



## Effects of different intensity grazing on ground-dwelling arthropods, especially Coleoptera

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**Key words:** adaptive grazing management; insects; plant leaf traits; plant community attributes; soil moisture

### Abstract

In order to investigate the effect of grazing on the inherent Arthropod-Plant relationship, various adaptive intensity grazing management experiments were conducted on typical steppe in Inner Mongolia. At the community level, arthropod richness was higher in light and heavy grazing than in moderate grazing, but there was no significant difference between grazing and no grazing. Both arthropod communities and Coleoptera prefer to survive in relatively dry soil environments. The lower the plant biomass, coverage, and height, the higher the Coleoptera abundance, likely due to grazing shaping a more open feeding space for visual predators. However, dry soil and more open feeding space are accompanied by more intense grazing interference, and the stronger the direct interference, the lower the biomass of arthropods, especially Coleoptera. The direct disturbance of grazing to arthropods (involuntary feeding and trampling) may often be underestimated, these direct disturbances may mask the indirect disturbance of grazing to arthropods through plants, and grazing may cause arthropods to choose a more stable environment rather than a better one. This means that it is necessary to incorporate surface arthropod-related monitoring data into the sustainable development and utilization management system of grasslands.

### Introduction

Large herbivore grazing has profound influence on soil physiochemical properties and biological communities (Lu et al. 2022), including arthropods that play a crucial role, in grassland ecosystems (Wilson 1987). On the one hand, the unconscious foraging and trampling of large livestock has a strong and direct effect on arthropods (Van et al. 2015), which is often underestimated. On the other hand, the large herbivore grazing induced variation in soil properties and plant communities can cascade to arthropod communities, and this ‘bottom-up’ effects (Hunter and Price 1992) of transmitting the variation in soil properties to plant communities and then to arthropod communities have been extensively investigated in grassland ecosystems (Lu et al. 2021).

The abundance and diversity of arthropods increase with the increase of plant production (Lu et al. 2021), as more food resources can support more abundant and diverse herbivores, and the increase includes

increase of generalists, specialists and unidentified predators (Lu et al. 2022). In addition to plant quantity, the vegetation environment, especially height and coverage, is also an important factor affecting arthropods. Many herbivores and predators may use chemical odour sensing and/or visual media search mechanisms to find their host plants or prey rather than searching randomly (Michel et al. 2007). The changes in vegetation height and coverage can alter the complexity of vegetation structure, thus the wind in vegetation canopy and the ability of arthropods searching for the odour concentration of host plants and prey (Cardé and Willis 2008); it can also directly affect the arthropods' visual search ability for host plants and prey (Randlkofer et al. 2010). Zhu et al. (Zhu et al. 2012) also found that plant structural heterogeneity (coefficient of variation of plant height) had a greater impact than plant species diversity on insect diversity in a meadow grassland.

The aim of this study was to elucidate the influence of large herbivores grazing on arthropod communities. The following two questions were studied: (1) What are the effects of large herbivores grazing on arthropod communities or Coleoptera? (2) How are the effects of grazing on plant communities and soil water content cascaded to arthropod communities or Coleoptera? The answers to these questions will deepen our understanding of the role of arthropods in maintaining ecosystem function and help develop management strategies to protect grassland ecosystems.

## **Methods**

### ***Study site***

This study was carried out with the Grassland Ecosystem Research Station of Inner Mongolia University, located in the Xilingol region of Inner Mongolia, China (44°15' N, 116°31' E, 1146 m a.s.l.), using four intensity grazing platforms (each paddock has 0, 3, 6, and 9 two-year-old sheep, named CK, LG, MG, HG; Fig.1). For specific regional climatic conditions, vegetation types, grazing designs and sampling methods for plant indicators, see (Shi et al. 2023).

### ***Arthropod sampling and identification***

The pitfall traps (plastic cups of 7cm in diameter and 7cm in depth) were used to sample the arthropods in the grasslands before the last rotational grazing of the season in August 2019, 2020 and 2021. Two trapping points, 10 m apart from each other, were set up on relatively consistent vegetation in each paddock, with three traps at each point. Approximately 5 ml of glycerol and 50 ml of 75% alcohol solution were added to each trap. The traps were placed in the grassland before 9:00am in a no-rain day for continuously collecting arthropods for 48 hours. All collected samples were stored in 75% alcohol solution, and returned to the laboratory and identified with optical microscopy according to references (Li et al. 1987). Specimens were identified to the family as far as possible, and a few unidentifiable arthropods to order. Adults and larvae were counted separately for most completely metamorphosed arthropods as they have different feeding habits. After identification, arthropods were placed on dry filter paper to constant weight, and weighted to 0.0001 g.

### ***Soil water content***

The top soil (0 – 10 cm) was sampled using the drill of 5 cm at the location close to the trapping points (3 drill at each point) after the arthropod collection and brought back to the laboratory for determining soil water content (SW) by weighing in fresh and dry after over-drying at 105 °C.

### ***Data processing and statistics***

The relative abundance (RA) of an arthropod order, i.e., the percentage of the arthropod order abundance in total arthropod abundance, were calculated. Based on the RA, We found that Coleoptera accounted for 45.54% of the total community, so we focused on Coleoptera in addition to the community. The effects of

large herbivore grazing on the arthropod traits as well as sampling years were also analyzed using repeated measure analysis of variance. Plant indicators were reduced to an indicator axis VPCA by PCA analysis (58.97%). Greater VPCA represents greater plant biomass, coverage and height, while density and species richness are reversed. The effects of vegetation and soil factors on arthropod communities or Coleoptera were studied by linear or nonlinear fitting.

**Results**

**Effects of grazing on ground-dwelling arthropod communities or Coleoptera.**

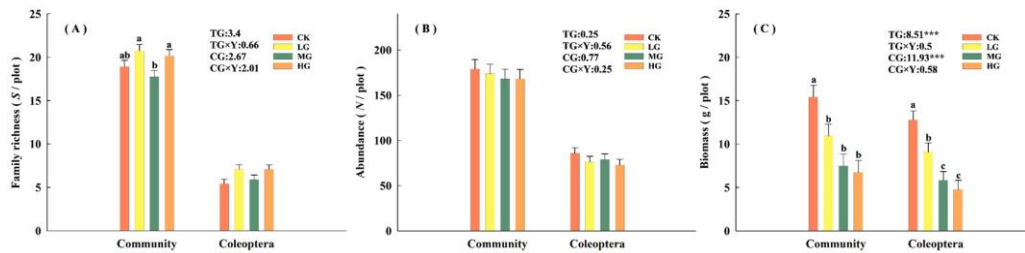


Fig. 1 Effects of different grazing intensities on ground-dwelling arthropod communities or Coleoptera. Different lowercase letters indicate significant differences between treatments (Duncan,  $p < 0.05$ ). T represents the total arthropod community; C represents Coleoptera; G stands for grazing; Y represents the year; G×Y represents the interaction between grazing and years. The number indicates the  $F$  value, and \*\*\* indicates  $P < 0.001$ .

**Effects of grazing on plant communities or soil water content.**

Table.1 Effects of different grazing intensities on vegetation, plant leaf characters and soil. All values are mean ± standard error. Lowercase letters a, b, and c indicate significant differences in the same indicator (Duncan,  $P < 0.05$ ).

Indicators		CK	LG	MG	HG
VPCA	PD	345.34±15.31b	321.72±31.24b	387.15±29.7ab	454.33±23.38a
	PR	7.25±0.7bc	7±0.96c	9.5±0.86b	12.25±0.7a
	PB	225.45±6.30a	214.06±12.50ab	188.59±13.10b	141.2±15.10c
	VC	66.11±2.27a	61.99±1.96ab	57.73±1.90b	56.75±2.66b
	PH	27.75±2.02a	28.56±1.69a	21.71±0.91b	16.53±0.68c
Plant	SD	12.71±1.04b	14.91±0.49a	13.03±0.56ab	9.68±0.34c
Soil	SW	0.1452±0.0046a	0.1440±0.0051a	0.1336±0.0039ab	0.1286±0.0029b

Abbreviations: PD: Plant density(individual/m<sup>2</sup>); PR: Plant species richness; PB: Plant biomass(g/m<sup>2</sup>); VC: Vegetation cover(%); PH: Plant height(cm); SD: Standard deviation of plant height(cm); SW: soil water content(g/g).

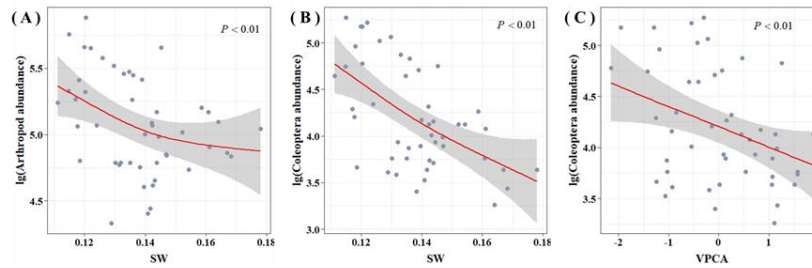
**Relationship between plant community or soil water content and arthropod community or Coleoptera.**

Fig. 2 Relationship between soil water content and the abundance of arthropod communities (A) or Coleoptera (B), and relationship between plant community attributes and Coleoptera abundance (C).

**Discussion**

Our results suggest that the difference in arthropod family richness across grazing intensities may be related with the grazing-induced changes in vegetation environment and the resources available to arthropods. In the *LG* grassland, vegetation height was uneven and structure was complex, and this type of vegetation provides a diverse living space (Zhu et al. 2012) and support a high arthropod family richness. In the *MG* grassland, the vegetation height variation and structural complexity was lower, thus support a lower arthropod family richness (Table.1). In the *HG* grassland, although vegetation structure was simple, the abundant faeces and blood of large herbivore provide more diverse food resources for scavengers and parasites (Van et al. 2015), which may be major factors for relatively high arthropod family richness in *HG* grasslands.

Grazing did not change the abundance of arthropod communities and Coleoptera, and neither community nor Coleoptera preferred moist environments. Indeed, low soil water content increases arthropod survival (O'Neill et al. 2003). But this change in soil water content is caused by grazing (Lunt et al. 2007). Similarly, grazing reduces plant biomass, plant height, and cover, which provides better hunting space for visual predators (Coleoptera) (Michel et al. 2007). The positive effects of grazing (drier soil and more open feeding space) are accompanied by stronger negative effects (trampling, unconscious feeding), and the reduction in plant biomass means fewer herbivores, suggesting that the two effects can cancel each other out to a certain extent (Van et al. 2015).

In no-grazing or light grazing grasslands, the vegetation is tall and dense, and the litter layer is thicker, which can provide adequate food (Lu et al. 2022) and a more stable living environment for arthropods (Pétillon et al. 2008). However, high grazing intensity increased the damage to arthropods caused by involuntary foraging and trampling (Wang et al. 2024), which is often underestimated. For example, while beetles' hard elytra allows them to adapt to more diverse environments (Parker 2016), beetles are also more likely to die when trampled by large herbivores. At the same time, some Coleoptera insects have faked death (Humphreys and Ruxton 2018), which may also increase the probability of being trampled to death.

Grazing reduced the biomass of arthropod community and Coleoptera. In the case of Coleoptera, which are mostly predators, this could disrupt the ecological balance of the entire ecosystem. At the same time, the direct disturbance of grazing appears to have a stronger effect on arthropods, changing the arthropod's preference for a suitable environment. This suggests that, in addition to the impact of environmental and management factors on arthropods, more attention needs to be paid to arthropod adaptation to different grassland use patterns.

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