A study of the effects of grazing behaviour on ecosystems in grassland ecosystems based on GPS data and plant surveys

Jianan Yao[1,2,3,*], Shifeng Wang[1,2], Binbin Wang[4], Junkui Niu[1,2], Junfeng Zhu[1,2], Wenbing Liu[1,2], Long Chen[4], and Lin Kang[4]

[1]Yinshanbeilu Grassland Eco-Hydrology National Observation and Research Station, China Institute of Water Resources and Hydropower Research, Beijing 100038, China
[2]State Key Laboratory of Simulation and Regulation of Water Cycle in River Basin, China Institute of Water Resources and Hydropower Research, Beijing 100044, China
[3]School of Science, Inner Mongolia University of Technology, Hohhot 010051, China
[4]Inner Mongolia Institute of Metrology Testing and Research, Hohhot 010010, China

*yaojn@iwhr.com

Abstract. Grassland ecosystems are one of the most widely distributed ecosystems on Earth, and grazing behavior helps to maintain the diversity of vegetation in grassland ecosystems. However, excessive grazing intensity can have obvious negative effects on vegetation cover. Therefore, it is extremely important to study the effects of grazing intensity on the amount, type and structure of vegetation in grassland ecosystems. The aim of this study was to investigate the effects of grazing behavior on ecosystems through GPS data and plant surveys. We carried out the following studies: Determine the trajectory and range of sheep movement by analyzing GPS data, and derive the calculation results of grazing intensity. We collected the vegetation around the wells through the needle prick method to analyze the vegetation coverage and vegetation diversity around the wells; we analyzed the impact of grazing intensity on the structure of plant communities and species diversity by tracking the GPS movement trajectories of grazing animals and combining the data from plant surveys. The research in this paper provides a reliable basis for scientific management and protection of ecosystems, and provides a basis for formulating reasonable grazing strategies, maintaining the ecological balance of grasslands, and preventing ecological problems that may be caused by overgrazing.

Keywords: Grazing Intensity; GPS locators; Vegetation; Grassland Ecosystems.

1 Introduction

Grassland ecosystems, as one of the most widely distributed ecosystems on Earth, occupy about 40% of the land surface and play a crucial role in maintaining ecological balance, conserving biodiversity and providing ecological services [1]. By regulating

A. E. Abomohra et al. (eds.), *Proceedings of the 2023 9th International Conference on Advances in Energy Resources and Environment Engineering (ICAESEE 2023)*, Atlantis Highlights in Engineering 29,
https://doi.org/10.2991/978-94-6463-415-0_34

the structure and composition of vegetation and preventing the overgrowth of certain plants, grazing behaviour helps to maintain the diversity of vegetation and create a relatively balanced ecosystem [2][3]. In terms of carbon cycling, grazing behaviour contributes to the cycling of carbon through grassland ecosystems, maintaining carbon balance and helping to mitigate climate change [4]. Grazing is also accompanied by greenhouse gas emissions, especially methane, which is one of the negative factors of global climate change [5][6]. Moderate grazing helps to maintain the balance of the water cycle and reduce soil erosion and soil loss [7]. However, overgrazing may lead to vegetation destruction and increase the risk of soil erosion [8]. Scientific and rational management and planning are essential to maximise the positive effects of grazing behaviour [9]. Therefore, studying the relationship between grazing behaviour and ecosystem health in order to develop sustainable grazing strategies is essential to promote the sustainable development of grassland ecosystems [10]. Wells are the main source of water in rural areas and grassland ecosystems, and in many areas, the activities of herbivores such as cattle and sheep may have a significant impact on the vegetation around wells and on the ecosystem as a whole [11].

The grazing behaviour of cattle and sheep regulates the structure and composition of vegetation through selective feeding, thus maintaining vegetation diversity and preventing overgrowth of certain plants. However, overgrazing may lead to soil erosion problems and jeopardise grassland ecology. In this paper, GPS technology was used to analyse the range, activity time and selective feeding behaviour of livestock in different areas. The relationship between GPS data and the ecological environment around the wells is used to analyse the dynamic relationship between plant community structure and grazing behaviour. The research in this paper provides a reliable basis for scientific management and protection of ecosystems and the formulation of reasonable grazing strategies.

2 Overview of the study area

Siziwangqi, belonging to Ulanchab City of Inner Mongolia Autonomous Region, is located in the central part of the autonomous region. With a total area of 25,516 square kilometres. Siziwangqi belongs to the mid-temperate continental monsoon climate zone. The area of natural grassland is 32.14 million mu, of which 30.76 million mu is pasture. Affected by natural and man-made factors, the grassland sand, degradation of the problem has not been curbed, grassland productivity decline, sheep farming income significantly reduced, resulting in pastoral areas due to poverty phenomenon is prominent.Although the protection and construction of grassland has been strengthened in recent years, it is difficult to change the traditional mode of animal husbandry production, and quantity-based animal husbandry still dominates. In particular, after the implementation of the grass-animal balance system, the number of heads of livestock kept per unit area of pasture has decreased, leading to a decline in herders' incomes, and the existence of a contradiction between ecological security and herders' increased incomes.

3 Research Methods

3.1 Data collection and vegetation survey

Grazing behaviour has wide-ranging and complex effects on grassland ecosystems. Grazing influences the species composition and community structure of vegetation. By analysing GPS trajectories, researchers are able to understand more accurately the animals' foraging behaviour, choice of resting sites and migration paths, providing data for the study of the ecological impact of grazing behaviour. In order to analyse the effects of grazing on the quantity, species and structure of vegetation in grassland ecosystems, we analysed the species and number of plants around the water wells, and then investigated the effects of grazing behaviour on grassland ecosystems.

As shown in Fig. 1, the GPS device map and the vegetation research site map, respectively. In order to obtain the GPS data and grazing trajectory of the sheep in the two experimental sites, it was obtained by wearing a GPS locator for the head sheep of the flock, which adopts CPS positioning, with a positioning accuracy of 5m, and the device adopts solar charging. The positioning interval was set to be 5 minutes to monitor the behavioural characteristics of the herd in real time, and the monitoring timeframe was the 2023 pasture growing season. The number and species of plants around the water wells in the two experimental sites were also investigated on site, and the corresponding data were recorded.

Fig. 1. Field test chart.(A)Map of GPS devices for sheep.(B)Vegetation research site.

3.2 Calculation of grazing intensity

Intensity of human activities is the degree of disturbance caused by human activities in a certain area. Grazing intensity, on the other hand, can be regarded as the degree of disturbance to the grassland caused by grazing activities within a region. Since the grazing activities of herders change with the movement of grassland units, the status of grassland resources in different units varies greatly, thus leading to the unevenness of the degree of disturbance to grassland caused by grazing. To solve this problem, a grazing probability indicator can be constructed for reflecting the grazing likelihood of different units in the region. Introducing the grazing probability deviation can then indicate the degree of deviation of the grazing pressure of each grassland unit relative to the overall regional grazing pressure. The grazing intensity symbol is I, which indicates the grazing intensity (sheep units/hm2) in a certain time, N represents the total number of livestock numbers converted to a uniform standard, and S is the range area (hm2). In the 2 typical pastures, the number of GPS points where the livestock appeared was counted. Calculations were performed to obtain the grazing intensity of the 2 typical pastures. The sampling points of each pasture were compared with the grazing intensity for data analysis of the two areas.

$$I = N / S$$

It was calculated that the grazing intensity I = 2.99 for selected herding households in Chagan Tolig Sumu and I = 47.60 for selected herding households in Honger Sumu.

3.3 Experimental data processing and analysis

In order to ensure the continuity of the data from the GPS device, we used a solar-powered GPS device. By interpolating the dynamic spatial model of GPS data processing, the trajectories of sheep activities were accurately restored as shown in Fig. 2, show the walking data and walking distance of the sheep, respectively. In the plant number and species survey, the pinning method was used for plant cover observation. As shown in Fig. 3, the number, species and coverage of vegetation around the water wells in the two experimental sites are shown respectively.

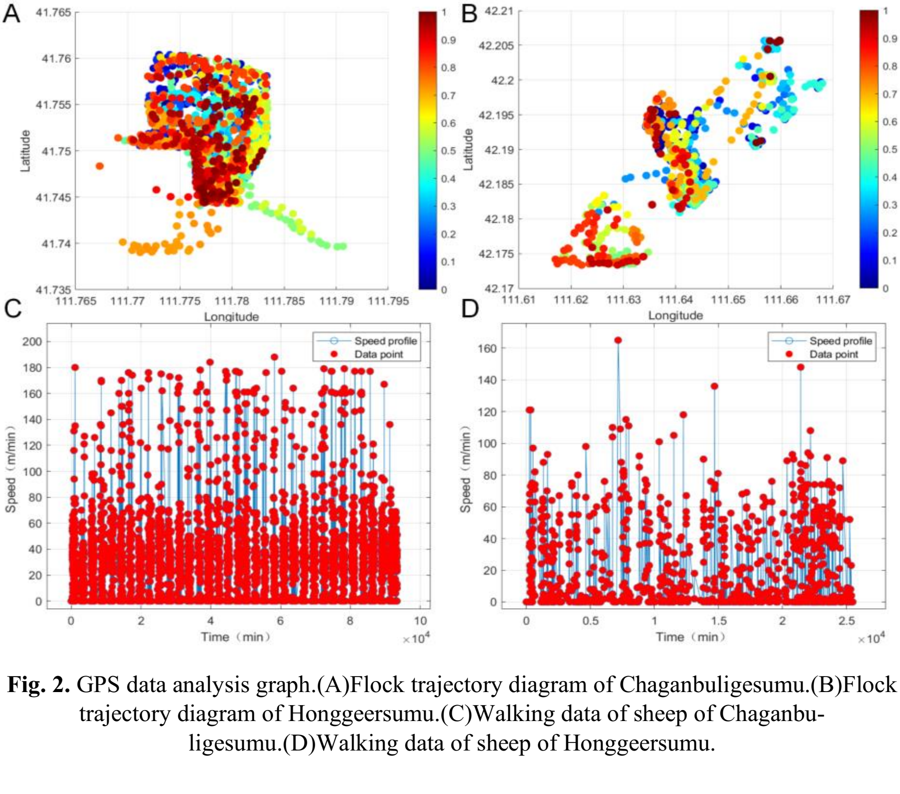

Fig. 2. GPS data analysis graph.(A)Flock trajectory diagram of Chaganbuligesumu.(B)Flock trajectory diagram of Honggeersumu.(C)Walking data of sheep of Chaganbuligesumu.(D)Walking data of sheep of Honggeersumu.

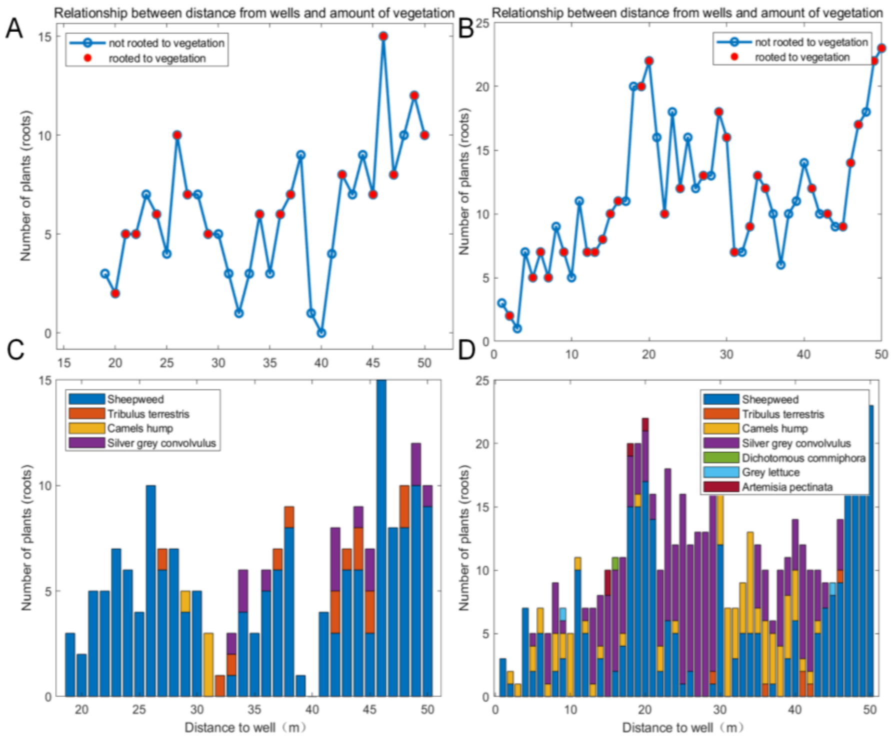

Fig. 3. Vegetation research data. (A)The amount and type of vegetation of Chaganbuligesumu.(B)The amount and type of vegetation of Honggeersumu.(C)Vegetation cover of Chaganbuligesumu.(D)Vegetation cover of Honggeersumu.

4 Analysis of results

The grassland vegetation showed significant changes under different grazing intensities. As shown in Fig. 4, with the gradual increase of grazing intensity, the number and species of grassland vegetation showed a decreasing trend. A decreasing trend in the number and species of vegetation was observed. When grazing intensity increased from 2.99 to 47.6, vegetation cover decreased from 56 to 37 per cent and vegetation species decreased from seven to four. At a grazing intensity of 2.99, the vegetation cover within 50 metres was 56%, indicating that relatively low grazing intensity favours vegetation growth and cover. However, when the grazing intensity increased to 47.6, the vegetation cover significantly decreased to 37%, indicating that too high a grazing intensity had a significant negative impact on the vegetation cover, thus affecting the diversity of vegetation.

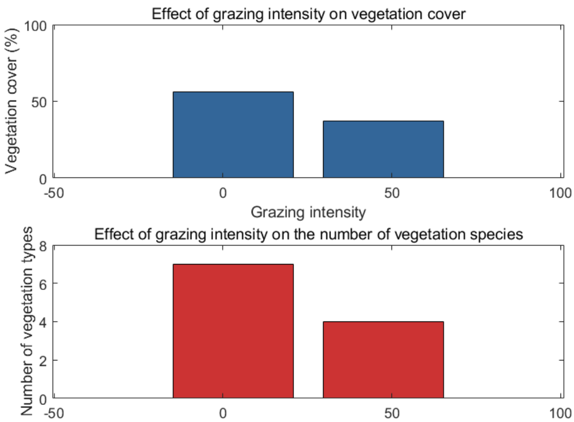

Fig. 4. Impact of grazing intensity on vegetation

5 Discussion

Under different grazing intensities, grassland vegetation shows significant changes, which have far-reaching effects on ecosystem stability and biodiversity. A decreasing trend in the amount of grassland vegetation was observed with the gradual increase in grazing intensity. This phenomenon could be attributed to the destruction of grassland vegetation due to excessive grazing and trampling by livestock, which led to the inhibition of vegetation growth. The decrease in the number of grassland communities may lead to the breakdown of the food chain in the ecosystem, affecting the interrelationships with other organisms. In addition, a reduction in the amount of vegetation may lead to a reduction in soil and water conservation capacity, increasing the risk of soil erosion, which in turn affects the health of the entire ecosystem; a reduction in the number of vegetation species as the intensity of grazing rises is another notable feature. Overgrazing may lead to the extinction or severe reduction of some plant species, thus affecting the diversity of grassland ecosystems. Therefore, grazing-induced reductions in vegetation species may pose a threat to the stability and sustainability of the entire ecosystem.

6 Conclusion

Under the grazing pattern, different grazing intensities affected both the number and cover of vegetation species, and the negative correlation between grazing intensity and vegetation number and species. Moderate grazing intensity helps to maintain the health and diversity of vegetation, while excessive grazing intensity may lead to vegetation degradation and ecosystem instability. The effect of grazing intensity on grassland vegetation is a complex and multi-layered process. Overgrazing may lead to marked changes in the amount, type and structure of vegetation in grassland ecosystems, which can have far-reaching effects on ecosystem health and function. Reduced numbers of grassland communities may lead to the breakdown of food chains in ecosystems, affecting interrelationships with other organisms. In addition, a reduction in the amount of vegetation may also lead to a decrease in soil and water conservation capacity, increase the risk of soil erosion, and thus affect the health of the entire ecosystem; therefore, it is important to formulate a reasonable ecological management strategy, conduct an in-depth study of the mechanisms of vegetation response under different grazing intensities, and use theories to guide grazing in order to ensure that grassland ecosystems are able to achieve sustainable development and the maintenance of ecological balance

Acknowledgements

This work was supported by the Inner Mongolia Autonomous Region Science and Technology Plan Project (No.2021GG0051), the Central Funds to guide local science and technology development of China (No. 2022ZY0027).

References

1. Foley, J. A. Global Consequences of Land Use[J]. Science, 2005, 309(5734):570-574. DOI:10.1126/science.1111772.
2. Wan H, Bai Y, Schnbach P, et al. Effects of grazing management system on plant community structure and functioning in a semiarid steppe: scaling from species to community[J]. Plant & Soil, 2011, 340(s1-2):215-226.DOI:10.1007/s11104-010-0661-2.
3. Sala O E, Chapin F I S, Armesto J J, et al. Sala, O. E. et al. Global biodiversity scenarios for the Year 2100. science[J]. Science, 2000, 287(5459):1770- 1774. DOI: 10.1126/science.287.5459.1770.
4. Smith P, Martino D, Cai Z et al. Greenhouse gas mitigation in agriculture[J]. 2008.
5. Jia T T, Liao L R, Wang J, et al. Effects of grazing on grassland ecosystems in the Loess Plateau based on Meta-analysis[J]. Journal of Grassland, 2022, 30(10): 10. DOI: 10. 11733/j.issn.1007-0435.2022.10.028.
6. Namgye, Szetoji, GaZanga, et al. Effects of microclimate and moderate grazing on plant community characteristics in alpine meadows[J]. Grassland Science, 2022, 39(12):2503-2515.
7. Sun C, Dong Q, et al. Effects of grazing on soil arthropod community structure and diversity in alpine grasslands of the Tibetan Plateau[J]. Journal of Grassland Science, 2022, 31(2):14. DOI:10.11686/cyxb2021309.
8. Xu M, Zhu W, Yang C, et al. Effects of different grazing intensities on soil seed bank in alpine meadows[J]. Grassland Science, 2023, 40(6):1461-1471.
9. Zhao X, Dong S, Yang M, et al. Socio-ecological system analysis of grazing on the Tibetan Plateau based on perturbation modelling[J]. Journal of Natural Resources, 2021. DOI: 10.31497/zrzyxb.20210816.
10. Zhao K, Zhu Y, Ha J, et al. Effects of grazing intensity and topography on carbon exchange in desert grasslands[J]. Chinese Journal of Grassland Science, 2021(012):043.
11. Mcsherry M E, Ritchie M E. Effects of grazing on grassland soil carbon: a global review[J]. Global Change Biology, 2013, 19(5): 1347-1357.DOI. 10.1111/gcb.12144.