Effect of grazing on the composition and floristic diversity during fallow at El-Tarf, Algeria

Efecto del pastoreo en la composición y la diversidad florística durante el barbecho en El-Tarf, Argelia

Efeito do pastejo na composição e na diversidade florística durante o pousio em El-Tarf, Argélia

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Abstract

In the El-Tarf region, located in northeastern Algeria, fallow lands are frequently used as grazing grounds for sheep flocks, where they are left all day with a significant grazing load. Limited studies conducted to assess the effects of grazing have yielded varied and sometimes contradictory results, thus underscoring the need for reliable local data. The study aims to assess the impact of grazing on the floristic richness, diversity, production, and chemical composition of fallow lands in the El-Tarf region (northeast Algeria). Measurements were taken during the optimal vegetation period from March to June over a period of 2 years (2019 and 2020). The experimental design included a single factor: grazing intensity (no grazing, moderate grazing, and intense grazing).The results indicated that grazing reduced floristic richness and diversity (Maximum Diversity, Shannon and Weaver Index, Evenness Index), but it did not have an effect on coverage. The non-grazed fallow land is richer, hosting 23 herbaceous species distributed among 8 botanical families, with the most represented being Asteraceae (39 %), followed by Poaceae (26 %). The Fabaceae, on the other hand, display a more modest representation, accounting for only 13 %.Grazing also decreased significantly the biomass and total aboveground herbaceous phytomass, with improvements noted in non-grazed conditions, recording values of 3.80 t.DM.ha^{-1} and 1.77 t.DM.ha^{-1}, respectively. In addition, grazing had a significant impact on chemical composition, with the highest values recorded for moderate grazing, reaching 14.7 % for total nitrogen content and 11.66 % for mineral content.

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Resumen

En la región de El-Tarf, ubicada en el noreste de Argelia, las tierras en barbecho son frecuentemente utilizadas como pastizales para rebaños de ovejas, donde pasan todo el día con una carga significativa de pastoreo. Los estudios limitados realizados para evaluar los efectos del pastoreo han arrojado resultados variados y a veces contradictorios, destacando así la necesidad de contar con datos locales confiables. El estudio tiene como objetivo evaluar el impacto del pastoreo en la riqueza florística, diversidad, producción y composición química de tierras en barbecho en la región de El-Tarf (noreste de Argelia). Las mediciones se realizaron durante el período óptimo de vegetación de marzo a junio durante un período de 2 años (2019 y 2020). El diseño experimental incluyó un solo factor: intensidad de pastoreo (sin pastoreo, pastoreo moderado y pastoreo intenso). Los resultados indicaron que el pastoreo redujo la riqueza florística y la diversidad (Diversidad Máxima, Índice de Shannon y Weaver, Índice de Equidad), pero no tuvo efecto en la cobertura. La tierra en barbecho no pastada es más rica, albergando 23 especies herbáceas distribuidas entre 8 familias botánicas, siendo las más representativas Asteraceae (39 %), seguidas por Poaceae (26 %). Por otro lado, las Fabaceae muestran una representación más modesta, representando solo el 13 %.El pastoreo también disminuyó significativamente la biomasa y la fitomasa herbácea total sobre el suelo, con mejoras observadas en condiciones no pastadas, registrando valores de 3.80 t.MS.ha^{-1} y 1.77 t.MS.ha^{-1}, respectivamente. Además, el pastoreo tuvo un impacto significativo en la composición química, con los valores más altos registrados para pastoreo moderado, alcanzando el 14.7 % para el contenido total de nitrógeno y el 11.66 % para el contenido mineral.

Palabras clave: Asteraceae, riqueza florística, intensidad de pastoreo, fitomasa herbácea, nitrógeno total.

Resumo

Na região de El-Tarf, localizada no nordeste da Argélia, as terras em pousio são frequentemente utilizadas como pastagens para rebanhos de ovelhas, onde ficam o dia todo com uma carga significativa de pastoreio. Estudos limitados conduzidos para avaliar os efeitos do pastoreio têm produzido resultados variados e às vezes contraditórios, destacando assim a necessidade de dados locais confiáveis. O estudo tem como objetivo avaliar o impacto do pastoreio na riqueza florística, diversidade, produção e composição química das terras em pousio na região de El-Tarf (nordeste da Argélia). As medições foram realizadas durante o período de vegetação ótimo de março a junho ao longo de um período de 2 anos (2019 e 2020). O desenho experimental incluiu um único fator: intensidade de pastoreio (sem pastoreio, pastoreio moderado e pastoreio intenso). Os resultados indicaram que o pastoreio reduziu a riqueza florística e a diversidade (Diversidade Máxima, Índice de Shannon e Weaver, Índice de Equidade), mas não teve efeito na cobertura. A terra em pousio não pastada é mais rica, hospedando 23 espécies herbáceas distribuídas entre 8 famílias botânicas, sendo as mais representadas as Asteraceae (39 %), seguidas pelas Poaceae (26 %). As Fabaceae, por outro lado, exibem uma representação mais modesta, representando apenas 13 %. O pastoreio também diminuiu significativamente a biomassa e a fitomassa herbácea total acima do solo, com melhorias observadas em condições não pastadas, registrando valores de 3,80 t.MS.ha^{-1} e 1,77 t.MS.ha^{-1}, respectivamente. Além disso, o pastoreio teve um impacto significativo na composição química, com os valores mais altos registrados para pastoreio moderado, alcançando 14,7 % para o conteúdo total de nitrogênio e 11,6 % para o conteúdo mineral.

Palavras chave: Asteraceae, fitomassa herbácea, intensidade de pastejo, nitrogênio total, riqueza florística.

Introduction

At the global scale, several authors have examined the repercussions of grazing on pastoral resources. They have also been the subject of numerous controversies due to contradictory results. Frequent and intensive grazing significantly influences ecosystem dynamics and, consequently, has a substantial impact on species richness and diversity (Herrero-Jáuregui and Oesterheld, 2018). In Marocco, Chebli, *et al*., (2021) emphasized in their study that overgrazing by sheep explains, the disappearance of pastoral species. Dan Gomma *et al.* (2019) have shown that the increase in the number of animals in grazing areas exerts considerable pressure on forage resources. This results in a decrease in productivity, biodiversity, the disappearance of quality forage species, and the proliferation of invasive species that are little or not appreciated. In contrast to previous results, Davies (2022) show that the effect of grazing is characterized over time by an increase in floral richness. According to analyses, controlled livestock grazing, at light to moderate intensities, can have positive effects on prairie vegetation compared to the total absence of grazing (Zhang *et al*., 2023). In Algeria, various studies have been published regarding the impact of grazing on vegetation evolution, mainly focusing on steppe areas. These research efforts have assessed the extent of the consequences of overgrazing on vegetation dynamics (Boukerker *et al.,* 2021). In the extreme northeast of Algeria, specifically in the El-Tarf region with a humid climate, grazing on fallow land remains a vibrant tradition, constituting an integral part of local production systems. The practice of grazed fallow is particularly widespread, especially when the production system is linked to extensive sheep farming (Matallah and Abbas, 2015), with a significant stocking rate. The impact of disturbance factors, especially sheep grazing, on the floristic and structural characteristics of the herbaceous layer remains unexplored in this region. This activity is increasingly threatened due to the degradation of climatic conditions, which exert an unfavorable influence on the productive capacities of natural pastures (Djohy *et al.,* 2022). Therefore, the objective of this study was to evaluate how grazing specifically affects the composition and floristic diversity, production, and chemical composition of fallow lands. As an integral part of grazing lands in the context of feeding a sheep herd exceeding 120.000 heads, it is expected that the quantity of grass decreases, but the quality of the grass proves to be higher compared to non-grazed areas. To test this hypothesis, our study focuses on evaluating the impact of grazing on the composition and floristic diversity, production, and chemical composition of fallow lands. The impact of disturbance factors, especially sheep grazing, on the floristic and structural characteristics of the herbaceous layer remains unexplored in this region. This activity is increasingly threatened due to the degradation of climatic conditions, which exert an unfavorable influence on the productive capacities of natural pastures (Djohy *et al.,* 2022). The analysis of temperature trends in Algeria reveals an upward trend for both minimum and maximum temperatures across all stations in the northern part of the country, and this trend continues to the present day. Over the past two decades, there has been a more pronounced increase in maximum temperatures compared to minimum temperatures. As for precipitation, a decrease is observed

in autumn and winter in the North, as well as in spring in the East of Algeria.

Materials and methods

Study area

Our study focuses on the El-Tarf region, located in the extreme northeast of Algeria. In this region, the livestock farming system is primarily extensive to semi-intensive, and the majority of the feed comes essentially from natural forages derived from fallow lands, pastures, and meadows (Arbouche *et al.,* 2016). According to the Emberger climatogram, it falls within the sub-humid Mediterranean bioclimatic zone with a warm winter. Before embarking on our fieldwork, we conducted surveys with the agricultural services department of El-Tarf to gather information on animal production, forage resources, and grazing intensity in the region. In total, we interviewed 92 sheep farmers, all of whom own fallow lands intended for grazing, selected randomly from the list provided by agricultural services. We observed that fallow land management primarily depends on farmers' practices, who follow two management models:

-Crop - fallow without grazing - crop.

-Crop - fallow grazing period - crop.

In our study, we selected three fallow grazing treatments as described in table 1:

Table 1. Annual grazing balance on grazed fallows (2 years).

Grazing Intensity	Average Stocking Rate per Hectare
G0 (no grazing)	0
G1 (moderate grazing)	1.5 SLU.ha^{-1} (ovine)
G2 (intensive grazing)	4.5 SLU.ha^{-1} (ovine)

SLU: Standard Livestock Units

The selected fallow lands share the same general ecological conditions (geographical coordinates, altitude, slope, exposure, and soil texture)**.**

Measurements on vegetation

The measured parameters were conducted during the optimal vegetation period from March to June, and over a period of 2 years (2019 and 2020).

Floristic composition (Number of families and species)

Floristic surveys are conducted in a minimum area of 100 m^2 (10 m x 10 m) per fallow (G0, G1, G2) with 5 repetitions. Quantitative measurements were carried out using the "point quadrats" aligned technique (Daget and Poissonet, 1971). This method involves extending a graduated tape 10 cm above the herbaceous vegetation with equidistant points at 10 cm intervals. Using a needle, the frequency of different elements (species, bare ground, etc.) was recorded. In each survey, two lines of 10 points are positioned along the diagonals of the study area. This survey was complemented by a comprehensive inventory of plant species across each pasture. Phytosociological surveys were carried out randomly employing the Braun-Blanquet method (1951) with one-square-meter quadrats positioned at the center of each plot. The quantity of surveys conducted was contingent upon the visually ascertained diversity of the vegetative cover; the more heterogeneous the cover, the greater the number of surveys, and conversely. The herbaceous species present were identified on-site with the assistance of an expert from El-Kala National Park (El-Tarf). The nomenclature we adopted is that of the synonymic index of North Africa by Dobignard and Chatelain (2010–2013).

Floristic Diversity

Diversity and evenness indices are defined as follows (Ojoatre, 2024):

*Max diversity: H max=$\log_2$ S

*Shannon-Wiener's index of species diversity: $H' = -\sum((n_i /N) \times \log_2 (n_i/N))$

*Evennes: E = H′/ Hmax

Where: n_i is the abundance of species i in the sample, and N is the total abundance. H' varies between 0, in the case where the population consists of only one species. S: number of species

Recovery of the vegetation

Herbaceous covering was assessed using the method of linear surveys (point-quadrats). Two 10-meter lines, parallel and located in the center of each plot, were surveyed (Daget and Poissonet, 1971). On each line, observations were made every 20 centimeters, which corresponds to a sampling of N = 100 points per plot.

Aboveground herbaceous phytomass

By definition, this is the mass expressed in dry matter of both living matter (biomass) and standing dead matter (necromass). The measurement of the total aboveground phytomass was conducted using the whole-plant harvesting method (Cherednichenko *et al.,* 2021). This involves cutting the aboveground plant material at ground level within 1 m² squares with 10 replicates per unit. Samples were collected species by species by hand, then placed in paper bags and weighed using an electronic scale in a cool environment. They were later transported to the laboratory where they were weighed again to determine the dry matter content. The results in dry weight (dried at 60 °C to constant weight) include total phytomass, necromass, and biomass.

Chemical composition

Forage samples were ground to determine their chemical composition (dry matter, mineral matter, total nitrogen content, and crude cellulose) using AOAC methods (1990).

Statistical analysis

The effect of grazing on the studied parameters was subjected to analysis of variance. The Newman-Keuls test was used to determine significant differences between group means. Data were assessed for normality to ensure that the criteria followed ANOVA rules. Linear mixed models (LMM) were employed for data with a normal distribution or data that could be transformed to achieve a normal distribution. The model used is in the following form: $Y_{ij} = \mu + P_i + eij$. With: Y_{ji} = the measured variable, P_i = fixed effect of the plot (i=1-3), and e_{ij} =the error.

Results and discussion

Effect of grazing on the floristic composition of fallow lands

Our results are in line with the conclusions published in studies on Algerian arid landscapes (Amrani and Chehma, 2020). Ungrazed fallow lands are richer, containing 23 herbaceous species ($P<0.05$) belonging to 8 botanical families (table 2 and 3), with Asteraceae being the most represented (39 %), followed by Poaceae (26 %).

The dominance of Asteraceae is attributed to the morphological, anatomical, and physiological characteristics of the species (Hussain, 2020). In our context, it is plausible to assume that grazing decreases the percentage contribution of Poaceae due to consumption by animals (figure 1).

Table 2. Impact of grazing intensity on floristic composition.

	Number of species	Number of families
G0 (3 plots)	23[a]	8[a]
G1(3 plots)	17[b]	6[a]
G2(3 plots)	12[ab]	7[a]
Probability grazing(P)	*	NS

*Significant (P < 0.05);NS : non-significant (P > 0.05). [a, b]the means followed by the same letter(s) constitute a statistically homogeneous group at a significance level of 0.05, according to the Newman-Keuls test

Table 3. List of species encountered in the three types of fallow.

Families	Species	Common names	G0	G1	G2
Asteraceae	*Filago pygmaea*	Pygmy cottonrose	+	+	-
Lamiaceae	*Mentha pulegium* L.	Pennyroyal	-	+	-
Primulaceae	*Lysimachia foemina*	Loosestrife	+	+	+
Poaceae	*Elymus repens*	Couch grass	+	+	+
Plantaginaceae	*Plantago lanceolata*	Ribwort plantain	+	-	-
Malvaceae	*Malva sylvestris*	Common mallow	-	+	-
Fabaceae	*Trifolium tomentosum* L.	Woolly clover	+	+	+
Asteraceae	*Lapsana communis*	Nipplewort	+	-	-
Euphorbiaceae	*Euphorbia helioscopala* L.	Sun spurge	+	-	-
Asteraceae	Lactuca serriola L.	Prickly lettuce	+	-	-
Fabaceae	*Medicago sativa*	Alfalfa	+	+	+
Plantaginaceae	*Plantago major*	Greater plantain	+	-	+
Asteraceae	*Leucanthemum vulgare Lam*	Oxeye daisy	+	-	+
Fabaceae	*Vicia hirsuta L.*	Hairy vetch	+	+	-
Ranunculaceae	*Ranunculus repens L.*	Creeping buttercup	+	-	+
Fabaceae	Coronilla *varia* L.	Crownvetch	-	+	-
Boraginaceae	*Cerinthe major*	Honeywort	-	-	+
Asteraceae	Taraxacum officinale L.	Dandelion	+	+	-
Asteraceae	*Galactites tomentosa*	Woolly milk thistle	+	-	+
Poaceae	*Anthoxanthum odoratum*	Sweet vernal grass	+	+	-
Fabaceae	*Melissa officinalis*	Lemon balm	-	+	-
Asteraceae	*Sonchus oleraceus* L.	Common sowthistle	+	+	-
Poaceae	*Bromus rubens L.*	Red brome	+	+	+
Poaceae	*Bromus tectorum*	Cheatgrass	+	-	-
Poaceae	*Avena sterilis*	Wild oat	+	-	-
Asteraceae	*Picris echioides* L.	Bristly oxtongue	+	+	+
Asteraceae	*Galactites duriaei*	Soft thistle	+	-	+
Poaceae	*Phalaris paradoxa*	Hooded canarygrass	+	-	-
Fabaceae	*Trifolium campestre*	Field clover	-	+	-
Poaceae	*Festuca paniculata*	Slender fescue	-	+	-

+: species observed in the surveys; - : species not observed in the surveys.

The dominance of Asteraceae is attributed to the morphological, anatomical, and physiological characteristics of the species (Zhang *et al*., 2023). Defensive strategies, including spines and secondary compounds, provide these family members with a significant mechanism against grazing, leading to their prevalence. The same authors further add that Asteraceae exhibit significant adaptability to local environmental conditions, the study region undergoes noticeable climatic changes, marked by a substantial increase in temperature over the years and a pronounced decrease in precipitation (Bouhraoua *et al.,* 2019). This climatic evolution accentuates the system's fragility, with less frequent precipitation and persistent irregularity. These variable climatic conditions directly impact the dynamics of Asteraceae species, compelling these plants to adjust their adaptive strategies to thrive in a changing environment. Thus, the combination of distinctive morphological features and defense mechanisms of Asteraceae, coupled with their remarkable adaptability to local conditions, makes them key players in the ecological dynamics of the region. These factors underscore the importance of a thorough understanding of the physiological responses and rhizospheric interactions of these plants in the face of contemporary environmental challenges.

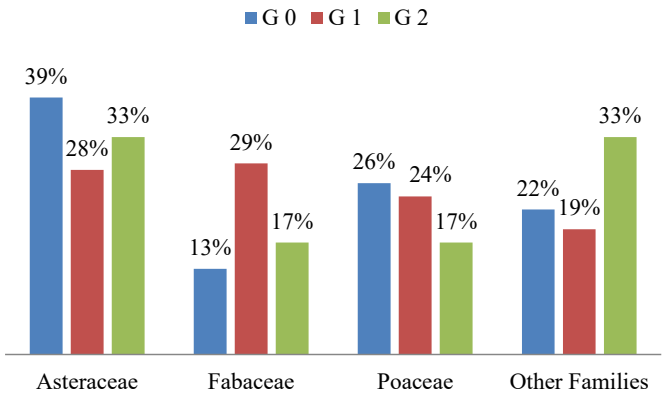

Figure 1. Botanical family composition in response to grazing intensity on fallow lands. G0: no grazing; G1: moderate grazing; G2: intensive grazing; %: Contribution of each family to the total number of species

It also appears that moderate grazing favors legumes (29 %). This specific enrichment resulting from moderate grazing can be attributed to several factors. Firstly, the feces of animals in moderate grazing bring essential nutrients to the soil, thus promoting fertility and nutrient availability for plants. Additionally, moderate grazing can lead to the importation of seeds, especially those of legumes, through the movement of animals from one place to another. This could be due to the likelihood that grazing areas with higher grazing intensities may have caused the spread of less palatable species. More palatable species may disappear due to frequent livestock grazing on highly palatable grasses and legume species (Zainelabdeen *et al*., 2020). This could be attributable to the association ability between grasses and legumes. Grasses, being taller, strongly compete for solar energy, thus favoring Fabaceae in areas with moderate grazing. Legumes benefit from reduced competitive pressure and increased light resources or nutrient input (P and K) through urine and feces. Herbivore grazing reduces shading caused by grasses, allowing plants to thrive. The noted variation among the examined pastures underscores the positive impact of moderate stocking rates on the growth of specific species, including *Mentha pulegium* (L.) and *Malva sylvestris* (L.), affiliated with the Lamiaceae and Malvaceae families, correspondingly. In heavily grazed pastures, a notable portion of the plant life, comprising *Lysimachia foemina*, *Plantago major, Ranunculus repens* (L.), and *Cerinthe major,* is distinctly characterized, with one representative from each family. This highlights the nuanced dynamics of plant development influenced by varying grazing intensities. According to Davies (2022), protection is expected to enhance the increase in the number of species due to the diversification of ecological niches. However, intensive livestock pressure can lead to soil resource degradation and a decrease in floral richness, while also promoting the emergence of unappealing species (Zhang *et al*., 2023). Furthermore, this excessive overgrazing pressure can contribute to a desertification process. Indeed, it results in the loss of the topsoil, which provides protection and coverage for the soil. This leaves the soil vulnerable to wind and water erosion, a reduction in water retention capacity, soil compaction, as well as the loss of mineral content and soil nutrients. According to Davies (2022), grazing can have a direct impact on plants by causing tissue loss through defoliation or trampling. In contrast to our results, in Mediterranean Pastures, Oikonomou *et al.,* (2023) demonstrated that floral richness could increase even with high grazing intensity if the system is nutrient-rich after grazing to facilitate the development of certain species. However, it has not been possible to precisely determine the critical livestock stocking threshold allowing these beneficial effects. With vegetation subjected to continuous year-after-year grazing, as in our conditions, it can be assumed that the plant response to defoliation will depend on each species' grazing tolerance level. In this case, it is crucial to determine whether the species favored by grazing are grazing-tolerant or not. Grazing can also alter the abiotic environment (light, fertility) of the plant and the biotic environment (competition intensity) (Poorter *et al*., 2023). In the long term, appetizing and unappetizing plants can be consumed by animals, leading to complete disappearance of vegetative cover.

Effect of grazing on floristic diversity indices

The diversity indices (table 4) have experienced a significant decrease as the stocking rate increased. Similar findings were observed in Husain *et al*. (2019) study on alpine meadows.

Table 4. Impact of grazing on diversity indices.

Floristic diversity indices	H max	H	E
G0	4.70 ± 0.46[a]	2.82 ± 3.50[a]	0.60 ± 3.40[a]
G1	4.68 ± 2.40[a]	2.67 ± 7.40[a]	0.57 ± 2.23[a]
G2	3.66 ± 3.34[b]	1.72 ± 3.20[b]	0.47 ± 2.50[b]
P	*	*	*

*Significant ($P < 0.05$). [a,b]the means followed by the same letter(s) constitute a statistically homogeneous group at a significance level of 0.05, according to the Newman-Keuls test

The Shannon-Weaver index (H') varies significantly between moderate and intense grazing ($P < 0.05$), but no significant difference is observed between moderate and no grazing pressure levels. In our conditions, this suggests that moderate grazing has preserved pasture diversity, while overgrazing has led to the deterioration of this forage resource. Hempson *et al*. (2022) reported in the Sahel that intensive grazing leads to the dominance of a small number of species (low H'). According to the same authors, the decrease in this index is a consequence of grazing. Overgrazing results in a clear domination of vegetation by one species or a small number of species; in contrast, other authors (Yerou *et al.,* 2022) in different agro-ecological zones noted that the Shannon diversity index is higher in heavily grazed pastures. In our conditions, grazing exerts selective pressure on vegetation, thus influencing floral composition and diversity. Therefore, intensive grazing acts as a filter to favor or eliminate certain species. Only species adapted to environmental conditions (filtering process) will form the species community encountered on fallow lands. The study highlights that the moderately grazed fallow land (G1) is characterized by the presence *of Mentha pulegium* L. *Malva sylvestris, Coronilla varia* L. *Melissa officinalis* and *Trifolium campestre*. This observation can be attributed to the strong adaptability of these species to moderate levels of grazing and trampling, as emphasized by Sitou *et al*. (2021). However, these species also appear to exhibit tolerance to a certain level of disturbance. This tolerance may be linked to specific life traits, such as the annual nature, survival capacity, and germinative power. It is important to note that among these mentioned species, three of them do not seem to be appreciated by sheep.

Effect of grazing on herbaceous plant cover and total herbaceous epigeous phytomass

Unlike the studies conducted by Davies (2022), grazing did not have a significant effect on herbaceous plant cover (table 5); it remains below 50 % in all three grazing types. Studies confirm that an increase in animal stocking rate beyond the pastoral balance threshold leads to a reduction in cover, phytomass, and hectare productivity (Hachmi *et al.,* 2018).

Table 5. Effect of grazing on overall cover.

	G0	G1	G2	p
Herbaceous plant cover (%)	30.0 ± 8.40	30.2 ± 9,30	30.3 ± 11.20	NS
Total phytomass (t.DM.ha^{-1})	3.80 ± 7.40^{a}	3.10 ± 5,30^{a}	2.58 ± 2.40^{b}	*
Biomass (t.DM.ha^{-1})	1.77 ± 2.50^{a}	1.63 ± 7,20^{a}	1.38 ± 2.30^{b}	*

*: significant (P < 0.05); NS: not significant (P > 0.05).$^{a, b}$ the means followed by the same letter(s) constitute a statistically homogeneous group at a significance level of 0.05, according to the Newman-Keuls test.

They noted that vegetation cover is influenced not only by animal consumption but also by the behavior of each plant species after grazing, as well as the heterogeneity of the environment. Grazing significantly reduces biomass and phytomass, which are more substantial in non-grazed conditions (table 5). This result is consistent with the findings of Yerou *et al*. (2022). By consuming certain species, animals can decrease or eliminate biomass. They can also disrupt the development of sexually reproducing species. It can be assumed that trampling by animals may also significantly affect plant tissues, leading to the death of part or the entire plant. Similarly, the study by Yé *et al.* (2016) suggests that browsing results in a notable decrease in aboveground biomass.

Effect of grazing on the chemical composition of fallow fields

Regardless of conditions, grazing increases the nitrogen content (P < 0.05) (table 6). In the absence of nitrogen fertilization, the TN content of the grass depends mainly on the nitrogen input from the soil and, to a lesser extent, on the nitrogen return from animal excrements (Yerou *et al*., 2023).

The TN level is higher under moderate grazing (14.7 %) (table 5) and remains above the critical crude protein utilization rate of 7 % (Yerou *et al*., 2023). This difference is likely related to its floristic richness in Fabaceae (29 %), which have a high protein content. This hypothesis justifies a study of the chemical composition of each herbaceous species. Godinot *et al*. (2022) showed that nitrogen levels are always higher in grazed situations at the end of winter. According to them, animals graze on average younger leaves than those observed in protected areas since grazing occurs daily. The average value recorded under moderate grazing is significantly higher than the values reported by Chaker Houd *et a*l. (2020), who worked in Algeria (16,5 %, 17,4 %, 26,7 %), and those of El-Housni *et al*., (2013), who found an average of 14.57 % in Morocco.

Grazing also reduced the crude fiber content. In non-grazed environments, species are richer in plant walls to colonize the vertical environment. However, in intensively grazed environments, the reduction in size is an avoidance phenomenon of grazing (Bricarello *et al*.,2023). The average value recorded under no grazing (26.5 %) is higher than the values observed by El-Housni *et al*. (2013) (25.26 % - 25.47 %). Thus, we reported that grazing had a significant effect on the levels of mineral matter (MM) and dry matter (DM), as observed by Amrani and Chehma (2020). Regardless of the intensity of grazing, the observed values of MM are lower than those indicated by Chaker *et al*. (2020), who conducted a comparison between grazed and cultivated fallows. It is noteworthy that DM values are the lowest in non-grazed fallows, but generally do not exceed the results reported in the meadows of the study area (Arbouche *et al*., 2016).In the study area, it is challenging to compare these results with those of other authors due to the scarcity of literature on this subject.

Conclusion

This study, conducted on the effects of grazing on the herbaceous layer of fallow lands in the El-Tarf region (northeast Algeria), revealed several findings:

The number of species decreases with increasing grazing intensity;

Grazing leads to a reduction in diversity indices, although no significant difference was observed between moderate and no grazing pressure levels;

Grazing does not have a significant effect on herbaceous vegetation cover, but it reduces the biomass and total phytomass.

The highest values in nitrogen and mineral matter are recorded under moderate grazing.

These findings could guide more applied research aiming to ensure the sustainability of pastoral systems in the region. While grazing does not completely destroy vegetation, excessive grazing could be detrimental if the system becomes nutrient-poor after grazing, which could facilitate the development of certain species.

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Table 6. Chemical composition of fallow land according to grazing intensity.

Grazing intensity	DM (%)	TN (%DM)	MM (%DM)	CC (%DM)
G0	24.54^{a}	12.58^{a}	11.53^{a}	26.50^{a}
G1	18.24^{b}	14.7^{b}	11.66^{b}	21.80^{b}
G2	18.43^{b}	12.89^{ab}	7.40^{ab}	20.30^{b}
p	*	*	**	**

DM : Dry mater; TN: Total nitrogen content; MM: Mineral matter; CC: Crude cellulose.
$^{a, b}$The means followed by the same letter(s) belong to a statistically homogeneous group at the 0.05.

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