

Plasticity of Leaf Morphological Traits Impacted by Livestock Grazing on Trees in Zagros Semi-Arid Forest [†]

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Abstract: Livestock grazing makes deformed, thorny, and twisted branches. The leaves are the main food resource for livestock. We aimed to investigate the leaf morphological characteristics of the Zagros Forest species under livestock grazing. Therefore, the leaf morphological characteristics of six forest species were investigated in five forest stands in Ilam province. Morphological traits, including leaf width, leaf length, petiole length, leaf area, and leaf dry weight, were measured. The results show that grazing affects most of the leaf morphological traits. To sum up, the findings showed that tree leaves are more susceptible to grazing stress as the grazing will damage the tree growth and forest regeneration and structure. Therefore, knowing how livestock causes damage to the forest trees will help to lessen forest destruction and manage the forest better.

Keywords: livestock grazing; leaf morphological traits; forest conservation; structural adaptation; Zagros Forest



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1. Introduction

Forests are the most important natural resources that provide economic, social, and environmental benefits and play an important and fundamental role to continue human and other organisms' lives. The Zagros Forests are the largest forest area in Iran and have always undergone changes and destruction [1]. One of the destructive influencing factors is livestock grazing. Heavy livestock grazing by compacting and disturbing the soil and reducing water infiltration rate damages the plant growth and makes deformed, thorny, and twisted branches. Leaves, as the main photosynthetic organ, respond fast to environmental changes. The leaves are a place for food production, and tree growth is the main food resource for livestock. The trees and forest structures are remarkably affected by livestock feeding [2].

The Zagros forests have been damaged by humans for decades, which has led to their destruction in various forms. Even now, the destruction process continues, and it is increasing. On the other hand, the growth of the population in recent years, as well as the need for forest dwellers for firewood, food sources for livestock, and agricultural land have caused excessive exploitation of these forests and have changed the face of these forests [3]. The factors of destruction in the Zagros forests include heavy livestock grazing, understory farming, wood fuel for rural uses, outbreaks of pests and diseases, and forest fires [4].

Trees in the Zagros forests are grazed by nomadic livestock throughout the year; only unfavorable weather conditions (snow) prevent the presence of livestock in the forest. Nomadic livestock enters the forest area earlier than the legal deadline set for exploitation and leave the forest area later than the stipulated time [5].

The aim of this research was to investigate the leaf morphological characteristics of the Zagros Forest species under livestock grazing.

2. Methods

To carry out this research, after preliminary surveys and field visits, as well as consultation with experts, five forest areas were selected from the forests of Ilam province (Figure 1). The location of the masses was recorded using a GPS device (Table 1). A plot of about 10,000 square meters (one hectare) was selected from each forest stand, considering the distribution of trees and with the aim of sampling most of the tree species.

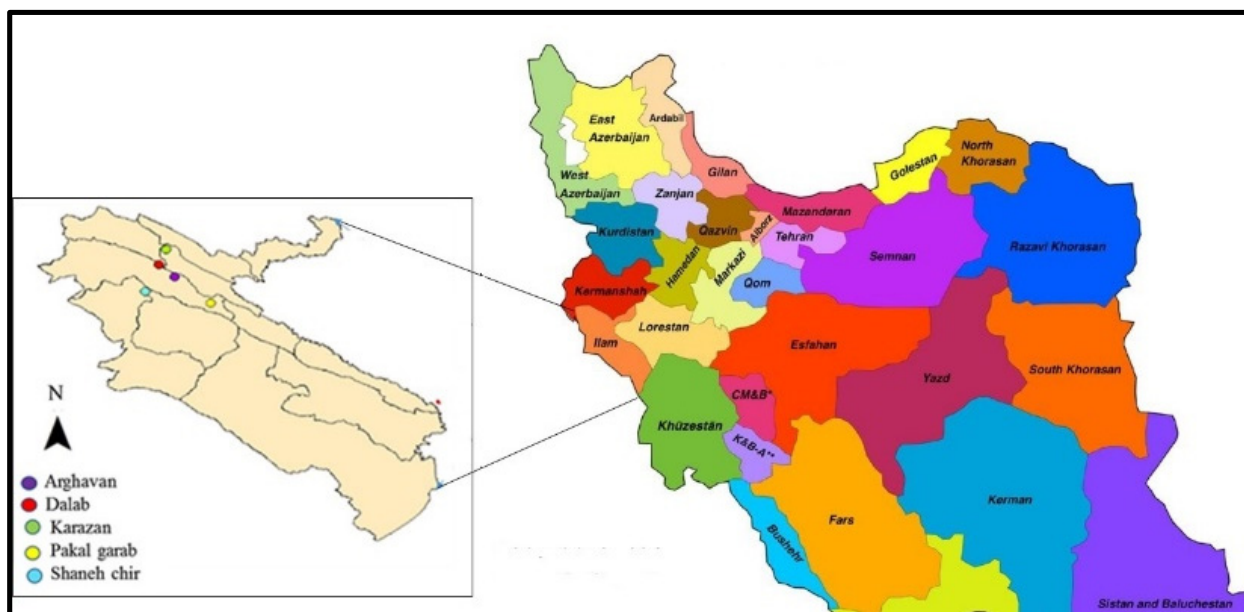


Figure 1. The position of Ilam province and sampling stands.

Table 1. Fundamental characteristics of sampling sites.

R.H. (%)	Precipitation mm	M.A.T. °C	Elevation a.s.l (m)	X UTM	Y UTM	Sampling Site
56	571	16.9	1993	639495	3721095	Arghavan
45	546	18.5	1510	634912	3739210	Karezan
56	403.8	16.9	1471	631053	3729153	Daalab
56	729.5	16.9	1247	659497	3703981	Pakal Gorab
56	389.3	16.9	1559	623473	3711605	Shena cheer

M.A.T.—mean annual temperature. R.H.—relative humidity.

The selected forest areas are permanently grazed by the goats and sheep of the livestock farmers in the growing season from May to November. The number of livestock in the region is uncertain and varies according to the weather conditions of the current year and the breeding rate of the livestock. Cattle are usually portable and transportable in the area and graze large areas of forest. Due to a large number of livestock and their long stay in the forest, no sign of regeneration and seed growth was observed on the forest floor.

In June, after the development of the leaves, five stands with signs of grazing were selected. About 50 pieces of leaf samples were randomly collected from the upper part of the tree that was not exposed to animal grazing and from the lower part that was easily used by the animal. The leaves were numbered based on the sampling area, the type of tree, and the induced stress and were placed in closed plastic and kept in a refrigerator at a temperature of +4 °C for further measurements.

The woody tree species that were grazed by livestock were: *Crataegus pontica* K.Koch, *Acer monspessulanum* L., *Lonicera nummulariifolia* Jaub. and Spach, *Cerasus incana* Boiss., *Paliurus spina-christii* Mill., and *Amygdalus orientalis* Duh. Leaf width (mm), leaf length (mm), petiole length (mm), leaf area (mm²), and leaf dry weight (g) were the characteristics measured.

Statistical Analysis

At first, the homogeneity of the data was checked by the Schapro–Wilk test, and the homogeneity of the variances was checked by the Lune test. Data analysis was performed using a paired t-test to compare the means at a 95% confidence level. All data analysis was conducted using SPSS 20 (SPSS Inc., Chicago, IL, USA) software.

3. Results and Discussion

The results of the analysis of the morphological traits of the studied species showed that the effects of livestock grazing on the traits of the leaf width and length, petiole length, leaf area, and leaf dry weight were significant (Figure 2A–E).

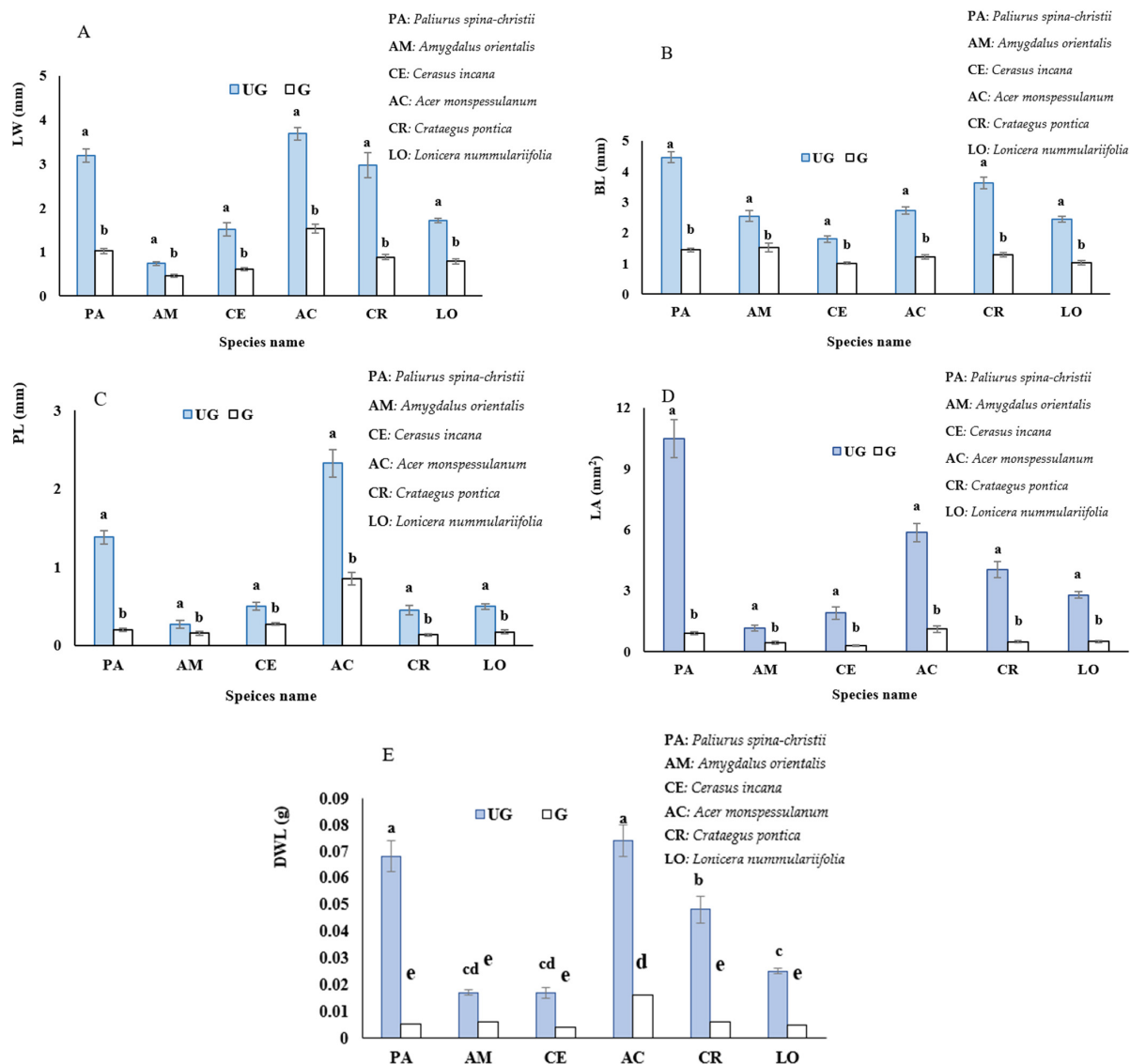


Figure 2. Mean comparison between the leaf traits under two different grazed (G) and un-grazed (UG) stresses. (A) Leaf width (mm); (B) Leaf length (mm); (C) Petiole length (mm); (D) Leaf area (mm²), and (E) Leaf dry weight (g).

The livestock over-grazing on the trees in the Zagros forests causes a change in the ecological diversity, woody species, and other destructive issues that harm the forests, impact the forest diversity, structure, and, finally, their survival [6].

The leaves of the trees as a place for food production, and the growth of trees are the main food used by livestock, and the life of the trees is endangered by feeding on them [2]. Intensifying the use of leaves seriously damages the survival of trees and results in forest decline. In such a situation, changes are evident in the form and shape of the leaves and branches of the trees so that the plant can resist the grazing stress and being eaten by the livestock. The growth rate of the leaves and branches, as well as the production of flowers and fruits on trees, is reduced, and in the long term, it reduces the potential production of the forest [6].

The main role of the petioles is to conduct the nutrients towards and out of the leaves. The longer the petiole is, the more water and nutrients are transferred to the leaves. The long length of the petioles causes more food and water to be transferred to the leaves and increases the photosynthetic rate and production in the plant at the beginning of the growing season [7]. The results of the present study showed that the petiole length in the different studied species in the grazed leaves was smaller than the healthy leaves (Figure 2C). Therefore, it was found that this trait was shorter in all the tree species affected by livestock grazing, and as a result, it reduced the exchange of water and nutrients in the leaves of the trees. The veins are the continuation of the petioles, so any change in the quantity and quality of the petioles will affect the functioning of the veins.

Due to the decreasing trend of the length and width of the leaf blade under the influence of livestock grazing, the leaf area also had the same decreasing trend, which was a logical and predictable result of the effect of grazing on the change in the morphological characteristics of the leaves (Figure 2A,B,D). Environmental stresses cause a decrease in the surface of the plant leaves [8]. Decreasing the leaf area of the plants due to animal grazing causes a decrease in photosynthesis and defects in plant growth as a result. It reduces the amount of plant production and yield. Grazing in each severity causes a decrease in the vegetative organs of the plant and causes a decrease in food production [9], which is completely consistent with the results of the present study.

The effect of livestock grazing was significant on the dry weight of the leaves and caused a decrease in dry weight, which is in line with the findings of Mofidi [10]. It can be concluded that grazing avoidance traits are usually associated with low palatability, such as small leaf size and high leaf dry matter [11]. In contrast, grazing-tolerant plants should have a high specific leaf area and low leaf roughness, which increases the stem regrowth ability and selectivity of herbivores [12].

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References

1. Ebrahimi Rastaghi, M. The destructive parameters of Zagros forests. *J. For. Range Land* **1996**, *18*, 28–31.
2. Kazemi, M. Nutritional value of some forest tree leaves to meet partial nutritional requirements of livestock. *J. For. Res. Dev.* **2021**, *7*, 137–154. (In Persian) [[CrossRef](#)]

3. Soheili, F.; Woodward, S.; Almasi, I.; Abdul-Hamid, H.; Naji, H.R. Variations in Wood Density, Annual Ring Width and Vessel Properties of *Quercus brantii* Affected by Crown Dieback. *Forests* **2021**, *12*, 642. [[CrossRef](#)]
4. Jazirehi, M.H.; Ebrahimi, R. *Silviculture in Zagros*; University of Tehran: Tehran, Iran, 2003; p. 558.
5. Rice, C.W.; Owensby, C.E. The effects of fire and grazing on soil carbon in rangelands. In *The Potential of U.S. Grazing Lands to Sequester Carbon and Mitigate the Greenhouse Effect*; Follett, R.F., Kimble, J.M., Lal, R., Eds.; CRC Press: Boca Raton, FL, USA, 2001; pp. 323–372.
6. Mohammadpour, M.; Tatian, M.R.; Tamartash, R.; Hossienzadeh, J. Investigating the effects of grazing intensity on the structure and diversity of woody species in the Ilam Strait Dalab forest. *Iran. J. For. Poplar Res.* **2018**, *26*, 306–318. [[CrossRef](#)]
7. Walls, R.L. Angiosperm leaf vein patterns are linked to leaf functions in a global-scale data set. *Am. J. Bot.* **2011**, *98*, 244–253. [[CrossRef](#)] [[PubMed](#)]
8. Azizi, K.; Naji, H.R.; Khoshroo, H.H.; Heydari, M. Effect of Altitude and Growing Season on Some Physiological Properties of Leaf from Persian Oak (*Quercus brantii*) in Zagros Forest (Case study: Ilam). *J. Plant Proc. Func.* **2020**, *9*, 101–114.
9. Moghaddam, M.R. *Range and Range Management*, 4th ed.; University of Tehran Press: Tehran, Iran, 2007; p. 470. (In Persian)
10. Mofidi, M.; Jafari, M.; Tavili, A.; Rashtbari, M.; Alijanpour, A. Grazing Exclusion Effect on Soil and Vegetation Properties in Imam Kandi. Rangelands, Iran. *Arid. Land Res. Manag.* **2013**, *27*, 32–40. [[CrossRef](#)]
11. Lloyd, K.M.; Pollock, M.L.; Mason, N.W.H.; Lee, W.G. Leaf trait–palatability relationships differ between ungulate species: Evidence from cafeteria experiments using naïve tussock grasses. *N. Z. J. Ecol.* **2010**, *34*, 219–226.
12. Cingolani, A.M.; Posse, G.; Collantes, M.B. Plant functional traits, herbivore selectivity and response to sheep grazing in Patagonian steppe grasslands. *J. Appl. Ecol.* **2005**, *42*, 50–59. [[CrossRef](#)]