Plastic Response of Individual Functional Traits in Seriphidium transiliense to Short-term Grazing Exclusion (Postprint)

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Abstract

To investigate the effects of grazing prohibition on plant individual functional traits, we measured the individual phenotypic characteristics, modular biomass, and their allocation ratios of Seriphidium transiliense, the constructive species in Artemisia desert grassland, under short-term grazing prohibition in Hutubi County, Manas County, and Ashili Township of Changji City, Xinjiang. The results showed that the response of individual functional traits of Seriphidium transiliense to short-term grazing prohibition varied among sites. Most traits such as plant height, aboveground biomass, leaf number, and leaf biomass in Hutubi and Manas plots increased significantly ($P<0.05$), whereas most functional traits in the Changji plot showed increases but were not significant. Overall analysis revealed that after short-term grazing prohibition, plant height, aboveground biomass, leaf number, stem biomass, and leaf biomass of Seriphidium transiliense increased significantly by 21.32%, 48.97%, 104.50%, 50.18%, and 100.00%, respectively ($P<0.05$), while root collar diameter and primary and tertiary branch numbers decreased significantly; secondary branch number, reproductive biomass, and allocation ratios of various modular biomasses showed no significant changes. Significant linkage effects existed between individual phenotypic traits of Seriphidium transiliense and its modular biomass and allocation ratios, and short-term grazing prohibition could significantly alter the correlations among some individual functional traits. The study indicates that short-term grazing prohibition promotes recovery of individual functional traits of Seriphidium transiliense, which is beneficial for restoration of degraded Artemisia desert grassland.

Full Text

Response of Short-term Grazing Exclusion to Individual Functional Traits of *Seriphidium transiliense*

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Abstract

This study measured the phenotypic traits, biomass, and allocation ratios of *Seriphidium transiliense* in sagebrush desert ecosystems across three experimental sites in Manas County, Hutubi County, and Ashili Township of Changji City, Xinjiang, to elucidate the response mechanisms to short-term grazing exclusion. The results demonstrated that the response of individual functional traits to short-term grazing exclusion varied among experimental plots. Most functional traits—including plant height, aboveground biomass, leaf number, and leaf biomass—in the Hutubi and Manas plots increased significantly ($P<0.05$), whereas those in the Changji plot showed increases but without statistical significance. Compared with the control plots, the plant height, aboveground biomass, leaf number, stem biomass, and leaf biomass of *S. transiliense* increased significantly by 21.32%, 48.97%, 104.50%, 50.18%, and 100.00%, respectively ($P<0.05$). In contrast, the taproot diameter, first-grade branch number, and third-grade branch number decreased significantly, while no significant changes were observed in second-grade branch number, reproductive biomass, or biomass allocation ratio ($P<0.05$). Correlation analysis revealed significant linkages between phenotypic traits and biomass allocation patterns, and short-term grazing exclusion significantly altered the correlations among individual functional traits. In summary, short-term grazing exclusion can promote the recovery of individual functional traits in *S. transiliense* and facilitate the regeneration of degraded sagebrush desert grassland ecosystems.

Keywords: short-term grazing exclusion; *Seriphidium transiliense*; functional trait; phenotypic trait; biomass allocation; Xinjiang

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1. Introduction

Grassland degradation has become a critical ecological issue in arid and semi-arid regions, with approximately 4.0×10 hm^2 of grassland area affected, representing 41.70% of total grassland resources [1]. Grazing exclusion has been

widely implemented as a restoration strategy to reverse degradation and improve ecosystem functioning [2-4]. Previous studies have documented the effects of grazing exclusion on vegetation biomass [5-7], soil nutrients [8-9], and plant functional traits [10-11]. However, the response mechanisms of individual plant species, particularly dominant shrubs such as *Seriphidium transiliense*, to short-term grazing exclusion remain poorly understood. This study investigates how *S. transiliense* modulates its phenotypic traits and biomass allocation strategies in response to grazing cessation across different ecological contexts.

2. Materials and Methods

2.1 Study Area and Experimental Design The study was conducted at three experimental sites in Xinjiang: Manas County (43°52 N, 87°03 E), Hutubi County (43°58 N, 86°32 E), and Ashili Township in Changji City (44°01 N, 86°09 E). Each site established grazing exclusion plots and corresponding control plots in June-July 2015. The exclusion plots were fenced to prevent livestock grazing, with plot sizes of 4000 m^2 in Manas and Hutubi, and 1000 m^2 in Changji. The control plots remained under traditional grazing management. Vegetation measurements were conducted in September 2017 after approximately 160-190 days of grazing exclusion.

2.2 Data Collection Fifteen individual *S. transiliense* plants were randomly selected from each plot for measurement of functional traits. The log response ratio (LRR) was calculated following Niu et al. [26] to quantify the response magnitude:

$$LRR = \log\left(\frac{\text{Trait value in exclusion plot}}{\text{Trait value in control plot}}\right)$$

Plant height was measured with a precision of 1 mm using a ruler. Aboveground biomass components—including stem biomass, leaf biomass, and reproductive biomass—were harvested and oven-dried at 65°C for 48 hours before weighing to 0.01 g precision. Belowground biomass was extracted from soil cores (0-30 cm depth) and processed similarly.

2.3 Statistical Analysis All data were analyzed using SPSS 19.0 software. The following biomass allocation indices were calculated:

- Aboveground biomass (AGB) = Stem biomass + Leaf biomass + Reproductive biomass
- Stem biomass allocation (SBA) = (Stem biomass / AGB) × 100%
- Leaf biomass allocation (LBA) = (Leaf biomass / AGB) × 100%
- Reproductive biomass allocation (RBA) = (Reproductive biomass / AGB) × 100%

Significance testing was performed using t-tests ($P<0.05$). SigmaPlot 14.0 was used for graphical visualization, with error bars representing standard errors.

3. Results

3.1 Effects on Biomass and Allocation Short-term grazing exclusion significantly increased total aboveground biomass by 38.54% across all sites ($P<0.01$). The biomass allocation pattern followed the order: stem biomass > leaf biomass > reproductive biomass. No significant differences in biomass allocation ratios were detected among the three experimental sites ($P>0.05$).

The stem biomass allocation in Hutubi and Manas plots increased by 133.18% and 180.13%, respectively ($P<0.01$), while leaf biomass allocation increased by 32.06% ($P<0.05$). The Changji plot showed no significant changes in biomass allocation patterns ($P>0.05$).

3.2 Response of Functional Traits Grazing exclusion significantly enhanced most phenotypic traits in Hutubi and Manas plots ($P<0.05$), but had limited effects in the Changji plot. Plant height, aboveground biomass, leaf number, stem biomass, and leaf biomass showed significant positive responses, while taproot diameter and branch numbers (first-grade and third-grade) decreased significantly. Second-grade branch number, reproductive biomass, and biomass allocation ratios remained unchanged ($P>0.05$).

Correlation analysis revealed significant positive relationships between aboveground biomass and leaf number ($r=0.66$, $P<0.01$), and between stem biomass and plant height ($r=0.73$, $P<0.01$). Grazing exclusion altered these correlation patterns, weakening some relationships while strengthening others, particularly those related to resource acquisition traits.

4. Discussion

The differential responses of *S. transiliense* across the three sites suggest that local environmental conditions mediate the effectiveness of grazing exclusion. The significant increases in aboveground biomass and leaf number in Hutubi and Manas indicate rapid recovery potential in moderately degraded sites, consistent with findings from Leymus chinensis grasslands [28]. The lack of significant response in Changji may reflect more severe degradation or different soil nutrient conditions [29].

The observed trade-offs between aboveground and belowground traits—where aboveground traits increased while taproot diameter decreased—support the optimal allocation theory [35]. This pattern suggests that *S. transiliense* prioritizes aboveground growth for light competition when grazing pressure is removed, while reducing investment in belowground structures. The stability of biomass allocation ratios indicates that this species maintains consistent resource allocation strategies despite short-term environmental changes.

Short-term grazing exclusion proved effective for initiating restoration of degraded sagebrush desert grasslands, particularly by enhancing key functional traits related to productivity and competitive ability. However, long-term mon-

itoring is needed to assess whether these initial responses translate to sustained ecosystem recovery.

5. Conclusion

Short-term grazing exclusion significantly promoted the recovery of individual functional traits in *Seriphidium transiliense*, with notable increases in plant height, aboveground biomass, and leaf number. The treatment altered trait correlations and biomass allocation patterns, facilitating the regeneration of degraded sagebrush desert grassland. These findings provide scientific support for implementing grazing exclusion as a restoration strategy in arid grassland ecosystems.

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Note: Figure translations are in progress. See original paper for figures.