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Nutritional Value Study Of Some Spontaneous Species From Saharan Rangelands: Case Of The Ouargla Region, Algeria

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ABSTRACT
Rangelands in Saharan regions are characterized by high geomorphological heterogeneity, which induces a specific floristic diversity for each ecosystem, associated with a highly significant difference in species density ***($p < 0.001$)****. This spatio-temporal complementarity provides herders with opportunities for selective transhumance to meet livestock requirements throughout the four seasons of the year. In the present study, a floristic characterization of several rangeland types was carried out, and the nutritional value of their main spontaneous species was evaluated.The results revealed that the rangeland type exerts a highly significant effect on vegetation canopy cover (****$p < 0.001$****). Within the "wadi beds" rangeland, Limoniastrum guyonianum displayed the highest cover* ***(17.4 m^3)****, while the lowest was recorded for Salicornia strobilacea****(0.003 m^3).*** *Across all studied rangelands, the vegetation structure remained scattered, with an abundance-dominance index not exceeding a value of* ***2****.Regarding the nutritional evaluation, deep interspecific contrasts were highlighted. The highest energy values were recorded for Salicornia strobilacea (****0.86 UFL and 0.81 UFV / kg DM)****, whereas the lowest were attributed to Stipagrostis pungens****(0.38 UFL and 0.35 UFV kg DM).*** *In terms of nitrogen value, Malcolmia aegyptiaca exhibited the highest contents (91 g PDIE and 82g PDIN / kg DM), while Stipagrostis pungens showed the lowest value (****49 g PDIE and 26 g PDIN / kg DM)****.*
Keywords: *Saharan rangelands, canopy cover, abundance-dominance, nutritional value.*

INTRODUCTION:

In arid and semi-arid regions, irregular rainfall severely limits herbaceous growth and biomass yield, thereby intensifying the challenge of providing adequate, high-quality animal feed (Boufennara et al., 2012). The Algerian Sahara, which extends over approximately 2 million km², represents the cradle of camel husbandry in the country despite its extremely harsh and arid climate. In this environment where food resources are naturally scarce, assessing the nutritional value of native plants is essential for determining rangeland carrying capacity, identifying potential nutrient deficiencies, and evaluating the need for dietary supplements ((Vallentine, 1990 ; Mohammad et *al.*, 2020 and Mosaffaei et *al.*, 2020).

Optimizing livestock performance while minimizing ecological impacts remains a primary challenge for rangeland managers. Achieving this balance requires a comprehensive understanding of how forage nutritive quality fluctuates across seasons and phenological stages (Arzani et *al.*, 2004;Asaadi and Yazdi, 2011;Saffariha et al., 2021 andCastro et al., 2021). Indeed, as plants advance in maturity, aging leads to a significant reduction in crude protein (CP) content and overall organic matter digestibility. This decline is systematically accompanied by a concomitant increase in cell wall components, notably acid detergent fiber (ADF), neutral detergent fiber (NDF), and lignin concentrations(Heady and Sampson, 1952) and Holchek& Herbal, 2004). Furthermore, these nutritional variations are closely coupled with morphological changes, particularly the leaf-to-stem ratio, which serves as a key determinant of overall forage quality Jafari (1993).

To address these challenges within local pastoral systems, the present study aims to evaluate the structural floristic characteristics of selected Saharan rangelands and to determine the nutritional and energy potential of their dominant spontaneous plant species.

MATERIALS AND METHODS

Study Area

The study was conducted in the Ouargla region (Algeria; $31^\circ 57' 47" \text{ N}$, $5^\circ 20' 31" \text{ E}$) between 2022 and 2024. The regional climate is classified as arid, characterized by cold, dry winters and hot, dry summers. This specific study zone was selected due to its high geomorphological diversity of rangeland ecosystems.

Floristic Surveys

To characterize the floristic composition, four highly contrasting rangeland types were selected based on their plant species diversity: Wadi beds, Dayas, Regs, and Ergs. Vegetation sampling was performed using the minimal area method, defined as the representative area containing almost all species of the plant community, beyond which an increase in surface area no longer yields additional species (Gounot, 1960). While the minimal area typically ranges from $10 \text{ to } 100 \text{ m}^2$ depending on floristic density (Daget et al., 2010), a maximal sampling plot of 100 m^2 was systematically adopted here to account for the sparse and scattered nature of Saharan vegetation. Within each plot, primary ecological indices—namely density, abundance-dominance, and plant canopy cover—were recorded.

Sampling and Chemical Analyses

Plant samples were collected across the different rangeland stations using the hand-plucking method to simulate actual grazing behavior, then dried in a forced-air oven, ground, and stored for subsequent laboratory analyses. Chemical composition was characterized by determining the mineral matter (MM) content via incineration in a muffle furnace at 550°C for 6 hours, while crude protein (CP / MAT) was quantified using the micro-Kjeldahl method. Cell wall constituents—specifically neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL)—were analyzed according to the Van Soest (1967) protocol.

Statistical Analyses

Statistical data processing was performed using XLSTAT software (Free Version 2026). The data matrix was first subjected to descriptive statistics (minimum, maximum, mean, standard deviation, and box-plot analysis). In a second step, a Principal Component Analysis (PCA) was executed to evaluate the multivariate relationships between rangeland types, plant species, and their nutritional characteristics.

2. RESULTS AND DISCUSSION

2.1. Floristic Characterization

The rangeland floristic inventory (Table 1) highlights a distinct interspecific variability in vegetation cover across the different study sites. Statistical analyses revealed a highly significant effect of rangeland type on both plant density ($p < 0.001$) and overall canopy volume ($p < 0.001$).

In Station 1 (Wadi beds), *Limoniastrum guyonianum* displayed the highest canopy volume (17.4 m^3) coupled with a relative density of 36\%, followed by *Tamarix gallica* (7.6 m^3), which maintained a substantial structural footprint despite its lower density (10\%). Both dominant species achieved an abundance-dominance index of 2. A comparable structural pattern was observed in Station 2 (Dayas), where *Tamarix aphylla* dominated the canopy volume (11m^3) despite its sparse density (11\%, abundance-dominance index of 2), followed by *Anabasis articulata* (8.1 m^3; 30\%).

Conversely, Station 3 (Reg) was characterized by a severely restricted floristic diversity, structurally limited to *Anabasis articulata* (80\% density; 0.4m^3cover) and *Ephedra alata* (20\% density; 1.6 m^3 cover). Finally, the sand dune systems (Ergs) exhibited contrasting monospecific dominance: *Anabasis articulata* predominated in the Erg of Station 4 (36\% density; 11.01 m^3 cover; abundance-dominance index of 2), whereas *Limoniastrum guyonianum* was the major structural component in the Erg of Station 5 (58\% density; 6.0 m^3 cover; abundance-dominance index of 2). For all other recorded plant species across the stations, the abundance-dominance indices remained marginal, scoring 1.

Table 1: Floristic characteristics and structural parameters of the studied Saharan rangelands.

Station	Rangeland Type	Plant Species	Relative Density (%)	Canopy Volume (m3/100 m2)	Abundance-Dominance Index
Station 01	Wadi beds	*Limoniastrum guyonianum*	**36**	**17 ,4**	**2**
		Salicornia strobilacea	20	0,03	1
		Tamarix gallica	10	**7,6**	**2**
		Zygophyllum album	8	0,15	1
		Juncus rigidus	23	0,052	1
		Euphorbia guyoniana	3	0,08	1
Station 02	Dayas	*Anabasis articulata*	**30**	8.1	2
		Asphodelus tenuifolius	20	0,080	1
		Ephedra alata	19	4.3	1
		Stipagrostis pungens	5	0,019	1
		Tamarix aphylla	11	**11**	**2**
		Citrollus colocynthis	4	0,20	1
		Euphorbia guyoniana	12	0,20	1
Station 03	Reg	*Anabasis articulata*	**80**	0,4	1
		Ephedra alata	20	1,6	1
Station 04	Erg 01	*Anabasis articulata*	36	**11,01**	2
		Malcomia eagyptiaca	**42**	0,040	1
		Ephedra alata	10	3.5	1
		Euphorbia guyoniana	7	0,08	1
		Stipagrostis pungens	3	0,07	1
		Citrollus colocynthis	2	0,3	*1*
Station 05	Erg 02	*Limoniastrum guyonianum*	**58**	**6**	**2**
		Zygophyllum album	37	0,5	1
		Ephedra alata	5	0,8	1

2.2. Chemical Composition of the Plant Species

The chemical composition of the harvested species (Figure 1 and Table 2) reveals pronounced interspecific variability across all analyzed components. Among these fractions, organic matter (OM) represents the highest proportion, ranging from 72.85% to 93.60% of dry matter (DM). Cell wall constituents constitute the second largest fraction, with neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents spanning from 21.87% to 73.11% DM, and from 14.59%to 47.16% DM, respectively. These are followed by crude fiber (CF / CBW), which ranges from11.40% to 43.40% DM, and acid detergent lignin (ADL), with values extending from 4.27%to 22.41% DM. Finally, crude protein (CP / MAT) records the lowest proportions among the evaluated chemical parameters, fluctuating between 3.94% and 13.04% DM.

Table 2: Chemical composition of selected spontaneous plant species from Saharan rangelands (% DM)

Station	Rangeland Type	Plant Species	OM	MM	CP	CF	NDF	ADF	ADL
Station 01	Wadi beds	*Limoniastrum guyonianum*	79,32	20,68	10,72	16,69	29,65	22,82	12,71
		Salicornia strobilacea	72,85	27,15	11,40	11,40	33,22	14,71	8,47
		Tamarix gallica	84,57	15,43	8,77	20,44	30,61	22,36	10,23
		Zygophyllum album	78,30	21,70	9,15	17,32	27,13	18,59	10,68
		Juncus rigidus	81,72	18,28	11,29	24,55	39,59	27,32	12,19
		***Euphorbia guyoniana*	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Station 02	Dayas	*Anabasis articulata*	83,04	16,96	6,59	25,08	48,66	27,11	9,48
		Asphodelus tenuifolius	81,61	18,39	10,56	21,81	35,91	19,43	6,56
		Ephedra alata	90,69	9,31	9,73	34,81	60,53	47,16	20,95
		Stipagrostis pungens	92,82	7,18	4,07	43,40	73,11	47,02	9,11
		Tamarix aphylla	74,35	25,65	7,41	16,18	28,79	19,24	9,82
		***Citrollus colocynthis*	0,00	0,00	0,00	0,00	0,00	0,00	0,00
		**Euphorbia guyoniana	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Station 03	Reg	*Anabasis articulata*	84,51	15,49	7,92	29,56	45,71	30,89	11,17
		Ephedra alata	82,48	17,52	9,16	27,51	40,82	25,35	8,89
Station 04	Erg 01	*Anabasis articulata*	82,93	17,08	8,78	32,14	41,32	27,31	8,19
		Malcomia eagyptiaca	83,94	16,06	13,04	27,57	40,68	27,55	7,78
		Ephedra alata	88,56	11,44	9,16	27,93	51,42	37,16	18,35
		** *Euphorbia guyoniana*	0,00	0,00	0,00	0,00	0,00	0,00	0,00
		Stipagrostis pungens	93,60	6,40	3,94	44,26	71,41	43,54	4,94
		** *Citrollus colocynthis*	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Station 05	Erg 02	*Limoniastrum guyonianum*	81,05	18,92	10,94	19,16	42,74	33,87	22,41
		Zygophyllum album	76,86	21,18	12,15	13,62	21,87	14,59	4,27
		Ephedra alata	88,53	11,63	7,53	24,70	49,73	34,73	16,50

Note:toxic species**

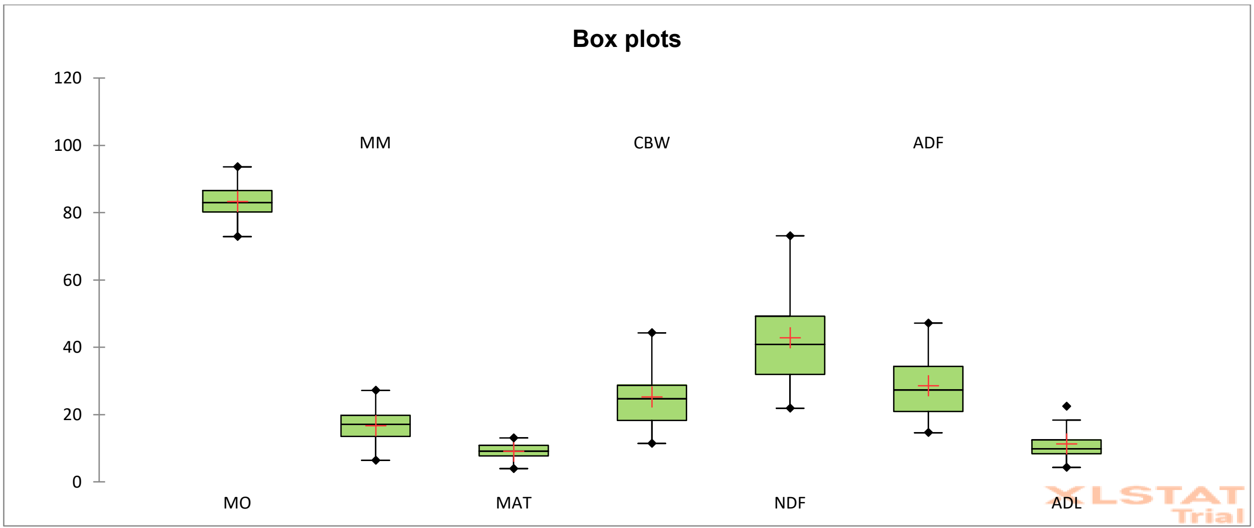

Figure 1: Box-plot distribution of the different chemical composition variables across the studied plant species.

The distribution of chemical composition values along the first principal axis (F1: 73.13%) clearly highlights two distinct, opposing groups. The variables ADF, OM, NDF, and CF are positively correlated and closely clustered together on the right side of the F1 axis. Conversely, they are negatively correlated with CP and MM, which are positioned on the far left of the axis. This spatial distribution demonstrates that an increase in cell wall constituents and organic matter is strongly associated with a corresponding decrease in crude protein and mineral matter concentrations.

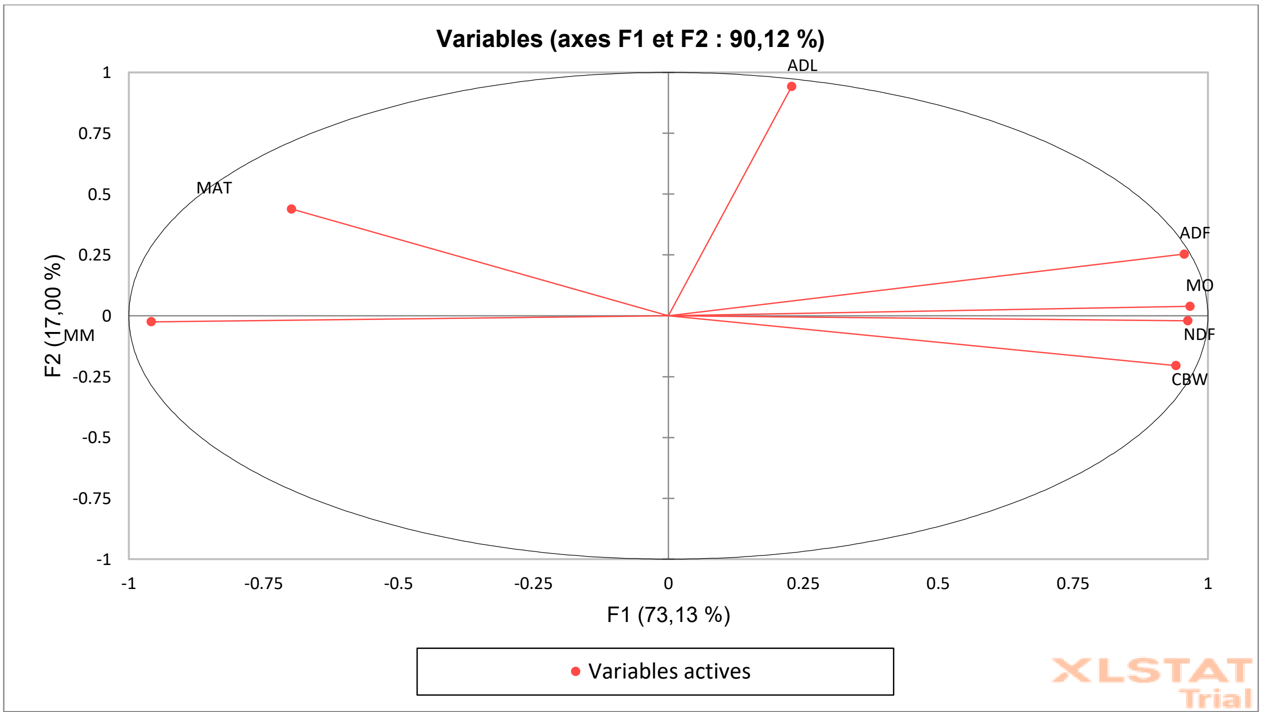

Figure 2 : PCA correlation circle of the chemical composition variables across the studied plant species

2.3. Nutritional Value of the Plant Species

The nutritional value was evaluated based on energy metrics (UFL/kg DM and UFV/kg DM) and protein values (PDIE g/kg DM and PDIN g/kg DM), which are reported in Table 3.

The highest energy values were observed in *Salicornia strobilacea* (0.86 UFL/kg DM and 0.81 UFV/kg DM), whereas *Stipagrostis pungens* exhibited the lowest energy contents (0.38 UFL/kg DM and 0.35 UFV/kg DM).

Regarding protein value, *Malcolmia aegyptiaca* displayed the highest concentrations (91 g PDIE/kg DM and 82 g PDIN/kg DM), while *Stipagrostis pungens* recorded the lowest overall protein value (49g PDIE/kg DM and 26g PDIN/kg DM).All nutritional variables clustered on the positive (right) side of the F1 axis. Specifically, the energy values (UFL/kg DM, UFV/kg DM) occupied the upper-right quadrant, while the protein values (PDIE g/kg DM and PDIN g/kg DM) were located in the lower-right quadrant of the F1 axis (Figure 3). Plant species with high energy values, such as *Salicornia strobilacea* and *Zygophyllum album*, were positioned at the extreme upper-right side of the F1 axis. Conversely, species with high protein values, such as *Malcolmia aegyptiaca*, mapped within the lower-right quadrant of the F1 axis.

Proximity to the axis origin (center) indicated a progressive decline in nutritional quality. Species showing moderate-to-good nutritional quality included *Limoniastrum guyonianum* (for energy value), alongside *Asphodelus tenuifolius* and *Juncus rigidus* (for protein values). On the other hand, *Tamarix gallica*, *Zygophyllum album*, *Ephedra alata*, *Tamarix aphylla*, and *Anabasis articulata* were negatively correlated with nutritional metrics, plotting on the left side of the F1 axis and reflecting a poor nutritional value. Finally, *Stipagrostis pungens* was situated at the extreme left of the F1 axis, corresponding to the lowest nutritional value recorded in this study.

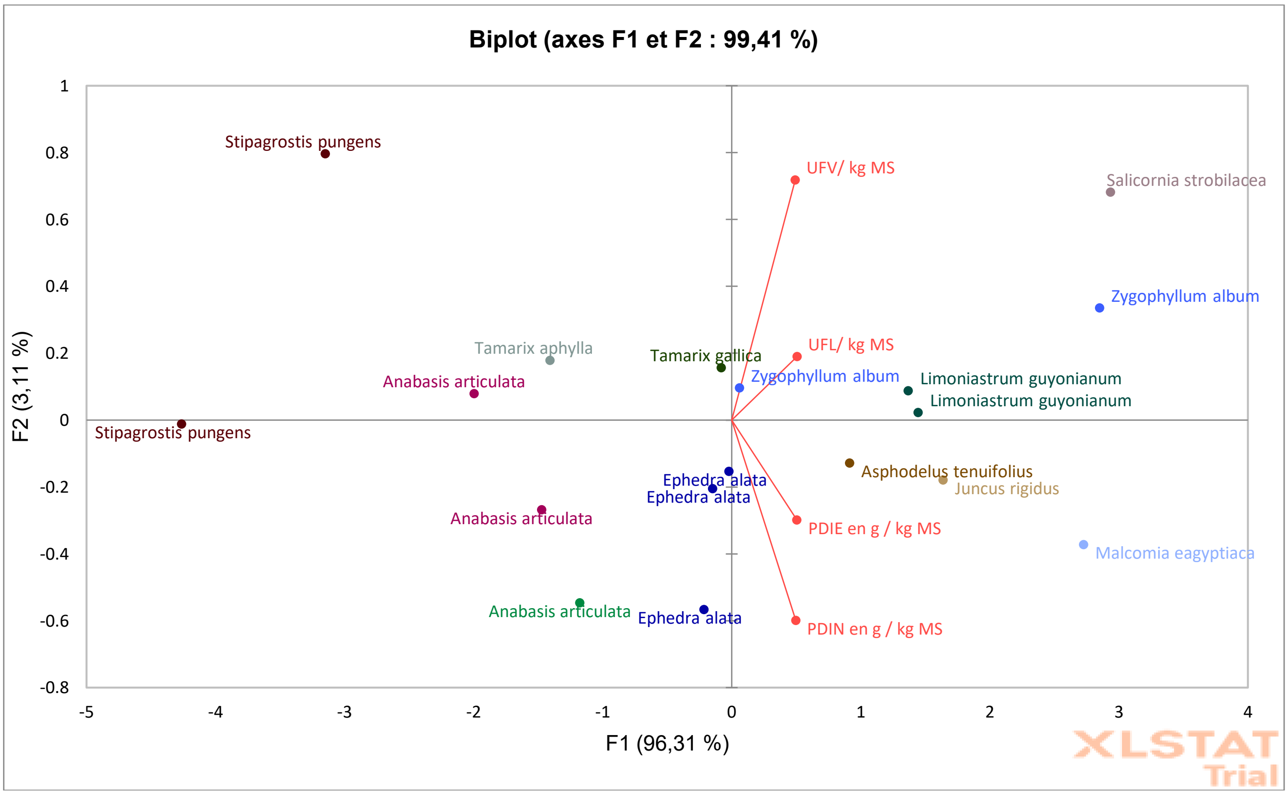

Figure 3: PCA biplot illustrating the relationship between plant species and their nutritional value metrics.

Table 3: Nutritional values of selected spontaneous Saharan plant specie

Station	Rangeland Type	Plant Species	UFL/ kg DM	UFV/ kg DM	PDIE (g / kg DM)	PDIN (g / kg DM
Station 01	*lits d'oued*	*Limoniastrum guyonianum*	0,74	0,68	80	68
		Salicornia strobilacea	0,86	0,81	89	72
		Tamarix gallica	0,67	0,59	72	55
		Zygophyllum album	0,67	0,60	72	58
		Juncus rigidus	0,75	0,67	84	71
		**Euphorbia guyoniana*	0,00	0,00	0,00	0
Station 02	*Dayas*	*Anabasis articulata*	0,56	0,47	60	42
		Asphodelus tenuifolius	0,70	0,64	78	67
		Ephedra alata	0,63	0,53	74	61
		Stipagrostis pungens	0,38	0,35	49	26
		Tamarix aphylla	0,59	0,52	62	47
		**Citrollus colocynthis*	0,00	0,00	0,00	0
		**Euphorbia guyoniana*	0,00	0,00	0,00	0
Station 03	*Reg*	*Anabasis articulata*	0,57	0,48	64	50
		Ephedra alata	0,66	0,57	74	58
Station 04	*Erg*	*Anabasis articulata*	0,57	0,48	67	55
		Malcomia eagyptiaca	0,79	0,73	91	82
		Ephedra alata	0,65	0,56	73	58
		**Euphorbia guyoniana*	0,00	0,00	0,00	0
		Stipagrostis pungens	0,46	0,49	51,25	28,84
		**Citrollus colocynthis*	0,00	0,00	0,00	0
Station 05	*Erg*	*Limoniastrum guyonianum*	0,74	0,68	81	69
		Zygophyllum album	0,83	0,79	88	77

Note:toxic species**

3. DISCUSSION

3.1. Floristic Status of the Rangelands

The field results demonstrate that Saharan rangelands are characterized by low vegetative cover. In terms of species abundance (density), significant variations were observed depending on the specific rangeland type. Notably, the Dayas and wadi beds exhibited considerably higher densities compared to the other rangeland types. Previous studies have similarly reported that plant density varies as a function of environmental conditions and the specific growth forms occupying the spatial matrix (Benguessoum and Bouhamed 2006; Medjber2014andKaouthar2016).Furthermore, floristic richness and diversity are highly dependent on the emergence of ephemeral species (Chehma et Longo , 2004andBouallala et *al.*, 2013). Despite these episodic pulses of diversity, Saharan rangelands remain generally open and sparse. This low density is primarily driven by chronic aridity, which acts as a selective pressure allowing only perennial species to persist. Perennials remain stable during prolonged dry periods, unlike ephemeral plants that appear exclusively following rainfall events (Chehma et*al.*, 2005 andChehma et Youcef, 2009). However, rangeland soils maintain a robust soil seed bank, which triggers rapid germination and emergence as soon as precipitations occur (Khenfer, 2020).Regarding vegetative cover, Mahma et al., (2025) noted that these arid ecosystems are structurally characterized by extremely low canopy cover. The plant cover across Saharan rangelands is highly fragmented and scattered due to drought. It is also characteristically devoid of a well-developed shrub layer, except within wadi beds and Dayas where dense tufts, hummocks, and woody shrubs can establish. Consequently, phytomass production exhibits high variability from one rangeland type to another, with wadi beds and topographical depressions recording the highest biomass yields (Chehma et al., 2008). Indeed, wadi beds are widely recognized as primary landscape units supporting woody shrub vegetation in hyper-arid zones (Barry et *al.*, 1981andOzenda, 1991).From a physiological standpoint, Saharan vegetation has evolved specialized adaptation mechanisms to withstand severe aridity, notably by reducing leaf surface area, limiting the number of leaves, or exhibiting complete aphylly (leaflessness) (Faye et *al*, 1999). These morphological adaptations directly reduce the overall plant cover, consequently altering the abundance-dominance structure of the rangeland communities.

3.2. Chemical Composition and Nutritional Value

The experimental results reveal pronounced interspecific variations in chemical components across the different rangelands. This heterogeneity is closely linked to soil properties and local geomorphology, both of which govern the retention and accumulation of seasonal floodwaters enriched with fertile alluvial elements (lemee, 1953 ;Tisserand, 1991 et Mahma, 2020). The most striking trend observed is that the majority of the evaluated species are highly enriched in structural cell wall constituents (NDF, ADF, and ADL) and crude fiber (CF). This structural pattern represents a primary defense mechanism against the hyper-arid Saharan climate and extreme temperatures (Mahma, 2020). Plants accelerate tissue lignification to mitigate evapotranspiration losses (Demarquilly, 1982 ; Ozenda, 1991 et Mauriès, 1994)and undergo a significant reduction in their leaf-to-stem ratio (Jarrige et *al.,* 1982 ; Ozenda, 1992 et FAYE, 1997). Because proteins are primarily synthesized and stored within the foliar tissues, this reduction in leaf mass directly decreases the crude protein (CP) content of the whole plant. This aligns with seasonal observations showing that autumn and winter periods are characterized by elevated structural carbohydrate fractions (NDF, ADF, ADL, and CF) alongside a concomitant drop in CP content (Chehma and Youcef 2009).Regarding nutritional parameters, a parallel interspecific variation was observed, with most species exhibiting low overall forage quality. This limitation stems from the identical environmental drivers that constrain chemical composition, as a direct functional relationship links a plant's structural chemistry to its nutritional value. The accumulation of cell wall constituents and the climate-induced reduction in leaf-to-stem ratios lead to highly fibrous, coarse, and unpalatable vegetation, which severely reduces its forage quality.During the dry season and extended periods of drought, arid plants routinely exhibit critically low concentrations of metabolic energy, protein, minerals, and vitamins (Tessema and Baars, 2004; Murthy, 2011and Hassen et al., 2017). Conversely, actively growing green forage maintains a superior nutritional profile. High-quality green forage is characterized not only by optimal energy and protein values but also by high voluntary intake (ingestibility); however, rising temperatures rapidly accelerate the lignification of structural supporting tissues(Demarquilly, 1982 ;Demarquilly and Andrieu, 1992).Recent research on tropical and arid pastures confirms that forage nutritional value varies strictly according to bioclimatic conditions, showing a significant decline in hotter and hyper-arid regions (Jayasinghe et al., 2022), as exemplified in our study by *Stipagrostis pungens*. Notable exceptions to this trend include *Salicornia strobilacea* and *Zygophyllum album*, which are characterized by lower lignin content, higher cellulose fractions, and superior organic matter digestibility (Ben Rejeb et *al*., 2020). In contrast to perennials, ephemeral species (locally known as *Acheb*) display high nutritional value and low levels of indigestible fiber fractions. In this study, *Malcolmia aegyptiaca* exhibited the highest crude protein value. Ephemerals are significantly less lignified (7\% to 9% DM) than their perennial counterparts (which reach up to 17% DM), allowing their crude protein content to routinely reach or exceed 12% DM (Longo-Hammouda et al., 2007).

4. CONCLUSION

Based on our investigation into the spontaneous flora of selected Saharan rangeland types and their nutritional value, the following conclusions can be drawn:

- **Floristic Density and Diversity:** Vegetation density and species richness vary significantly according to the rangeland type, with each environment exhibiting unique geomorphological and edaphic (soil-related) characteristics.
- **Vegetative Cover and Structure:** Saharan rangelands are characterized by highly fragmented and sparse flora due to the hostile prevailing environmental conditions. This induces low overall canopy cover, with a slight exception observed in Dayas and wadi beds where cover is moderately low. This localized exception is driven by the presence of trees and woody shrubs (such as *Tamarix gallica* and *Tamarix aphylla*), alongside hummock-forming chamaephytes (such as *Limoniastrum guyonianum* and *Anabasis articulata*). Consequently, the Braun-Blanquet abundance-dominance index rarely exceeds a score of 2.
- **Chemical Profile and Nutritional Quality:** A pronounced interspecific variability in chemical composition was highlighted among the plant species across the evaluated rangelands. This phenomenon, governed by soil properties and climatic severity, induces a high accumulation of structural cell wall constituents at the expense of crude protein (CP) content. This critical structural imbalance directly and negatively constrains the overall nutritional value of these pastoral species.

Recommendations and Future Perspectives

To mitigate degradation and support the rehabilitation of these fragile arid rangelands, the following strategic actions and research avenues are proposed:

- **Rangeland Afforestation and Restoration:** Implement targeted replanting programs using native or well-adapted species that can withstand local edaphic and hyper-arid conditions while providing high nutritional value for livestock.
- **Resting and Grazing Exclosures (*Mise en défens*):** Apply temporary grazing exclosures on highly degraded or overgrazed rangeland units. Restricting livestock access is essential to allow the natural regeneration of key perennial species and the recovery of the soil seed bank.
- **Development of Irrigated Pastoral Perimeters:** Establish center-pivot irrigated pastoral areas supported by state development programs. Providing strategic irrigation helps break seed dormancy in arid soils, promoting the mass emergence and establishment of valuable forage species to alleviate grazing pressure on natural rangelands.

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