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Ethnobotanical study of wild forage plants in the semi-arid region of Bordj Bou Arreridj, Algeria

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While ethnobotanical studies often focus on a broad range of plant uses, this study in a pastoral region specifically examined local knowledge concerning forage plants, providing valuable insights for sustainable livestock feeding practices. This pioneering study, conducted in Algeria's semi-arid region, documents local knowledge of wild forage plants utilized by pastoralists. The survey was conducted using a snowball sampling method. Data was collected between February and July 2022. 84 participants, including male and female shepherds, farmers, veterinarians, and forest rangers aged 25 to 85, were involved in the study. The data collection process included semi-structured interviews, discussions, guided field visits, and participatory observation. The data obtained were analyzed using a relative frequency citation (RFC) index, presented in percentages and graphs using Microsoft Excel. 133 forage interest plants were recorded belonging to 90 genera and 43 families, 92 of which were reported to be medicinal. Asteraceae (with 27 plant species), Poaceae (17), Fabaceae (11) and Apiaceae (8) were the most frequently cited families. The parts most consumed by livestock were the aerial parts (96 plant species), followed by the leaves and tender branches (21), the whole plant (9), and the leaves (7). Herbaceous species represent 76% of the total species, followed by shrubs (14%) and trees (10%). Grazing and mowing were the most common harvesting techniques. The most frequently cited species were *Artemisia herba-alba*, *sinapis arvensis*, *Stipa tenacissima*, *Zizyhus lotus* and *Atriplex canescens*.

Keywords: Ethnobotany, pastoral communities, semi-arid region, wild forage

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INTRODUCTION

The livestock sector is undergoing significant growth, solidifying its crucial role in global food security. Livestock husbandry significantly impacts people's livelihoods, influencing global dietary trends and health outcomes, particularly in developing countries. It contributes to over a third of the agricultural production value (Upton, 2004). In Algeria, most of the land is classified as pastoral and falls predominantly under semi-arid and arid climates (Senoussi et al., 2021). Livestock production plays a crucial role in the region's socio-economic development (Bengouga et al., 2019). Almost every farming family has livestock, and smallholder farmers rely on their observations and experience in feeding and managing their livestock (Geng et al., 2020).

Forages, encompassing both cultivated crops and wild vegetation, constitute an essential pillar of successful animal production systems, especially for ruminants that primarily derive their nutrition, health, and productivity from this source (Katoch, 2022). In addition to their economic benefits as a source of nutrients, wild forages play a significant role in environmental sustainability through soil conservation (Jinger et al., 2023). They also minimize competition for land needed for human crop production in developing countries by reducing dependence on cultivated feed sources (Villalba et al., 2021). Furthermore, due to their affordability, effectiveness, and ease of access, they serve as a source of herbal medicines for humans and animals (Rydén et al., 2005 and Miara et al., 2019).

Bordj Bou Arreridj in northern Algeria exhibits a mosaic of ecological zones, encompassing the high plateaus, mountainous regions, and the steppe zone. This significant topographic variation, along with a semi-arid continental climate, features harsh winters and hot dry summers, supporting a diverse range of plant species that have adapted to these different environmental conditions (Douguedroit, 1997). Given their multifunctional role as a source of forage and medicinal plants and their remarkable adaptability to the environmental conditions of the semi-arid region. Their resilience and versatility contribute significantly to the survival, sustenance and prosperity of these communities, highlighting their ecological importance in these challenging environments (Souahi et al., 2022). As such, these plant species are integral to the socio-economic fabric of the semi-arid region, emphasizing the need for their conservation and sustainable use. However, the traditional knowledge associated with these plants, accumulated over generations and deeply rooted in the practices of indigenous communities, risks being gradually eroded. This system of knowledge, mainly transmitted orally and through practical experience within

communities, is increasingly challenged by ongoing socio-economic development and the decline of intergenerational transmission among younger generations. It is, therefore, of great importance to systematically survey, document, and analyze the diversity of forage plants and the associated traditional knowledge in the region. These efforts aim not only to protect and perpetuate ethnic cultural heritage but also to promote sustainable livestock development and ultimately improve the well-being of local people.

The growing imperative for sustainable livelihoods has driven scientific research into strategies that reconcile agricultural production with ecological preservation (Garibaldi et al., 2017). While ethnobotanical studies investigating fodder plants for ruminants have been conducted in various countries, including, Austria (Vogl et al., 2016), Ethiopia (Bahru et al., 2014), Brazil (Nunes et al., 2015) and Pakistan (Shaheen et al., 2020), such studies remain limited in Algeria, particularly within the semi-arid region.

There is a lack of systematic, thorough, and comparative studies investigating these resources and their traditional uses. This study aims to fill this gap by (1) exploring and documenting traditional knowledge about forage plants in Bordj Bou Arreridj, (2) identifying the forage species most cited in livestock feeding, (3) identifying the overlap between forage and medicinal capacities of these wild plants, and (4) offering appropriate recommendations for biodiversity protection and the sustainable use of forage species.

MATERIALS AND METHODS

Study area

The research took place in Bordj Bou Arreridj, located in the northeast of Algeria at 36.0698° N, 4.7661° E (Figure 1). The site covers an area of 3,920.42 km^2 and has a diverse topography, featuring a range of elevations from 302 to 1,885 m. The area encompasses three main zones: the mountainous Bibans range in the north, the high plateau area in the

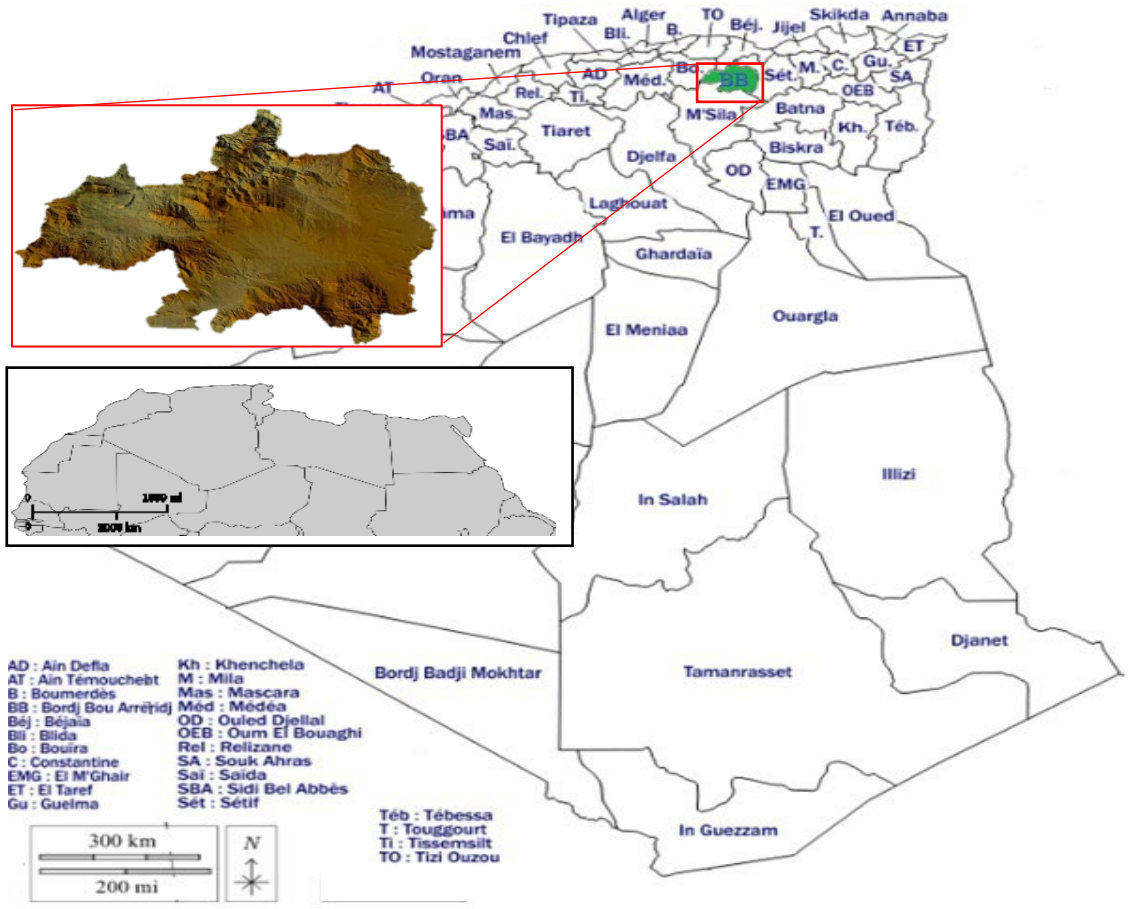

Figure 1. Location map of the study area, Bordj Bou Arreridj, Algeria.

Central region, and the southwestern section, which gradually gives way to a steppe zone. The region has a semi-arid bioclimate influenced by the topography, with July being the hottest month (average maximum temperature of 35°C) and January the coldest (average minimum temperature of 1°C). Rainfall in the area is uneven throughout the year with an average of 321.9 mm. April is generally the wettest month with an average rainfall of 50.6 mm, while July receives the least rainfall with an average of only 5.5 mm. Agriculture and livestock are the main economic activities in Bordj Bou Arreridj, with a total of 246,154 hectares dedicated to cereal production. Livestock statistics indicate a total of 356422 livestock, mainly made up of 21744 cattle, 272945 sheep, and 61773 goats (Agricultural Service Directorate of Bordj Bou Arreridj 2023).

Data collection

The selection of study sites was made in February 2022, where thirteen (13) communes were identified as data collection sites. The survey was conducted between February and July 2022, using a snowball sampling technique to collect information (Naderifar et al., 2017). 84 informants, including male and female shepherds, farmers, veterinarians, and forest rangers, participated in the study. The participants ranged in age from 25 to 85. The data collection involved semi-structured interviews, discussions, guided field walks, and participatory observation. All interviews were conducted in the Algerian Arabic dialect (DARIJA). The survey was designed to obtain basic information on local forage plants, including their names, life forms, medicinal or non-medicinal use, availability season, edible parts of the plant, animal consumers, palatability, and foraging methods. During the guided fieldwork, plant samples were collected, identified, and preserved as voucher specimens at the research laboratory of medicinal and aromatic plants of the University of Blida 1, Algeria.

Methodology for data evaluation

A detailed account of the plant species used as forage is maintained by each participant and compiled in a spreadsheet using the Microsoft Excel software, including local and scientific nomenclature, family name, palatability, parts consumed, life form, and foraging method. The ranking order of the listed forage plant species was established by applying the Relative Frequency of Citation (RFC) index, as proposed by Sujarwo & Caneva (2016) and Harun et al. (2017). The RFC formula used in this context is as follows:

$$RFC = FC/N$$

Where FC: is the number of participants who have referred to the species as fodder and N: is the total number of participants involved in the study ($0 < RFC < 1$).

RESULTS

Livestock distribution and knowledge holders' profile

In the high plateau areas, breeders bring their livestock to stalls, where they mow natural fodder mixed with corn grains and wheat bran or even freshly chopped cultivated fodder or hay, supplemented by seasonal grazing. In contrast, in the steppe areas, the primary mode of livestock feeding involved grazing on indigenous wild plants, many of which were considered medicinal, such as *Artemisia herba-alba* (White Wormwood or Chih in Arabic), *Stipa tenacissima* (Esparto Grass or Halfa), and *Atriplex canescens* (Four-winged Saltbush or Gtaf), was the main form of livestock feeding.

The ethnobotanical survey was carried out with 84 residents of Bordj Bou Arreridj. They consisted of 71 men and 13 women, aged between 25 and 85 years old. The age distribution was as follows 5 (25-35), 18 (36-45), 29 (46-55), 22 (56-65), and 10 (66-85). The participants' professions included 45 shepherds, 12 veterinarians, 9 forest rangers, and 18 farmers (Figure 2) The knowledge and experience of the respondents varied significantly. Notably, the interviewees of an older age group and with minimal formal education had unique insights, while male participants had a wider knowledge of forage species as compared to females, who showed a particular inclination towards medicinal forage plant species. In addition, the research identified three primary livestock categories in the study region: sheep, goats, and cattle, with sheep farming emerging as the dominant type, followed by goats and cattle, respectively. Furthermore, the spatial distribution of these livestock varied across the region. Cattle were mainly found in the high plateau areas of Ras El Oued in the east and Medjana in the central part of Bordj Bou Arreridj. Goats, on the other hand, were more commonly associated with the steppe areas of El Ach and Rabta in the southern part, while sheep showed adaptability to both environments with a preference for the southern steppe areas of El Hamadia and El Ach.

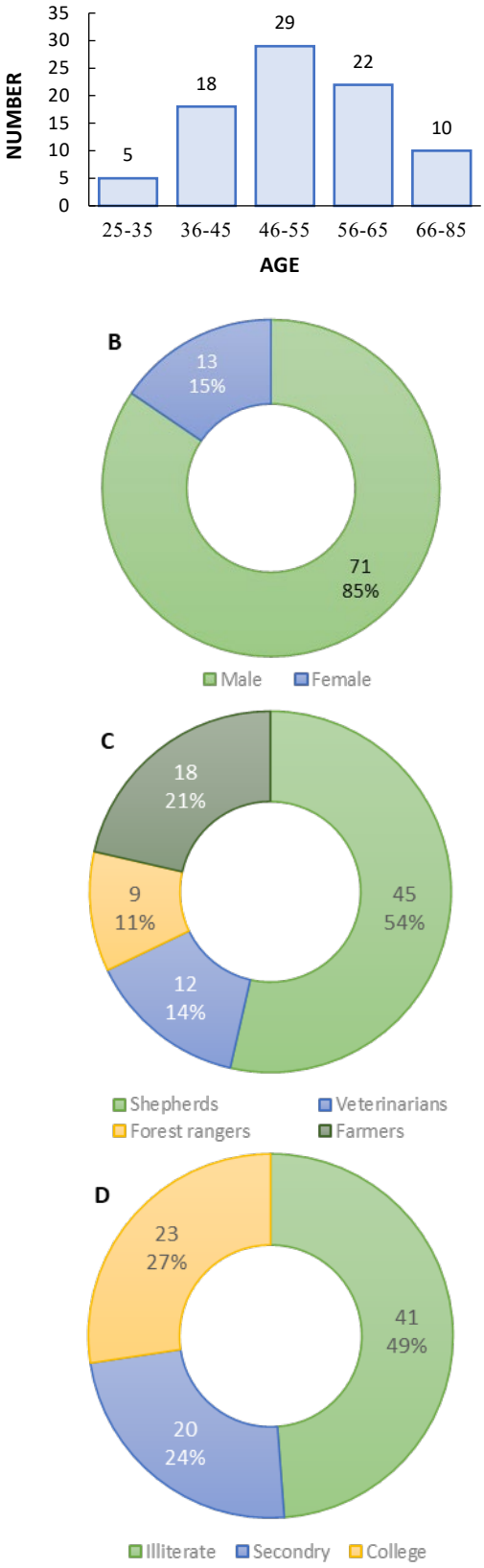

Figure 2. Informants' profiles (A) the age, (B) gender, (C) profession and (D) educational level.

Diversity, life forms, parts consumed, and medicinal properties of forage plants

A total of 133 plant species were documented for their use in livestock feeding. Out of these, 92 species were found to have medicinal properties (Table 1). These species were classified into 90 genera and 43 families, with Asteraceae (27), Poaceae (17), Fabaceae (11) and Apiaceae (8) being the most frequently cited families (Figure 3). These four families contained 47% of the total plant species, while 25 families (19%) were represented by a single species each. The remaining families contributed between 2 and 5 species each, a total of 34%. The study also indicated that the most consumed parts of the forage plants by the livestock were the aerial parts (96), followed by the leaves and tender branches (21), the whole plant (9), and the leaves (7) (Figure 4). The distribution of forage plants in terms of plants' life type (Figure 5) revealed that herbs accounted for 76% of the total species, followed by shrubs (14%) and trees (10%).

Accessibility and palatability

In Bordj Bou Arreridj, the livestock consume the nutritious and tender part of the forage plants, with the consumption period depending on the plant's growth cycle. A seasonal analysis of forage availability revealed that the highest number of species (42) were available in spring (Figure 6) including *Sinapis arvensis* and *Convolvulus durandoi.* In addition, 32 species were available all year round (e.g., *Artemisia herba-alba* and *Atriplex canescens*), while a smaller portion exhibited seasonal accessibility: spring to summer (19 species, e.g., *Moricandia arvensis* and *Rosa canina*), spring to autumn (18 species, e.g., *Ziziphus lotus* and *Cichorium intybus)*, summer only (13 species, e.g., *Chenopodium album*), and summer to autumn (9 species, e.g., *Tribulus terrestris*). In terms of palatability, the majority of forage plants used were classified as highly palatable or moderately palatable (61 and 47 respectively) with species like *Cynodon dactylon*, *Avena fatua* and *Sonchus oleraceus*, with only a small number classified as less palatable (25) like *Sinapis pubescens.*

Forage plant ranking based on RFC

In the present study, a total of 133 were analyzed and ranked using the relative frequency of citation (RFC) score. The values of the RFC ranged from 0.01 to 0.57, with 44 species exceeding the average RFC of 0.06, while 89 species have RFC values below this average.

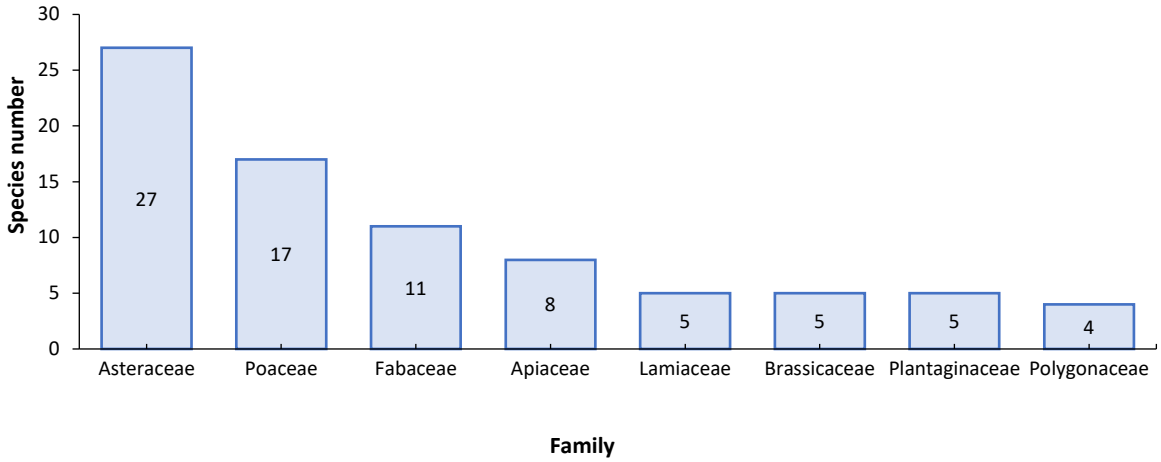

Figure 3. Most cited families of wild forage plants in Bordj Bou Arreridj.

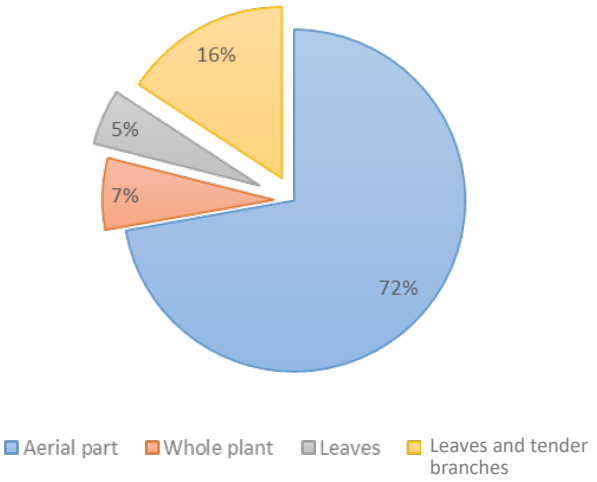

Figure 4. Parts consumed of recorded wild forage plants in Bordj Bou Arreridj.

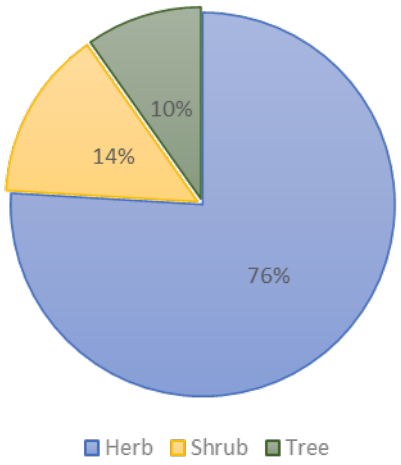

Figure 5. Life forms of wild forage plants in Bordj Bou Arreridj.

The most cited species were *Artemisia herba-alba* (RFC: 0.57), *Sinapis arvensis* (0.4), *Stipa tenacissima* (0.29), *Zizyhus lotus* (0.27), *Atriplex canescens* (0.21), and *Juniperus phoenicea* (0.21). In addition, seven other plant species have RFC values above 0.14, such as *Opuntia ficus-indica*, *Quercus ilex*, *Medicago sativa*, and *Anthemis nobilis* (0.19 each), while *Papaver rhoeas*, *Trifolium repens*, and *Sinapis pubescens* each have RFC value of 0.17 each. The least cited species were *Xanthium strumarium*, *Centaurea pullata*, *Acacia saligna, Dittrichia viscosa*, and *Matthiola lunata*, each with an RFC value of 0.01.

DISCUSSION

The region of Bordj Bou Arreridj has a diverse topography, which contributes to an abundance of diverse wild forage plant resources. This has made the region an agroecological zone, where local people have developed extensive traditional knowledge on the use of these species (Miara et al., 2019). These wild plants serve not only to provide valuable forage resources for livestock, potentially comparable to or even exceeding the quality of some cultivated forage resources (Zirmi-Zembri & Kadi, 2016; Kadi & Zirmi-Zembri, 2016) but also play a crucial role in their health. However, a recent investigation has shown that most of this knowledge is held by older smallholder farmers, who rely on wild fodder plants to feed their animals. In recent decades, the traditional system of livestock production has been widely replaced by modern livestock management practices among younger generations. These modern systems use exotic fodder species that require large amounts of irrigation water, making the practice unsustainable. Unfortunately, with this transition in livestock activities, information on the use and

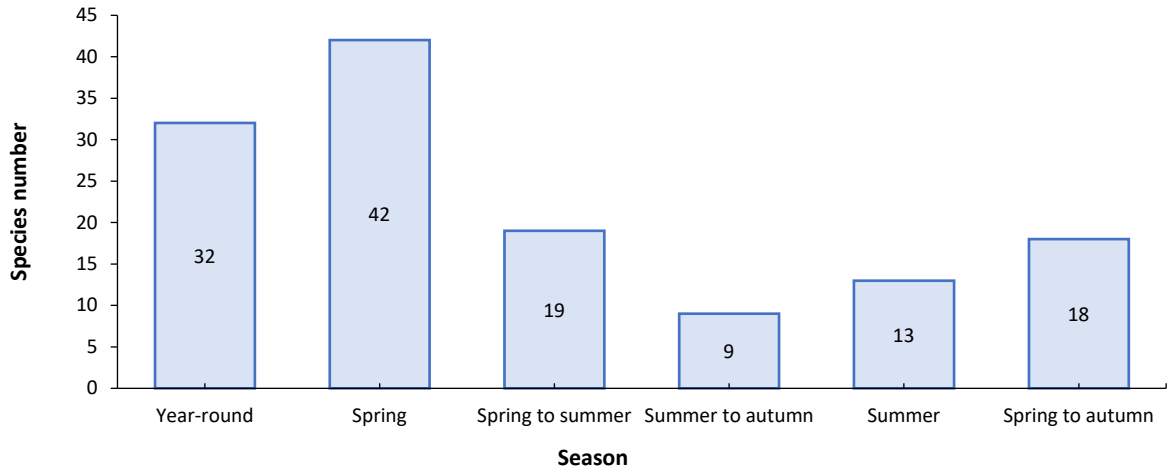

Figure 6. Seasonality of wild forage species in Bordj Bou Arreridj.

handling of these wild fodder plants has become obsolete, leading to the gradual disappearance of traditional knowledge of forage species. As a result, the number of smallholder livestock producers is declining, further putting traditional knowledge of the use of wild fodder species at risk.

Influence of forage diversity on herbivore diet selection

A total of 133 wild forage plant resources were recorded in this study, with Asteraceae, Poaceae, and Fabaceae being the most encountered families. This finding is consistent with previous research conducted by Neffar et al. (2016) and Merdas et al. (2017), who also reported similar family dominance in semi-arid halophytic pastures and Algerian arid steppe rangelands, respectively. Notably, The Asteraceae family was the most species-rich, confirming reports of its prevalence across the Mediterranean region by Carpino et al. (2003), Jeanmonod et al. (2011), and Neffar et al. (2018). Closely following were the Poaceae and Fabaceae families, both well-known for containing valuable forage plants. Most identified plants were herbaceous therophytes (annuals), which depend on rainfall for their life cycle. This finding aligns with the report by Merdas et al. (2017), who observed therophytes as the dominant life form in the Algerian arid steppes. These characteristics suggest that these therophytes are likely well adapted to the challenging environmental conditions of the region.

The selection of plant life forms for forage varies considerably across herbivore groups within a particular region. Herbivores show discernible preferences, and free-grazing animals tend to select the best plants while avoiding toxic or less nutritious ones (Soder et al., 2009). Cattle primarily target grasses, such as *Trifolium repens*, with occasional reports of consumption of tree leaves such as *Olea europaea.* Goats show a preference for browsing on woody plants, such as *Atriplex canescens* and *Anabasis articulata*, while sheep occupy an intermediate position, consuming a mixture of grasses and other plant materials, including shrubs and trees. Caprine herbivores demonstrate an exceptional ability to consume all the plant species cited within the Bordj Bou Arreridj ecosystem. However, palatability assessments reveal a strong preference for 100% of the reported plant species. Notably, 93% of these species are preferred fodder for sheep and 42% for cattle. Differences in palatability were observed across various plant parts. Specifically, only 7% of forage species were consumed as whole plants, such as *Cynodon dactylon*, and *Lolium multiflorum.* In contrast, 72% of the plants were consumed for their aerial parts, while 16% were selectively consumed as leaves and tender branches. The preference for consuming these species as whole plants can be attributed to their small size and tender herbaceous texture. These findings align with similar results reported in the existing literature (Geng et al., 2017).

Seasonality and palatability of forage plants

Understanding the seasonality and proportion of use of forage species is crucial for their effective use as a feed resource for herbivores (Yang et al., 2021). Therophytes showed seasonality in their availability, with peak use occurring during the rainy spring season.

Table 1. List of the wild forage plants in the semi-arid region of Bordj Bou Arreridj, Algeria

Family	Arabic name	Scientific name	Voucher	Type	Class	Season	Palatability	Foraging method	Uses in medicine	RFC
Amaranthaceae	Hamrani	*Amaranthus blitoides* S. Watson	RA-40	H	Ther	Summer to autumn	***	Mow/ Graze	Non	0.01
	-	*Amaranthus retroflexus* L.	RA-115	H	Ther	Summer	***	Mow/ Graze	Med	0.01
	Gtaf	*Atriplex canescens* (Pursh) Nutt	RA-116	S	Cha	Year-round	***	Grazing	Med	0.21
Anacardiaceae	Darw	*Pistacia entiscus* L.	RA-21	T	Phan	Year-round	**	Grazing	Med	0.09
Apiaceae	Talghouda	*Bunium fontanesii* Pomel	RA-09	H	Cryp	Spring to autumn	**	Grazing	Med	0.10
	Zrodiya lberiya	*Daucus carota* L.	RA-14	H	Ther	Spring	**	Mow/ Graze	Med	0.01
	Makhleb doriss	*Eryngium campestre* L.	RA-71	H	Hemi	Spring	*	Grazing	Med	0.01
	Basbas lberi	*Foeniculum vulgare* Mill.	RA-95	H	Ther	Spring	**	Mow/ Graze	Med	0.01
	Zayata	*Helosciadium nodiflorum* (L.) W.D.J. Koch	RA-97	H	Ther	Spring to autumn	***	Mow/ Graze	Med	0.03
	Timachta	*Scandix pecten-veneris* L.	RA-103	H	Hemi	Spring	***	Mow/ Graze	Non	0.10
	Bounafa'	*Thapsia garganica* L.	RA-109	H	Hemi	Spring	*	Grazing	Med	0.03
	Tabelawt	*Turgenia latifolia* (L.) Hoffm.	RA-112	H	Ther	Spring	*	Grazing	Non	0.01
Asparagaceae	Zitot	*Muscari comosum* (L.) Mill.	RA-110	H	Cryp	Spring	**	Grazing	Non	0.04
Asphodelaceae	Barwag	*Asphodelus microcarpus* Rchb.	RA-08	H	Hemi	Summer	*	Grazing	Med	0.04
Asteraceae	Boumlel	*Anthemis nobilis* L.	RA-01	H	Ther	Summer to autumn	***	Mow/ Graze	Med	0.19
	Achbet meryem	*Artemisia absinthium* L.	RA-11	H	Cha	Summer to autumn	*	Grazing	Med	0.01
	Chi'h	*Artemisia herba-alba* Asso	RA-13	S	Cha	Year-round	***	Grazing	Med	0.57
	-	*Atractylis cancellata* L.	RA-18	H	Ther	Spring to summer	*	Grazing	Med	0.03
	Ladad	*Atractylis gummifera* L.	RA-19	H	Cha	Summer	*	Grazing	Med	0.06
	-	*Bombycilaena erecta* (L.) Smoljan.	RA-20	H	Ther	Summer	**	Grazing	Non	0.01
	Eljamra	*Calendula arvensis* L.	RA-27	H	Ther	Spring	**	Grazing	Med	0.01
	Chdak ljmal	*Carduus pycnocephalus* L.	RA-29	H	Hemi	Summer to autumn	*	Grazing	Med	0.03
	Grayn jdi	*Carthamus tinctorius* L.	RA-34	H	Ther	Spring	**	Grazing	Med	0.09
	Giz	*Catananche caerulea* L.	RA-35	H	Hemi	Spring	***	Grazing	Med	0.01
	-	*Centaurea pullata* L.	RA-38	H	Ther	Spring	**	Grazing	Med	0.01
	Hendeeba	*Cichorium intybus* L.	RA-45	H	Hemi	Spring to autumn	***	Mow/ Graze	Med	0.01
	-	*Cirsium arvense* (L.) Scop.	RA-46	H	Ther	Summer	*	Grazing	Non	0.03
	Ja'da	*Cotula cinerea* Delile	RA-52	H	Ther	Spring	**	Grazing	Med	0.13
	Khorchef lberi	*Cynara cardunculus* L.	RA-58	H	Hemi	Summer	**	Grazing	Med	0.01
	Magraman	*Dittrichia viscosa* (L.) Greuter	RA-63	H	Hemi	Year-round	*	Grazing	Med	0.01
	Chouk lejmal	*Echinops spinosissimus* Turra	RA-66	H	Hemi	Spring to summer	*	Grazing	Med	0.06
	-	*Hertia cheirifolia* Kuntze	RA-30	H	Hemi	Spring to autumn	**	Grazing	Med	0.01
	-	*Launaea nudicaulis* (L.) Hook.f.	RA-70	H	Ther	Spring	**	Grazing	Med	0.03
	Feryas	*Onopordum macracanthum* Schousb.	RA-98	H	Ther	Spring to summer	*	Mow/ Graze	Non	0.10
	Gernina	*Scolymus hispanicus* L.	RA-102	H	Ther	Spring	**	Mow/ Graze	Med	0.13
	Talma	*Scorzonera laciniata* L.	RA-117	H	Cha	Spring	***	Mow/ Graze	Med	0.07
	Boul dib	*Senecio vulgaris* L.	RA-118	H	Ther	Spring	***	Mow/ Graze	Med	0.01
	Khanfoufa	*Silybum marianum* (L.) Gaertn.	RA-120	H	Ther	Spring	**	Mow/ Graze	Med	0.11
	Tifef	*Sonchus oleraceus* L.	RA-121	H	Ther	Spring to summer	**	Mow/ Graze	Med	0.11
	Darset la'jouz	*Taraxacum officinale* F.H. Wigg.	RA-122	H	Hemi	Spring	***	Grazing	Med	0.06
	Haska	*Xanthium strumarium* L.	RA-128	H	Ther	Spring to summer	*	Grazing	Med	0.01
Boraginaceae	Lsan thour	*Borrago officinalis* L.	RA-37	H	Ther	Summer to autumn	*	Grazing	Med	0.04
	-	*Echium creticum* L.	RA-69	H	Ther	Spring	**	Grazing	Med	0.01
	Gozayeh	*Pituranthos chloranthus (Coss. & Durieu) Schinz*	RA-124	H	Cha	Spring to summer	**	Grazing	Non	0.03
Brassicaceae	Hara lbayda	*Capsella bursa-pastoris* Medik.	RA-42	H	Ther	Spring	**	Mow/ Graze	Non	0.03
	Rjel ljaja	*Matthiola lunata* DC.	RA-43	H	Hemi	Spring	**	Grazing	Non	0.01
	Kromb	*Moricandia arvensis* L.	RA-65	H	Ther	Spring to summer	**	Mow/ Graze	Non	0.09
	Hara	*Sinapis arvensis* L.	RA-84	H	Ther	Spring	**	Mow/ Graze	Med	0.40
	Werdal	*Sinapis pubescens* L.	RA-106	H	Hemi	Year-round	*	Mow/ Graze	Non	0.17
Cactaceae	Hendi	*Opuntia ficus-indica* (L.) Mill	RA-47	S	Phan	Year-round	***	Mow/ Graze	Med	0.19
Caprifoliaceae	-	*Scabiosa stellata* L.	RA-136	H	Ther	Spring to summer	**	Grazing	Non	0.03
Caryophyllaceae	Kasar lhjar	*Paronychia argentea* Lam.	RA-56	H	Hemi	Spring to autumn	***	Grazing	Med	0.04
	-	*Silene pratensis* Godr.	RA-137	H	Ther	Spring	**	Grazing	Non	0.01
Chenopodiaceae	Ajram	*Anabasis articulata* (Forssk.) Moq.	RA-02	S	Ther	Year-round	***	Grazing	Med	0.01
	Ramram	*Chenopodium album* L.	RA-81	H	Ther	Summer	***	Mow/ Graze	Med	0.01
Convolvulaceae	Lawaya	*Convolvulus durandoi* Pomel	RA-67	H	Cryp	Spring	***	Mow/ Graze	Med	0.03
	-	*Cuscuta americana* L.	RA-123	H	Ther	Spring	**	Grazing	Non	0.03
Cucurbitaceae	Fegouss lehmir	*Ecballium elaterium* (L.) A. Rich.	RA-28	H	Hemi	Summer	*	Grazing	Med	0.03
Cupressaceae	Sarwel	*Cupressus sempervirens* L.	RA-04	T	Phan	Year-round	**	Grazing	Med	0.01
	Taga	*Juniperus oxycedrus* L.	RA-87	T	Phan	Year-round	**	Grazing	Med	0.11
	A'rar	*Juniperus phoenicea* L.	RA-96	T	Phan	Year-round	***	Grazing	Med	0.21
Euphorbiaceae	Hlib daba	*Euphorbia helioscopia* L.	RA-48	H	Ther	Spring	*	Grazing	Med	0.01
Fabaceae	-	*Acacia saligna* (Labill.) H.L. Wendl.	RA-33	T	Phan	Year-round	*	Grazing	Med	0.01
	Kdad	*Astragalus spinosus* (Forssk.) Muschl.	RA-53	S	Cha	Year-round	**	Grazing	Med	0.13
	Gendoul	*Calicotome spinosa* (L.) Link	RA-57	S	Ther	Year-round	**	Grazing	Non	0.10
	Kharoub	*Ceratonia siliqua* L.	RA-59	T	Phan	Year-round	***	Grazing	Med	0.01
	Jelbana	*Lathyrus sylvestris* L.	RA-80	H	Ther	Spring	***	Mow/ Graze	Non	0.11
	-	*Medicago hispida Gaertn.*	RA-82	H	Ther	Spring to summer	***	Mow/ Graze	Non	0.03
	Safsfa	*Medicago sativa* L.	RA-85	H	Hemi	Spring to summer	***	Mow/ Graze	Med	0.19
	-	*Ononis reclinata* L.	RA-100	H	Ther	Spring to autumn	***	Mow/ Graze	Non	0.01
	Ratma	*Retama sphaerocarpa* (L.) Boiss.	RA-113	S	Phan	Year-round	**	Mowing	Med	0.13
	Tartag	*Spartium junceum* L.	RA-129	S	Phan	Year-round	**	Grazing	Med	0.03
	Nfel	*Trifolium repens* L.	RA-130	H	Ther	Year-round	***	Mow/ Graze	Non	0.17
Fagaceae	Balout	*Quercus ilex* L.	RA-07	T	Phan	Year-round	***	Grazing	Med	0.19
Iridaceae	Sif ghrab	*Gladiolus illyricus* Koch	RA-91	H	Ther	Spring	***	Mow/ Graze	Non	0.03
Juncaceae	Smar	*Juncus acutus* L.	RA-93	H	Cryp	Year-round	*	Grazing	Non	0.04
Lamiaceae	Chendgora	*Ajuga iva* (L.) Schreb.	RA-17	H	Cha	Spring to summer	***	Grazing	Med	0.07
	Meriweth	*Marrubium vulgare* L.	RA-31	H	Hemi	Spring	*	Grazing	Med	0.09
	Flio	*Mentha pulegium* L.	RA-36	H	Ther	Summer	***	Grazing	Med	0.01
	Khayata	*Teucrium polium* L.	RA-76	H	Cha	Summer to autumn	***	Grazing	Med	0.10
	Gomayech	*Thymus munbyanus* Boiss. & Reut.	RA-108	H	Cha	Spring to summer	**	Grazing	Med	0.14
Malvaceae	Khobiz	*Malva sylvestris* L.	RA-62	H	Ther	Spring to autumn	***	Mow/ Graze	Med	0.10
Moraceae	Karma	*Ficus carica* L.	RA-55	T	Phan	Spring to autumn	***	Mowing	Med	0.03
Myrtaceae	Kalitous	*Eucalyptus globulus* Labill.	RA-54	T	Phan	Year-round	**	Grazing	Med	0.01
Oleaceae	Zitoun	*Olea europaea* L.	RA-111	T	Phan	Year-round	***	Mowing	Med	0.09
Papaveraceae	-	*Fumaria officinalis* L.	RA-32	H	Ther	Spring	***	Mow/ Graze	Med	0.01
	Roz' ljaj	*Fumaria parviflora* Lam.	RA-125	H	Ther	Spring	***	Mow/ Graze	Med	0.03
	Gbobech	*Papaver rhoeas* L.	RA-126	H	Ther	Spring	***	Mow/ Graze	Med	0.17
Pinaceae	Sanawber	*Pinus halepensis* Mill.	RA-86	T	Phan	Year-round	**	Grazing	Med	0.03
Plantaginaceae	Taselgha	*Globularia alypum* L.	RA-61	S	Cha	Spring to autumn	*	Grazing	Med	0.11
	-	*Plantago lagopus* L.	RA-101	H	Ther	Spring	***	Grazing	Non	0.01
	-	*Plantago lanceolata* L.	RA-132	H	Hemi	Year-round	***	Grazing	Med	0.03
	Khnouft lgata	*Veronica hederifolia* L.	RA-133	H	Ther	Spring to summer	***	Mow/ Graze	Non	0.01
	-	*Veronica persica* Poir.	RA-139	H	Ther	Spring to summer	***	Mow/ Graze	Non	0.01

Poaceae	Habet lhajla	*Aegilops triuncialis* L.	RA-10	H	Ther	Spring	***	Mow/ Graze	Non	0.03
	Diss	*Ampelodesmos mauritanicus* (Poir.) T. Durand & Schinz	RA-16	H	Cryp	Year-round	**	Grazing	Non	0.14
	Gssab	*Arundo donax* L.	RA-23	H	Cryp	Year-round	***	Grazing	Med	0.03
	Khortal lberi	*Avena fatua* L.	RA-24	H	Ther	Spring	***	Mow/ Graze	Non	0.03
	-	*Bromus rubens* L.	RA-26	H	Ther	Spring	***	Mow/ Graze	Non	0.01
	Nejem	*Cynodon dactylon* (L.) Pers.	RA-39	H	Hemi	Year-round	***	Grazing	Non	0.11
	Bechna	*Eleusine indica* (L.) Gaertn.	RA-41	H	Ther	Summer to autumn	***	Mow/ Graze	Non	0.03
	Sboult lfar	*Hordeum murinum* L.	RA-64	H	Ther	Spring	***	Mow/ Graze	Non	0.11
	Dil lferouch	*Lagurus ovatus* L.	RA-72	H	Ther	Spring to autumn	***	Mow/ Graze	Non	0.01
	Medhoun	*Lolium multiflorum* Lam.	RA-79	H	Ther	Spring to summer	***	Mow/ Graze	Non	0.07
	Senegh	*Lygeum spartum* L.	RA-88	H	Cryp	Year-round	**	Grazing	Non	0.07
	Brika	*Phalaris brachystachys* Link	RA-90	H	Ther	Spring to summer	***	Mow/ Graze	Non	0.01
	-	*Poa annua* L.	RA-94	H	Hemi	Spring	***	Mow/ Graze	Non	0.01
	Dil lkelb	*Setaria verticillata* (L.) P. Beauv.	RA-114	H	Cha	Spring to summer	***	Mow/ Graze	Non	0.01
	Soma'a	*Stipa capensis* (Nees) Kuntze	RA-119	H	Ther	Spring	***	Grazing	Non	0.06
	-	*Achnatherum parviflorum* (Desf.) M.Nobis	RA-134	H	Hemi	Spring to summer	***	Mow/ Graze	Med	0.03
	Halfa	*Stipa tenacissima* L.	RA-138	H	Cryp	Year-round	**	Grazing	Med	0.29
Polygonaceae	-	*Persicaria maculosa* Gray	RA-49	H	Ther	Spring to autumn	***	Mow/ Graze	Non	0.01
	-	*Polygonum aviculare* L.	RA-50	H	Cha	Summer to autumn	***	Mow/ Graze	Med	0.01
	Homayda	*Rumex acetosella* L.	RA-131	H	Ther	Spring to autumn	***	Mow/ Graze	Med	0.09
	Homydat lbagra	*Rumex crispus* L.	RA-135	H	Hemi	Spring to autumn	***	Mow/ Graze	Med	0.01
Portulacaceae	Rejla	*Portulaca oleracea* L.	RA-83	H	Ther	Summer	***	Mow/ Graze	Med	0.06
Resedaceae	Dil lkhrouf	*Reseda alba* L.	RA-25	H	Hemi	Spring	**	Mow/ Graze	Med	0.09
Rhamnaceae	Sedra	*Ziziphus lotus* Lam.	RA-89	S	Phan	Spring to autumn	***	Grazing	Med	0.27
Rosaceae	Za'rour	*Crataegus azarolus* L.	RA-12	S	Phan	Spring to autumn	**	Grazing	Med	0.04
	Boumkari	*Crataegus sanguinea* Pall.	RA-77	S	Phan	Spring to autumn	**	Grazing	Med	0.01
	Nasrin	*Rosa canina* L.	RA-104	S	Phan	Spring to summer	**	Grazing	Med	0.01
	Tout lo'lig	*Rubus fruticosus* L.	RA-107	S	Cha	Summer	**	Grazing	Med	0.01
Rubiaceae	Losayga	*Galium aparine* L.	RA-68	H	Ther	Spring	**	Mow/ Graze	Med	0.03
Rutaceae	Fijl	*Ruta chalepensis* L.	RA-127	S	Cha	Summer	*	Grazing	Med	0.04
Salicaceae	Trambl	*Populus alba* L.	RA-105	T	Phan	Spring to autumn	**	Grazing	Med	0.01
Solanaceae	A'wsej	*Lycium europaeum* L.	RA-05	S	Phan	Year-round	**	Grazing	Med	0.03
	A'neb dhib	*Solanum nigrum* L.	RA-92	H	Ther	Summer	**	Mow/ Graze	Med	0.01
Tamaricaceae	Tarfa	*Tamarix gallica* L.	RA-99	S	Phan	Year-round	***	Grazing	Med	0.13
Thymelaeaceae	Azaz	*Daphne gnidium* L.	RA-06	S	Cha	Year-round	*	Grazing	Med	0.01
	Methnan	*Thymelaea hirsuta* Endl.	RA-74	S	Phan	Year-round	*	Grazing	Med	0.04
Ulmaceae	Nchem	*Ulmus minor* Mill.	RA-78	T	Phan	Spring to autumn	***	Grazing	Non	0.03
Urticaceae	Horayeg	*Urtica dioica* L.	RA-51	H	Hemi	Spring	*	Grazing	Med	0.10
Zygophyllaceae	Bounagar	*Tribulus terrestris* L.	RA-44	H	Ther	Summer to autumn	***	Mow/ Graze	Med	0.01

H= Herb; T=Tree; S= Shrub; Ther= Thermophte; Hemi= Hemicriptophyte; Cryp= Cryptophyte; Cha=Chamaephyte; Pher= Phanerophyte; * = Weakly palatable; ** = Fairly palatable; *** = Highly palatable; Med=Medicinal; Non= Not medicinal.

Perennial woody plants, in contrast to herbaceous species, show a more continuous availability throughout the year. This characteristic is particularly relevant during the dry season when herbaceous plants are less available. Consequently, perennial woody plants may become the primary forage source for herbivores during these periods (Lo et al., 2022).

According to local people, some low-palatability plants, namely *Sinapis pubescens*, are known to cause undesirable flavors in animal milk when consumed. As a result, farmers have taken to drying these plants before feeding them to their livestock. Additionally, farmers have found that certain spiny plants, such as *Astragalus spinosus*, can be made more palatable by cooking them to remove their spines. Other plants, such as *Silybum marianum*, have a low palatability when raw, so they are dried before feeding to improve their taste. It has been reported that the palatability of some forage species can decrease after flowering, resulting in reduced consumption by herbivores. These plants are therefore collected before they start to flower. Moreover, some less palatable species, such as *Thymelaea hirsuta*, have been identified by ecologists and forest rangers as indicators of overgrazing, and are therefore used for monitoring purposes.

Potential for livestock intoxication by wild plants

Veterinary professionals operating within the region have expressed their apprehension regarding the likelihood of livestock being adversely affected by the consumption of certain wild plants. This risk is particularly high for animals that are newly introduced to the area or are experiencing their first grazing season after being kept indoors. Although indigenous livestock are not completely immune, they appear to be less likely to be affected (Parton & Bruere, 2002). This could be attributed to their established foraging patterns and their awareness of the potential toxicity of certain plants. It is worth noting that the risk of intoxication tends to increase during periods of drought-induced pasture scarcity and overgrazing events (Desta, 2019; Mossie & Yirdaw, 2023). Further research is necessary to identify the specific plant species responsible for these concerns, which may include *Thapsia garganica*.

A sustainable approach to livestock health management through medicinal forage plants

A significant overlap was observed between plants identified as forage and their report to be medicinal. Specifically, 69.2% (92 out of 133) of the documented forages were also reported as having medicinal value.

Furthermore, species ranked within the topmost consumed forages based on the RFC ranking were also reported medicinal: *Artemisia herba-alba, Opuntia ficus-indica* and *Atriplex canescens*. This strong alignment resonates with recent research on the multifunctional role of wild plants (Ali et al., 2021; Abbas et al., 2022 and Martins et al., 2023), suggesting a potential link between forage value and inherent medicinal benefits. Integrating such medicinal forages into grazing systems leverages the natural medicinal properties of these plants. This approach has the potential to reduce reliance on synthetic veterinary drugs, potentially mitigating the risk of drug resistance in livestock populations (French, 2018). Furthermore, the incorporation of medicinal forages may offer additional environmental benefits, such as reducing methane emissions (Villalba et al., 2019).

CONCLUSIONS

This study provides a comprehensive account of 133 indigenous wild forage species in the semi-arid region of Bordj Bou Arreridj. The findings include details of the consumed plants. These wild species play a crucial role in ensuring the long-term sustainability of small-scale farming practices. However, various challenges, such as ongoing socio-economic development and the reluctance of younger generations to preserve traditional knowledge pose significant threats to these valuable resources. Therefore, the preservation and dissemination of local knowledge on wild forage plants becomes crucial for the resilience of these communities. This study contributes to the preservation of ethnobotanical knowledge. Future research can delve into detailed phytochemical and nutritional characterization to improve our comprehension of these plants and their applications in sustainable agriculture, including specific forage crops, intercropping strategies, and reforestation initiatives in the Green Dam region.

REFERENCES

Abbas, E. Y., Ezzat, M. I., Hefnawy, H. M. E., Abdel-Sattar, E. (2022) An overview and update on the chemical composition and potential health benefits of Opuntia ficus-indica (L.) Miller. Journal of Food Biochemistry, 11(46), n/a-n/a. https://doi.org/10.1111/jfbc.14310

Ali B, Musaddiq S, Iqbal S, Rehman T, Shafiq N., Hussain. A. (2021) The Therapeutic Properties, Ethno pharmacology and Phytochemistry of Atriplex Species: A review. Pakistan Journal of Biochemistry and Biotechnology, 2(1), 49–64. https://doi.org/10.52700/pjbb.v2i1.38

Bahru, T., Asfaw, Z., Demissew, S. (2014) Ethnobotanical study of forage/fodder plant species in and around the semi-arid Awash National Park, Ethiopia. Journal of Forestry Research, 25(2), 445–454. https://doi.org/10.1007/s11676-014-0474-x

Bengouga, K. LahmadiSalwa, L., Zeguerou, R., Maaoui, M., and Halis, Y. (2019) Livestock in rural piedmont regions of Algeria. Biotechnology in Animal Husbandry, 35(2), 199–208. https://doi.org/10.2298/BAH1902199B

Carpino, S., Licitra, G., Van Soest, P. J. (2003) Selection of forage species by dairy cattle on complex Sicilian pasture. Animal Feed Science and Technology, 105(1), 205–214. https://doi.org/10.1016/S0377-8401(03)00054-3

Douguedroit, A. (1997) "Book Review: Bioclimatologie et biogéographie des steppes arides du Nord de L'Afrique ". H. N. le Houerou, Options Méditerranéennes, série B, n° 10, Institut Agronomique Mediterraneen de Montpellier (Montpellier) 1995, No. of pages: 397. Price: FF400. ISBN: 85352-146-X. International Journal of Climatology, 17(13), 1495–1496. https://doi.org/10.1002/(SICI)1097-0088(19971115)17:13<1495: AID-JOC217>3.0.CO;2-0

French, K. E. (2018) Plant-Based Solutions to Global Livestock Anthelmintic Resistance. Ethnobiology Letters, 9(2), 110–123. https://doi.org/10.14237/ebl.9.2.2018.980

Garibaldi, L. A., Gemmill-Herren, B., D'Annolfo, R., Graeub, B. E., Cunningham, S. A., Breeze, T. D. (2017) Farming Approaches for Greater Biodiversity, Livelihoods, and Food Security. Trends in Ecology and Evolution, 32(1), 68–80. https://doi.org/10.1016/j.tree.2016.10.001

Geng, Y. Hu. G., Ranjitkar, S., Wang, Y., Bu, D., Pei, S., Ou, X., Lu, Y., Ma, X., Xu, J. (2017) Prioritizing fodder species based on traditional knowledge: A case study of mithun (Bos frontalis) in Dulongjiang area, Yunnan Province, Southwest China. Journal of Ethnobiology and Ethnomedicine, 13(1), 24. https://doi.org/10.1186/s13002-017-0153-z

Geng, Y., Ranjitkar, S., Yan, Q., He, Z., Su, B., Gao, S., Niu, J., Bu, D., Xu, J. (2020) Nutrient value of wild fodder species and the implications for improving the diet of mithun (Bos frontalis) in Dulongjiang area, Yunnan Province, China. Plant Diversity, 42(6), 455–463. https://doi.org/10.1016/j.pld.2020.09.007

Harun, N., Chaudhry, A. S., Shaheen, S., Ullah, K., Khan, F. (2017) Ethnobotanical studies of fodder grass resources for ruminant animals, based on the traditional knowledge of indigenous communities in Central Punjab Pakistan. Journal of Ethnobiology and Ethnomedicine, 13(1), 56. https://doi.org/10.1186/s13002-017-0184-5

Jeanmonod, D., Schlüssel, A., Gamisans, J. (2011) Analyse de la Flore Corse: Aspects biologiques. Candollea, 66(1), 5. https://doi.org/10.15553/c2011v661a1

Jinger, D., Kaushal, R., Kumar, R., Paramesh, V., Verma, A., Shukla, M., Chavan, S. B., Kakade, V., Dobhal, S., Uthappa, A. R., Roy, T., Singhal, V., Madegowda, M.,

Kumar, D., Khatri, P., Dinesh, D., Singh, G., Singh, A. K., Nath, A. J., Kumawat, S. (2023) Degraded land rehabilitation through agroforestry in India: Achievements, current understanding, and future prospectives. Frontiers in Ecology and Evolution, 11. https://doi.org/10.3389/fevo.2023.1088796

Kadi, S. A., Zirmi-Zembri, N. (2016) Valeur nutritive des principales ressources fourragères utilisées en Algérie. 2- Les arbres et arbustes fourragers. Livestock Research for Rural Development, 28(8), Article #146. https://hal.science/hal-01742651/document

Katoch, R. (2022) Nutritional Quality Management of Forages in the Himalayan Region. Springer Singapore. https://doi.org/10.1007/978-981-16-5437-4

Lo, A., Diouf, A. A., Diedhiou, I., Bassène, C. D. E., Leroux, L., Tagesson, T., Fensholt, R., Hiernaux, P., Mottet, A., Taugourdeau, S., Ngom, D., Touré, I., Ndao, B., Sarr, M. A. (2022) Dry season forage assessment across Senegalese rangelands using earth observation data. Frontiers in Environmental Science, 10, 931299. https://doi.org/10.3389/fenvs.2022.931299

Martins, M., Ribeiro, M. H., Almeida, C. M. M. (2023) Physicochemical, Nutritional, and Medicinal Properties of Opuntia ficus-indica (L.) Mill. and Its Main Agro-Industrial Use: A Review. Plants, 12(7), 1512. https://doi.org/10.3390/plants12071512

Merdas, S., Menad, A., Mostephaoui, T., Sakaa, B. (2017) Plant community structure and diversity under grazing gradient in arid Mediterranean steppe of Algeria. Journal of Materials and Environmental Sciences, 8(12), 4329–4338. https://doi.org/10.26872/jmes.2017.8.12.456

Miara, M. D., Bendif, H., Ouabed, A., Rebbas, K., Ait Hammou, M., Amirat, M., Greene, A., Teixidor-Toneu, I. (2019) Ethnoveterinary remedies used in the Algerian steppe: Exploring the relationship with traditional human herbal medicine. Journal of Ethnopharmacology, 244, 112164. https://doi.org/10.1016/j.jep.2019.112164

Miara, M. D., Bendif, H., Rebbas, K., Rabah, B., Ait Hammou, M., Maggi, F. (2019) Medicinal plants and their traditional uses in the highland region of Bordj Bou Arreridj (Northeast Algeria). Journal of Herbal Medicine, 16, 100262. https://doi.org/10.1016/j.hermed.2019.100262

Naderifar, M., Goli, H., Ghaljaie, F. (2017) Snowball Sampling: A Purposeful Method of Sampling in Qualitative Research. Strides in Development of Medical Education, 14(3). https://doi.org/10.5812/sdme.67670

Neffar, S., Chenchouni, H., Si Bachir, A. (2016) Floristic composition and analysis of spontaneous vegetation of Sabkha Djendli in north-east Algeria. Plant Biosystems - An International Journal Dealing with All Aspects of Plant Biology, 150(3), 396–403. https://doi.org/10.1080/11263504.2013.810181

Neffar, S., Menasria, T., Chenchouni, H. (2018) Diversity and functional traits of spontaneous plant species in Algerian rangelands rehabilitated with prickly pear (Opuntia ficus-indica L.) plantations. Doga, Turkish Journal of Botany, 42, 448–461. https://doi.org/10.3906/bot-1801-39

Nunes, A. T., Paivade Lucena, R. F., Ferreira Dos Santos, M. V., Albuquerque, U. P. (2015) Local knowledge about fodder plants in the semi-arid region of Northeastern Brazil. Journal of Ethnobiology and Ethnomedicine, 11(1), 12. https://doi.org/10.1186/1746-4269-11-12

Rydén, P., Esikuri, E. E., Lambert, J. D. H. (2005) "Capitalizing on the bio-economic value of multi-purpose medicinal plants for the rehabilitation of drylands in sub-Saharan Africa ". The International Bank for Reconstruction and Development. https://api.semanticscholar.org/CorpusID:54955353

Senoussi, A., Schadt, I., Hioun, S., Chenchouni, H., Saoudi, Z., Aissaoui Zitoun–Hamama, O., Zidoune, M. N., Carpino, S., Rapisarda, T. (2021) Botanical composition and aroma compounds of semi-arid pastures in Algeria. Grass and Forage Science, 76(2), 282–299. https://doi.org/10.1111/gfs.12510

Shaheen, H., Qureshi, R., Qaseem, M. F., Bruschi, P. (2020) The fodder grass resources for ruminants: A indigenous treasure of local communities of Thal desert Punjab, Pakistan. PLOS ONE, 15(3), e0224061. https://doi.org/10.1371/journal.pone.0224061

Soder, K. J., Gregorini, P., Scaglia, G., Rook, A. J. (2009) Dietary Selection by Domestic Grazing Ruminants in Temperate Pastures: Current State of Knowledge, Methodologies, and Future Direction. Rangeland Ecology and Management, 62(5), 389–398. https://doi.org/10.2111/08-068.1

Souahi, H., Gacem, R., Chenchouni, H. (2022) Variation in Plant Diversity along a Watershed in the Semi-Arid Lands of North Africa. Diversity, 14(6), 450. https://doi.org/10.3390/d14060450

Sujarwo, W., Caneva, G. (2016) Using quantitative indices to evaluate the cultural importance of food and nutraceutical plants: Comparative data from the Island of Bali (Indonesia). Journal of Cultural Heritage, 18, 342–348. https://doi.org/10.1016/j.culher.2015.06.006

Upton, M. (2004) "The Role of Livestock in Economic Development and Poverty Reduction. Food and Agriculture Organization of the United Nations ". Pro-Poor Livestock Policy Initiative, PPLPI Working Papers. The Role of Livestock in Economic Development and Poverty Reduction (publishing.service.gov.uk)

Villalba, J. J., Ates, S., MacAdam, J. W. (2021) Non-fiber Carbohydrates in Forages and Their Influence on Beef Production Systems. Frontiers in Sustainable Food Systems, 5, 566338. https://doi.org/10.3389/fsufs.2021.566338

Villalba, J. J., Beauchemin, K. A., Gregorini, P., MacAdam, J. W. (2019) Pasture chemoscapes and their ecological services. Translational Animal Science, 3(2), 829–841. https://doi.org/10.1093/tas/txz003

Vogl, C. R., Vogl-Lukasser, B., Walkenhorst, M. (2016) Local knowledge held by farmers in Eastern Tyrol (Austria) about the use of plants to maintain and improve animal health and welfare. Journal of Ethnobiology and Ethnomedicine, 12(1), 40. https://doi.org/10.1186/s13002-016-0104-0

Yang, J., Luo, J., Gan, Q., Ke, L., Zhang, F., Guo, H., Zhao, F. Wang, Y. (2021) An ethnobotanical study of forage plants in Zhuxi County in the Qinba mountainous area of central China. Plant Diversity, 43(3), 239–247. https://doi.org/10.1016/j.pld.2020.12.008

Zirmi-Zembri, N., Kadi, S. A. (2016) Valeur nutritive des principales ressources fourragères utilisées en Algérie. 1- Les fourrages naturels herbacés. Livestock Research for Rural Development. Volume 28, Article #145. Retrieved March 24, 2024, from http://www.lrrd.org/lrrd28/8/zemb28145.html

Carpino, S., Licitra, G., Van Soest, P. J. (2003) Selection of forage species by dairy cattle on complex Sicilian pasture. Animal Feed Science and Technology, 105(1), 205–214. https://doi.org/10.1016/S0377-8401(03)00054-3.