydalis govaniana*; H-*Eriophyton tibeticum*; I-*Medicago sativa*; J-*Prangos pabularia*; K-*Ephedra gerardiana*; L-*Medicago falcata*.

Results

Characteristics of Informants

In the present study, 105 informants (83 men and 22 women) between the ages of 40 and 90 participated (Table 1). It was found that women were hesitant to express their opinion. The study found that most ethnoveterinary knowledge is orally transferred from one generation to another, and some information has been lost at each level. The informants themselves say that compared to them, their forefathers knew much more.

Table 1. Demographic details of the informants.

Education	
Illiterate	74
Up to 10th class	21
Above 10th Class	10
Occupation	
Agriculture	67
Govt. Employee	15
Traditional healers	3
Others	20

Diversity of medicinal plants used in ethnoveterinary practices

The local respondents used 25 medicinal plants belonging to 14 families for ethnoveterinary purposes (Table 2). Fabaceae and Asteraceae were the most represented families (5 species each), followed by Lamiaceae (3 species) and Apiaceae (2 species), while the remaining families were represented by single species each (Fig. 5). Of these ethnoveterinary plant species, 92% (23 species) were herbs, while shrubs and trees were represented by single species each. Inhabitants of indigenous communities of Ladakh often prepare veterinary medicines from plant preparations, although materials such as rock salt, calcite, hot vegetable oil, jaggery, and soda ash were also reported. The parts of the plant species most commonly used in ethnoveterinary medicinal preparation were whole plant (51%), followed by leaves (16%), shoot (8%), stem and seed (6% each), and the remaining were root, flower, and fruits (Fig.6).

Use value

The important medicinal plants based on use-value were *Thymus linearis* (UV= 0.48), *Cicer microphyllum*(UV= 0.31), *Corydalis govaniana* (UV= 0.24), *Physochlaina praealta* (0.21) and *Rumex patientia* (UV=0.19). The least used ones were *Gentiana gelida* and *Trigonella emodi* (UV=0.04 each) (Table 2).

Informant consensus factor (ICF)

Based on the information shared by the informants, the diseases were grouped into eight categories (Table 3). The maximum number of plant species was reported for the treatment of nutritional disorders (7 species), followed by dermatological disorders (6 species), gastrointestinal disorders, and parasitic disorders (4 species each). The most prevalent ethnoveterinary diseases in the Ladakh region were wounds, stomachache, bloating of the stomach, galactorrhea, retention of the placenta, and internal parasites. Respiratory, viral, and health-related disease categories represented the highest (ICF=1.0) value. In all three disease categories, single species *Cicer microphyllum*, *Prangos pabularia*, and *Ephedra gerardiana* were used for foot and mouth disease, hypothermia, and cough, respectively. Other categories with ICF on the higher side are gynecological, obstetrics, parasitic, and gastrointestinal disorders (Table 3).

Discussion

The principal livelihood of the indigenous communities of Ladakh, particularly the population residing in the remote and hilly areas, comes from animal husbandry. Low oxygen levels (Gupta *et al.* 1996), extreme climatic conditions (Kala & Mathur 2002), marked water scarcity (De Bello *et al.* 2011), and limited availability of pasture lands are the major stressors for livestock. Indigenous plants and traditional knowledge are vital in treating and minimizing the livestock mortality rate. Ethno-medical knowledge is a long process that increases with age and frequently applies that knowledge (Phillips & Gentry 1993). Most of this knowledge is usually transferred orally from one generation to another. If not conveyed in the proper manner or to a person or at the time, it sometimes ends with the death of an elder person (Sharma *et al.* 2012). The rapid decline of traditional knowledge among the younger generation secondary to improvisation in education status and the low interest in inheriting them is a significant concern (Bhatia *et al.* 2014). It can be better translated by the fact that, out of 105 informants, 75 were between 61-90 years old during the present survey. Women are involved with the majority of the activities related to livestock. However, the male population and traditional faith healers carried the primary burden of ethnoveterinary medical practice. In the present study, the number of male informants was 83. Khattak *et al.* (2015) reported that elderly men have better traditional knowledge than their counterpart's women, which is similar to our result. Sharma *et al.* (2012) reported that 80.3% of the informants were women and had expertise in various generalized cattle-related ailments in the Kathua district of Jammu and Kashmir. This difference might be due to cultural differences and practices between the two regions. In the present study, we reported 25 plant species for which the informants had concrete, reliable, and consistent information about their potential ethnoveterinary uses. The first author, Zohra Batool (resident of the Kargil), had spent the most of her time with local residents during the study period in order to get as much information as possible from them. However, the number of plants used in the region to treat various livestock diseases is less than in its neighboring Himalayan region because of its unique topography and various ecological factors. Furthermore, the area is generally referred as a " cold desert" (Gairola *et al.* 2014) and is characterized by extreme weather conditions, marked water scarcity, short vegetation periods, and scattered vegetation, which are confined to small pockets (Ballabh *et al.* 2008). The ethnoveterinary use of medicinal plants has also been reported in previous studies in the Indian Himalayan region (Sharma & Manhas 2015; Ahmad *et al.* 2017; Phondani *et al.* 2010; Kirmani *et al.* 2020; Dutta *et al.* 2021; Singh *et al.* 2022) and neighboring countries like Pakistan (Ahmed & Murtaza 2015; Khattak *et al.* 2015; Shoaib *et al.* 2021) and Nepal (Gyawali & Paudel 2017; Uprety *et al.* 2022).

Table 2. List of ethnoveterinary plant species used by indigenous people of Ladakh.

Botanical Name [Voucher Number]	Family	Local Name	Status	Habit	Part Used	Usage form	Route of administration	Traditional methods of ethnoveterinary uses	$\sum U_i$	UV
Artemisia absinthium L. [RRLH-24306]	Asteraceae	Khampa	Wild	Herb	WP	Paste	Topical	The dried plant part is crushed into a paste form and applied to the affected areas for wound healing.	7	0.07
Artemisia gmelinii Weber ex Stechm. [RRLH-24302]	Asteraceae	Hotong	Wild	Herb	WP	Paste, Decoction	Topical, Oral	Paste of the whole plant is effective for wound healing, and the boiled portion of the plant preparation is used for internal parasites of horses and alopecia of sheep and goats.	11	0.11
Seriphidium maritimum (L.) Poljakov Syn. *Artemisia maritima* L. [RRLH-26640]	Asteraceae	Burtse	Wild	Herb	L, ST, WP	Decoction	Oral	The decoction of plant parts is used to remove the internal parasites of horses and other cattle.	7	0.06
Cicer microphyllum Benth. [RRLH-24072]	Fabaceae	Sari	Wild	Herb	WP	Rubbing	Topical	The whole plant is directly applied to the affected areas of the mouth and tongue in case of foot and mouth disease in the cow.	32	0.31
Cichorium intybus L. [RRLH-240148]	Asteraceae	Shianthi	Cultivated/Wild	Herb	L, SH	Gravy	Oral	Plant parts are boiled with a mixture of flour and buttermilk to cure retention of the placenta.	10	0.09
Cirsium arvense (L.) Scop. [RRLH-26636]	Asteraceae	Biangtser, Jiangtser	Wild	Herb	WP	Raw	Oral	The whole plant is given with fodder to prevent and cure alopecia in sheep and goats and is also used for softening hair in sheep and goats to produce good quality wool.	8	0.07
Corydalis govaniana Wall. [RRLH-25800]	Papeveraceae	Makshang	Wild	Herb	FL, WP	Decoction	Oral	Flowers and the whole plant are boiled to cure stomachache and abdominal bloating in cows, sheep, and goats. The cooked portion of the plant is used to extract placental retention in cows.	25	0.24
Delphinium cashmerianum Royle [RRLH-26637]	Ranunculaceae	Bilamenduk	Wild	Herb	R	Paste	Topical	The roots are dried, make a thick paste, and applied to the affected wound areas.	8	0.07
Ephedra gerardiana Wall. ex Stapf [RRLH-24319]	Ephedraceae	Tsephat	Wild	Shrub	WP	Decoction	Oral	The whole plant is boiled to make a decoction to cure cough in the donkey. It is also given with fodder.	9	0.08
Gentiana gelida Pall. [RRLH-26639]	Gentianaceae	Tikta	Wild	Herb	WP	Decoction	Oral	The whole plant is boiled with leftover food to cure the abdominal bloating of cows, donkeys, and horses. It is also given with fodder.	5	0.04
Heracleum pinnatum C.B. Clarke [RRLH-25476]	Apiaceae	Khras, Spisho	Wild	Herb	R	Paste	Topical	Paste of the root is applied on the affected skin to cure swelling of animals and wounds healing.	13	0.13
Hordeum vulgare L. [RRLH-25479]	Poaceae	Tsrab	Cultivated	Herb	SD	Raw	Oral	Seeds are made into flour first, local bread, and given to cows to extract the placenta.	8	0.07
Iris lactea Pall. [RRLH-240158]	Iridaceae	Kresma	Wild	Herb	WP	Raw	Oral	The whole plant is given raw and with fodder to cure agalactorrhea in the cow.	11	0.11

Medicago falcata L. [RRLH-240152]	Fabaceae	Bol-Buksuk	Wild	Herb	WP	Raw	Oral	The whole plant is given as fodder for agalactorrhea in cows and offered with rock salt to cure animal malnutrition.	13	0.13
Medicago sativa L. [RRLH-24087]	Fabaceae	Ol-Buksuk	Wild	Herb	WP	Raw	Oral	The whole plant is given as fodder and rock salt to cure malnutrition.	10	0.09
Melilotus officinalis (L.) Pall. [RRLH-25586]	Fabaceae	Buksuk	Wild	Herb	WP	Raw	Oral	The whole plant is given as fodder for agalactorrhea in cows and offered with rock salt to cure animal malnutrition.	8	0.07
Mentha longifolia (L.) L. [RRLH-24332]	Lamiaceae	Phololing	Cultivated/Wild	Herb	L,SH	Decoction	Oral	Plant parts are boiled and given to animals to cure stomachache.	12	0.12
Physochlaina praealta (Decne.) Miers [RRLH-24080]	Solanaceae	Lantang	Wild	Herb	L, WP	Paste	Topical	Pastes of leaves are applied to the affected areas to kill the external parasite in sheep and goats.	22	0.21
Prangos pabularia Lindl. [RRLH-25548]	Apiaceae	Palangs	Wild	Herb	WP	Raw	Oral	The whole plant is given as fodder to cure hypothermia in cattle.	6	0.05
Prunus armeniaca L. [RRLH-24741]	Rosaceae	Chuli	Cultivated/Wild	Tree	SD	Gravy	Oral	The seeds are crushed until the oil comes. The left-over portion of the seeds is mixed with flour and leftover vegetables. The mixture is boiled till it gets converted into gravy which is locally known as "Chak". It is given to cows to treat abdominal bloating and agalactorrhea.	13	0.13
Podophyllum hexandrum Royle [RRLH-24053]	Berberidaceae	Denmokushu	Wild	Herb	FR, WP	Raw	Oral	The fruit and whole plant are given directly to remove the intestinal worms of cattle.	10	0.09
Rumexpatientia L. [RRLH-24322]	Polygonaceae	Shoma	Wild	Herb	L,SH, WP	Dec, Rw	Oral	Leaves and shoots are boiled to cure retention of the placenta, and the whole plant is given fodder in case of agalactorrhea in cows.	20	0.19
Eriophyton tibeticum (Vatke) Ryding Syn-*Stachys tibetica* Vatke [RRLH-24084]	Lamiaceae	Jatuk-napo	Wild	Herb	WP	Decoction, Raw	Oral	Paste of the whole plant is applied to affected wounds of sheep and goats.	8	0.07
Thymus linearis Benth. [RRLH-24059]	Lamiaceae	Tumburu	Wild	Herb	WP,ST,L,FL	Paste	Topical	First, the plant is dried, crushed into a paste, and applied to the affected areas for wound healing in cattle.	50	0.48
Trigonella emodi Benth. [RRLH-26638]	Fabaceae	Buksuk	Wild	Herb	WP	Paste	Topical, Oral	Paste of the whole plant is effective for wound healing, and the boiled portion of the plant preparation is used for internal parasites of horses and alopecia of sheep and goats.	5	0.04

***Abbreviation:** Wp- Whole plant; St-Stem; Sd-Seed; Sh- Shoot; L- Leaf; Fl-Flower; Fr-Fruit; Rt-Root

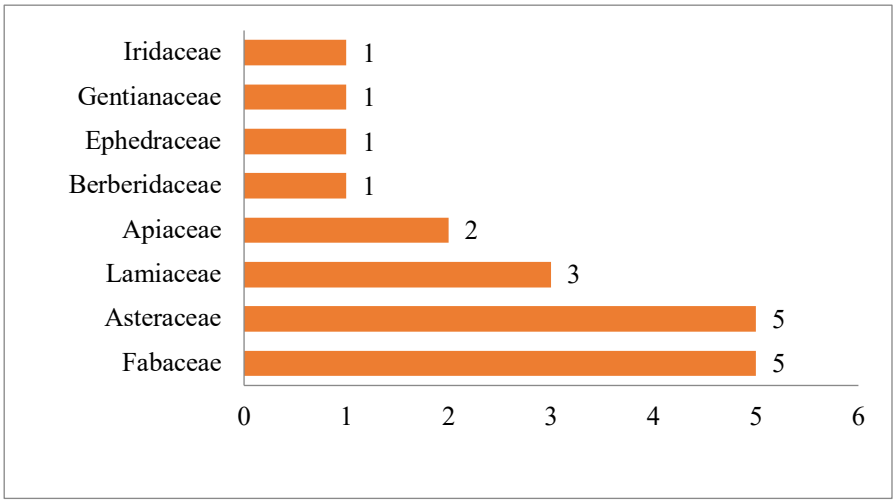

Figure 5. Most representative families of the study area with respective species contribution.

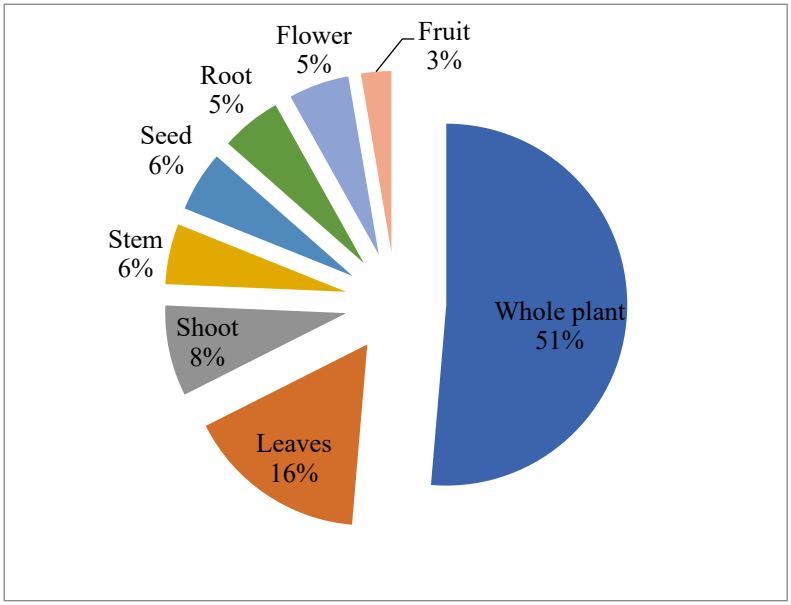

Figure 6. Percentage of plant parts used in the study area.

Table 3. Veterinary Livestock diseases and related Informant consensus factor (ICF).

Disease category	Nur	Nt	ICF
Respiratory diseases	9	1	1.00
Health-related diseases	6	1	1.00
Viral disease	32	1	1.00
Gynecological and obstetrics diseases	58	5	0.93
Parasitic diseases	39	4	0.92
Gastrointestinal diseases	35	4	0.91
Dermatological diseases	47	6	0.89
Nutritional diseases	48	7	0.73

Asteraceae and Fabaceae were the dominant families in the present study. The dominant use of plant species of these two families for ethnoveterinary purposes has also been previously reported from Jammu and Kashmir (Singh *et al.* 2022; Dutta *et al.* 2022). Other studies conducted in Western Himalayan regions have also reported wider utilization of Asteraceae plants in ethnoveterinary ailments (Ahmad *et al.* 2017; Ahmed & Murtaza 2015; Tariq *et al.* 2014; Wani *et al.* 2022). This similarity in ethnoveterinary use might be due to the abundance of the plant species of these families. A recent study conducted by Hassan *et al.* (2022) in the Kashmir Himalaya found Asteraceae and

Ranunculaceae as the dominant families in ethnoveterinary practices. In contrast, tribal nomadic shepherds in the Northwestern Himalaya mostly use Poacaeae plant species (Radha *et al.* 2022).

Most of the plant species used for ethnoveterinary treatment by local people of this region was herbs. Herbs are used because of frequent availability, ease of collection and application (Khan *et al.* 2021), and abundant growth in the poor nutrient soil (Sharma *et al.* 2012), which favors the topographical and climatic conditions of the study area. Traditional knowledge of medicinal plants and uses varies from region to region because of differences in the traditional healthcare system, cultural diversities, plant availability, and morphological observation. Medicinal uses of different parts of the plants were reported in the literature for similar or different medical conditions. In the present study, the whole plant of *Artemisia absinthium* in the form of paste was used to treat the wounds of animals. However, the juices of aerial parts, leaves and the whole plants of *Artemisia absinthium* L. is used as a remedy against abdominal worms, anthelminthic, liver infection and as an appetizer in livestock (Dutta *et al.* 2022). In India's Kashmir Himalayan region and Pakistan's South Waziristan region, the whole plant of *Artemisia absinthium* was used as an anthelmintic agent (Ahmad *et al.* 2017; Aziz *et al.* 2018a). *Artemisia absinthium's* anti-inflammatory activity, which is responsible for wound healing pathophysiology, is secondary to tetramethoxy hydroxylflavone (Lee *et al.* 2004). Other pharmacological activities of *Artemisia absinthium* reported in both in-vivo and in-vitro studies were hyper-secretary, digestibility enhancement, antiulcer, hepatic, neuroprotective, anthelmintic, antiparasitic, antimicrobial, antifeedant and others (Beigh & Ganai 2017). Leaves and shoot parts of *Cichorium intybus* were given orally to treat retention of placenta in cattle in the study area. (Abidin *et al.* 2021) also reported the use of the aerial part of *C. intybus* to treat retention of placenta along with other ailments like gastric problems, body tonic, blood clotting, bone fracture, wounds, constipation, fever, diarrhea, anaplasmosis, conjunctivitis, foot and mouth ulcers, mastitis, trypanosomiasis, pneumonia and helminthiasis of cows, camels and buffaloes by indigenous communities in Southwest Pakistan. Indigenous people of the Tari region of Uttarakhand used crushed leaves of *C. intybus* with water to treat urinary disorders or hematuria in goats (Khadda *et al.* 2018). The whole plant of *Cirsium arvense* (L.) Scop. was used to treat alopecia and hair tonic in the present study. In contrast, the people in the Kathua and Rajouri districts of Jammu & Kashmir used raw and powder forms of seed and root to treat pneumonia, food poisoning, blood in stool & urine, and as an appetizer (Sharma & Manhas 2015; Sharma *et al.* 2012; Dutta *et al.* 2022). The whole plant of *Ephedra gerardiana* to treat cough in the present study is similar to the study conducted on Trans-Himalayan migratory shepherds in the Kannur district of Himachal Pradesh-India (Radha *et al.* 2020). The stem of the *E. gerardiana* was also used in treating cough in Jumla region of Nepal (Gyawali &Paudel 2017). The use of leaves, shoot, and whole plants of *Seriphidium maritimum* to treat parasitic infestations in the horse and other cattle in the present study is similar to that reported by (Rehman *et al.* 2022). The whole plant of *Cicer microphyllum* was used to treat foot and mouth disease (FMD) in the present study. Besides, this plant species has also been reported to treat '*Kachu'* (a kind of mouth cancer in cattle) in Ladakh region (Adhikari 2017; Shabir *et al.* 2019). Different indigenous people of different places use different plants to treat the FMD. For example, leaves of *Azadirachta indica* in the Sariska region of Rajasthan-India and aerial part of *C. intybus* in Southwest Pakistan were used to treat FMD (Abidin *et al.* 2021). Apart from medicinal plants, another element, such as soda ash, is also used to treat foot and mouth disease (FMD) by the local people of the study area (Yineger *et al.* 2007). The leaves and shoots of *Mentha longifolia* (L.) L. were boiled and given as decoction to treat stomachache in the study area. In contrast, the Gujjar & Bakarwal tribes of Poonch use leaf decoction to cure pyrexia in cattle (Dutta *et al.* 2021). The whole plant paste of *Thymus linearis* is used by the local people to treat wounds in cattle. In contrast, the whole plant of *T. linearis* is fed to cattle to help them recover from dehydration, especially during the summer months in Ladakh (Rinchen & Pant 2014). Whereas, in the Poonch district of Jammu & Kashmir whole plant of *Thymus linearis* is used to treat snake bite in cattle (Khan & Kumar 2012). Furthermore, leaves and flower parts of *Thymus* are also used to treat the digestive disorder in animals by local people of Deosai plateau-Pakistan (Khan *et al.* 2015).

The leaf and shoot decoction of *Rumex patientia* L. is used in the retention of the placenta, while the whole plant is given as fodder in case of agalactorrhea in cows (Table 2). Pastoralists in Kashmir Himalaya use the dried root powder of *R. patientia* to cure dyspepsia and liver fluke (Ahmad *et al.* 2017). In contrast, the semi-nomadic Gujjar tribe of the Kashmir Himalaya uses the root powder in combination with the root of *Taraxacum officinale* to treat liver fluke and other intestinal problems in animals (Khuroo *et al.* 2007). In the study area, *Artemisia gmelinii* and *Cirsium arvense* were used to treat alopecia and hair softening in sheep and goats. Sheep and goats constitute 56% of the total livestock in the Ladakh region (Reference). Wool of Malluk and Merino Malluk breeds of sheep are well known for making fine-quality tweeds, pullovers, and blankets. The high ICF values among all the disease categories suggest an ample exchange of information between the informants (Sharma *et al.* 2014) and a higher consensus on the methodology of using the plant species for treating aliments of a particular category. The source

of 80% of medicinal plants in the present study was wild; however, the cultivation of these medicinal plants is marginal in the study area. The extraction of wild medicinal flora at a higher rate and the limited availability of pasture lands put immense pressure on the natural habitat of these important floras. For the first time, the present study analyzed and compared the ethnoveterinary plants of the region with other studies through a literature survey. Analysis of the present study data helped in discovery of some novel plant species as well as novel use reports.

To ascertain the novelty in the ethnoveterinary use of the plant species, we compared the results of the present study with the previous studies in the North-Western Himalayas and neighboring countries of Nepal, China, and Pakistan. The comparative analysis found that 44% of plant species from the present study were also reported in previous studies from an ethnoveterinary point of view. These include *Artemisia absinthium*, *Seriphidium maritimum*, *Cichorium intybus*, *Cirsium arvense*, *Ephedra gerardiana*, *Hordeum vulgare*, *Mentha longifolia*, *Prunus armeniaca*, *Rumex patientia*, *Podophyllum hexandrum*, and *Thymus linearis*. 56% of the plant species were reported for the first time in the fieldwork data. These include *Artemisia gmelinii*, *Cicer microphyllum*, *Corydalis govaniana*, *Delphinium cashmerianum*, *Gentiana gelida*, *Heracleum pinnatum*, *Iris lactea*, *Medicago falcata*, *Medicago sativa*, *Melilotus officinalis*, *Physochlaina praealta*, *Prangos pabularia* and *Trigonella emodi* (Table 4). It's pertinent to mention that out of 25 species, 11 plant species were reported in previous literature, and the use reports of 7 plants were mentioned for the first time in the present study. The enlisted plant cited frequently in the literature was *Mentha longifolia* (9 times) followed by *Ephedra gerardiana*, *Hordeum vulgare* (6 times each) and *Artemisia absinthium*, *Thymus linearis* (5 times each) (Table 4). New use reports were mentioned in the case of *Artemisia absinthium* for wounds; *Cirsium arvense* for alopecia and hair tonic; *Hordeum vulgare* for retention of the placenta; *Prunus armeniaca* for abdominal bloating and agalactorrhea; *Rumex patientia* for retention of placenta and agalactorrhea*; Podophyllum hexandrum* for intestinal worms and *Thymus linearis* for wounds (Table 2).

Table 4. Ethnoveterinary uses of the plants of the present study cited in previous studies conducted in the North-Western Himalayas and neighboring countries viz. Nepal, Pakistan, and China.

Botanical Name / Family	**Total citation**	**Earlier ethnoveterinary studies cited the plant's use for any medicinal use in livestock**	**References**	**Study areas**
Artemisia absinthium L.	5	Abdominal worms	Ahmad *et al.* (2017), Sultan *et al.* (2022)	Kashmir Himalaya- India, Bandipora- Jammu & Kashmir- India
		Anthelminthic	Aziz *et al.* (2018a), Aziz *et al.* (2018b)	South Waziristan (FATA)-Pakistan, Bajaur Agency-Pakistan
		Refrigerant	Ali *et al.* (2019)	Khurram-Pakistan
		Abdominal pain	Ali *et al.* (2019)	Khurram-Pakistan
		Indigestion	Ali *et al.* (2019)	Khurram-Pakistan
Artemisia gmelinii Weber ex Stechm.		[NR]		
Seriphidium maritimum (L.) Poljakov Syn- *Artemisia maritima* L.	2	Intestinal worms (Cows and Buffaloes)	Rehman *et al.* (2022)	Khyber Pakhtunkhwa-Pakistan
		Indigestion	Singh *et al.* (2009)	Uttarakhand Himalaya-India
Cicer microphyllum Benth.		[NR]		
Cichorium intybus L.	1	Gastric problems	Abidin *et al.* (2021)	South-West-Pakistan
		Body tonic	Abidin *et al.* (2021)	South-West-Pakistan

		Blood clotting	Abidin *et al.* (2021)	South-West-Pakistan
		Bone fracture	Abidin *et al.* (2021)	South-West-Pakistan
		Wounds	Abidin *et al.*(2021)	South-West-Pakistan
		Constipation	Abidin *et al.* (2021)	South-West-Pakistan
		Fever	Abidin *et al.* (2021)	South-West-Pakistan
		Diarrhoea	Abidin *et al.* (2021)	South-West-Pakistan
		Retention of the placenta	Abidin *et al.* (2021)	South-West-Pakistan
		Anaplasmosis	Abidin *et al.* (2021)	South-West-Pakistan
		Conjunctivitis	Abidin *et al.* (2021)	South-West-Pakistan
		Foot and mouth ulcers	Abidin *et al.* (2021)	South-West-Pakistan
		Mastitis	Abidin *et al.* (2021)	South-West-Pakistan
		Trypanosomiasis	Abidin *et al.* (2021)	South-West-Pakistan
		Pneumonia	Abidin *et al.* (2021)	South-West-Pakistan
		Helminthiasis	Abidin *et al.* (2021)	South-West-Pakistan
Cirsium arvense (L.) Scop.	3	Pneumonia	Sharma & Manhas (2015)	Kathua-Jammu- India
		Appetizer	Sharma *et al.* (2012)	Kathua-Jammu- India
		Food poisoning	Sharma *et al.* (2012)	Kathua-Jammu- India
		Blood in urine/stool	Sharma *et al.* (2012)	Kathua-Jammu- India
		Digestion	Prakash *et al.* (2021)	Shimla-Himachal Pradesh-India
Corydalis govaniana Wall.		[NR]		
Delphinium cashmerianum Royle		[NR]		
Ephedra gerardiana Wall. ex Stapf	6	Cough	Gyawali & Paudel (2017), Radha *et al.* (2020)	Jumla-Nepal, Kinnaur- Himachal Pradesh-India
		Cold	Radha *et al.* (2020)	Kinnaur- Himachal Pradesh-India
		Dermatological disorders	Ahmad *et al.* (2015)	Thakht-e-Sulaiman hills-West Pakistan
		Digestive problem	Ali *et al.* (2019)	Khurram-Pakistan

		Pain	Singh *et al.* (2009)	Uttarakhand Himalaya-India
		Wound healing	Ahmad *et al.* (2015)	Thakht-e-Sulaiman hills-West Pakistan
		Poisoning	Baskota & Doj Raj (2013)	Jumla-Nepal
Gentiana gelida M. Bieb.		[NR]		
Heracleum pinnatum C.B. Clarke		[NR]		
Hordeum vulgare L.	6	Generalized weakness	Sharma *et al.* (2012)	Kathua- Jammu-India
		Blood in the stool	Sharma *et al.* (2012)	Kathua- Jammu-India
		Food and mouth disease	Sharma *et al.* (2012)	Kathua- Jammu-India
		Increase milk yield	Sharma & Manhas (2015)	Kathua- Jammu-India
		Diuretic	Kumar & Chander (2018)	Shivalik- Himachal Pradesh-India
		Diabetes	Kumar & Chander (2018)	Shivalik- Himachal Pradesh-India
		Digestive complaints	Xiong & Long (2020)	Southwest Guizhou-China
		Cough	Mussarat *et al.* (2014)	Dera Islam Khan-Pakistan
		Weakness	Khan *et al.* (2015)	Khyber Pakhtunkhwa-Pakistan
Iris lactea Pall.		[N.R.		
Medicago falcata L.		[N.R.]		
Medicago sativa L.		[N.R.]		
Melilotus officinalis (L.) Pall		[N.R.]		
Mentha longifolia (L.) L.	10	Diarrhea	Aziz *et al.* (2018a), Murad *et al.* (2014)	South Waziristan (FATA)-Pakistan Malakand Valley, District Dir (Lower), Khyber Pakhtunkhwa, Pakistan
		Low body temperature	Murad *et al.* (2014)	Malakand Valley, District Dir (Lower), Khyber Pakhtunkhwa, Pakistan
		Anti-cholera	Ahmed & Murtaza (2015)	Bheri, District Muzaffarabad,Pakistan
		Anti-dyspepsia	Ahmed & Murtaza (2015)	Bheri, District Muzaffarabad,Pakistan
		Anti-emetic	Ahmed & Murtaza (2015)	Bheri, District Muzaffarabad,Pakistan

		Bloating	Suroowan *et al.* (2017)	South Asia
		Refrigerant	Ali *et al.* (2019)	Kurram district, Pakistan
		Digestive problems	Ali *et al.* (2019)	Kurram district, Pakistan
		Improve digestion	Rehman *et al.* (2022)	North Waziristan, Khyber Pakhtunkhwa, Pakistan
		Anti-lice	Rehman *et al.* (2022)	North Waziristan, Khyber Pakhtunkhwa, Pakistan
		Retention of the placenta	Aziz *et al.* (2018a)	South Waziristan (FATA)-Pakistan
		Postpartum health tonic	Aziz *et al.* (2018a)	South Waziristan (FATA)-Pakistan
		Throat infection "Aphara"	Shoaib *et al.* (2021)	Kaghan Valley, Western Himalayas-Pakistan.
		Abdominal pain	Ahmad *et al.* (2015)	Thakht-e-Sulaiman hills, west Pakistan
		Off-feeding	Khan *et al.* (2015)	Deosai Plateau, Pakistan
		Pyrexia	Dutta *et al.* (2021)	Poonch, Jammu & Kashmir, India
Physochlaina praealta (Decne.) Miers		[N.R.]		
Podophyllum hexandrum Royle Berberidaceae	2	Snakebite	Khan & Kumar (2012)	Poonch- Jammu & Kashmir-India
		Gynaecopathia	Shang *et al.* (2012)	Sichuan province, China
		Inflammation	Shang *et al.* (2012)	Sichuan province, China
Prangos pabularia Lindl.		[N.R.]		
Prunus armeniaca L.	4	Constipation	Rehman *et al.* (2022)	North Waziristan, Khyber Pakhtunkhwa, Pakistan
		Abdominal pain	Aziz *et al.* (2018b)	Bajaur Agency-Pakistan
		Flatulence	Aziz *et al.* (2018b)	Bajaur Agency-Pakistan
		Appetizer	Aziz *et al.* (2018b)	Bajaur Agency-Pakistan
		Intestinal worms	Dutta *et al.* (2021), Dutta *et al.* (2022)	Poonch, Jammu & Kashmir-India, Jammu & Kashmir-India
Rumex patientia L.	2	Liver fluke disease	Ahmad *et al.* (2017)	Kashmir Himalaya
		Liver fluke	Khuroo *et al.* (2007)	Kashmir Himalaya

Eriophyton tibeticum (Vatke) Ryding Syn- *Stachys tibetica*Vatke		[N.R.]		
Thymus linearis Benth.	5	Indigestion	Khan *et al.* (2021)	Neelum Valley, Kashmir Himalaya, Pakistan
		Haemoglobinuria	Khan *et al.* (2021)	Neelum Valley, Kashmir Himalaya, Pakistan
		Snakebite	Khan & Kumar (2012)	Poonch- Jammu & Kashmir-India
		Flu "Malla"	Shoaib *et al.* (2021)	Kaghan Valley, Western Himalayas-Pakistan
		Digestive problem	Ali *et al.* (2019)	Kurram district, Pakistan
		Stomach infection	Prakash *et al.* (2021)	Shimla district, Himachal Pradesh, india
		Fever	Prakash *et al.* (2021)	Shimla district, Himachal Pradesh, india
Trigonella emodi Benth.		[N.R.]		

*[N.R.]-Not reported

Conclusion

Livestock plays a vital role in the fragile ecosystem of Ladakh and represents an important sector of the agriculture economy. It ensures the nutritional and employment security of the region's indigenous inhabitants, mainly residing in remote and hilly areas. The present study documented 25 plant species used in ethnoveterinary practices to treat various livestock diseases by inhabitants of indigenous communities of Ladakh. This study captivates researchers' interest in further research into these plants' chemical composition, mode of action, safety, efficacy, conservation, and sustainable use of plant resources. The high ICF values for most disease categories were on the higher side, reflecting an ample exchange of traditional knowledge among the informants and the current practice of these medicinal plants by the local people in the study area. However, overexploitation and limited availability of pasture lands are a matter of grave concern and may result in the disturbance of natural habitats and the extinction of these critical species. Therefore, local people should educate constructively to understand the importance of their indigenous plant and enlighten on advanced preservation techniques. Furthermore, the Government should establish small-scale industries to utilize and employ the local inhabitants to produce cost-effective medicines based on the regional traditional health care system.

Declarations

Ethics approval and consent to participate: Ethics approval was not required by the Institute of the principal author. Prior verbal informed consent was taken from all the participants before collecting the information from them.

Consent for publication: All authors read the final manuscript and approved it for publication.

Availability of data and materials: All data related to the manuscript is present within the paper.

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Author's Contribution: SG and ZB conceptualize the study. ZB conducted the field study, collected the information. ZB and KS wrote the manuscript. KS and SG revised and edited the manuscript. SG gave logistic and administrative support.

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