Moderate grazing intensity enhances regrowth without altering spatial heterogeneity in a perennial ryegrass pasture

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Abstract

The key to sustainable pasture management is balancing the needs of grazing herbivores with preserving vegetation condition and growth potential over time. One factor that influences this balance is the spatial heterogeneity of grazed vegetation, a consequence of grazing behavior and a driver of forage harvesting efficiency in animals. This study assessed how grazing intensity (GI) affects spatial heterogeneity of sward structure and post-grazing regrowth. The experiment was conducted in spring-summer 2022 on a *Lolium perenne* pasture. It compared low GI (25% sward height reduction) to moderate GI (50%) on 180 m² paddocks grazed by sheep in a rotational system with a 3-day occupation time. GI treatments were applied by adjusting herd size, three sheep for low GI and six for moderate GI. Normalized Difference Vegetation Index (NDVI) data, acquired using unmanned aerial systems, were combined with ground-based sward height measurements. Over two grazing cycles (C1 and C2), Moran's global (P = 0.16) and local (P = 0.84) indices, plus semivariance analyses, revealed increased spatial heterogeneity across paddocks, with no significant differences between GI treatments. However, moderate GI tended to favor regrowth during C2 (0.16 vs 0.08 cm day^{-1}, P = 0.02), suggesting more efficient forage utilization under moderate grazing.

Key words: sward height, pasture regrowth, grazing management, grazing intensity

Introduction

Grazing animals do not harvest herbage uniformly: selective biting, movement between feeding stations, and asynchronous regrowth create vegetation patches at different stages, which shape both pasture productivity and intake efficiency (Rook et al., 2004). Conventional post-grazing targets aiming to maximize harvest rates in rotational settings help maintain a homogeneous sward, but lead to low post-grazing heights, slow plant recovery and reduced intake rates. The "rotatinuous" stocking method proposes to reconcile efficient forage collection with rapid plant regrowth by setting higher post-grazing sward height targets to maintain a high animal intake rate (Savian et al., 2020). Nevertheless, such a strategy leaves more ungrazed vegetation after paddock occupation, with potential short-term effects on sward heterogeneity during subsequent grazing-regrowth cycles. To test this hypothesis, we compared the effects of two post-grazing targets (25% vs. 50% sward height reduction) on sward spatial heterogeneity and plant regrowth in a ryegrass pasture rotationally grazed by sheep.

Materials and methods

The experiment was conducted on a 1.1 ha perennial ryegrass pasture at Gembloux Agro-Bio Tech (Belgium) in spring-summer 2022. Twenty 18 × 10 m paddocks were rotationally grazed by 6-month-old Charolais ewe lambs with a 3-day occupation time. Two treatments were applied: starting from the same pre-grazing sward height (SH) of 12 cm, the moderate grazing intensity (GI) treatment (T2, 50% GI) had a post-grazing SH of 6 cm while the low GI treatment (T1, 25% GI) had a post-grazing SH of 9 cm. Lambs were weighed at the beginning and end of each grazing cycle, which corresponds to the time it takes for animals to return to the same paddock. They had an average weight of 41 kg at the start of cycle 1 and 43 kg at the start of cycle 2, with no difference between treatments.

Each treatment was monitored over two grazing cycles: 18 and 30 days (low GI) vs. 24 and 36 days (moderate GI). SH was monitored at 40 georeferenced points per paddock using a sward stick before and after grazing. Multispectral cameras embarked in an unmanned aerial system (DJI P4, 35 m flight height) captured NDVI rasters (1.4 cm resolution; 5.4×10^5 pixels per paddock). Heterogeneity was assessed using global and local Moran's I, along with semivariograms derived from NDVI data. The main parameters calculated were the nugget (C_o), reflecting fine-scale variability; the sill ($C_o + C$), representing total variance; and the range (α), indicating the spatial extent of autocorrelation. Generalized linear mixed models (gamma distribution, log link) tested the effects of treatment, cycle, and moment (pre-/post-grazing) on sward height, NDVI, and spatial metrics, with paddock included as a random factor. The paddock was the experimental unit (n = 10 per treatment).

Results and discussion

Pre-grazing NDVI did not differ between treatments (cycle 1: 0.74 ± 0.08 in T1 vs. 0.75 ± 0.08 in T2; cycle 2: 0.73 ± 0.07 vs. 0.75 ± 0.08; Table 1; $P = 0.79$ and $P = 0.66$, respectively). After three days of grazing, NDVI declined to 0.66 ± 0.11 in T1 but to 0.57 ± 0.12 in T2 during cycle 1 ($P < 0.01$) and to 0.65 ± 0.10 vs. 0.52 ± 0.16 in cycle 2 ($P < 0.01$), confirming greater biomass removal under moderate grazing (Table 1). Figure 1 (paddock 5, T2) illustrates the sharper color shift towards yellow/pink and the steeper post-grazing semivariogram that accompanies this stronger biomass removal.

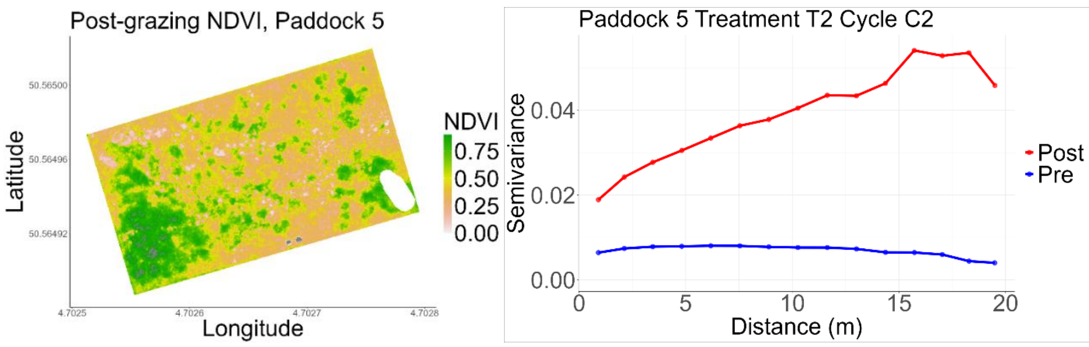

Figure 1: Post-grazing NDVI map of paddock 5 (T2) and corresponding semivariogram, cycle 2

Global Moran's I increased after grazing in every cycle (cycle 1: 0.75 to 0.82 in T1 and 0.74 to 0.83 in T2; cycle 2: 0.77 to 0.87 and 0.79 to 0.91; Table 1). The treatment effect was non-significant for both global ($P = 0.16$) and local ($P = 0.84$) Moran's I, whereas the moment (pre- and post-grazing) effect was highly significant ($P < 0.01$). Local Moran's I and the semivariogram sill followed the same pattern, confirming greater patchiness once animals had grazed. Post-grazing sills, for example, doubled from 7.2×10^{-3} to 15×10^{-3} in T2 (cycle 1) and from 5.6×10^{-3} to 26×10^{-3} in T2 (cycle 2; Table 1). These results show that a 50% height reduction does not homogenize the sward any more than a 25% reduction because lambs create and maintain patches through selective foraging, avoidance of stemmy or dung-contaminated zones and asynchronous regrowth (Brambilla et al., 2013).

Table 1: NDVI, global and local Moran's I, and semivariogram parameters (nugget Co, sill Co + C, and range α) by treatment (T1, T2), cycle (C1, C2), and grazing moment (pre- and post-grazing)

			NDVI	Global M I	Local M I	C_o	$C_o + C$	α
T1	C1	Pre	0.74 ± 0.08	0.75 ± 0.03	0.57 ± 1.03	0.0038	0.0051	3.19 ± 0.67
		Post	0.66 ± 0.11	0.82 ± 0.03	0.86 ± 2.44	0.0068	0.011	3.89 ± 0.64
	C2	Pre	0.73 ± 0.07	0.77 ± 0.03	0.34 ± 0.96	0.0032	0.0042	3.26 ± 0.93
		Post	0.65 ± 0.10	0.87 ± 0.01	0.59 ± 1.82	0.0062	0.012	6.23 ± 3.42
T2	C1	Pre	0.75 ± 0.08	0.74 ± 0.03	0.49 ± 0.79	0.0038	0.0072	3.07 ± 0.65
		Post	0.57 ± 0.12	0.83 ± 0.01	0.75 ± 1.88	0.010	0.015	3.64 ± 1.46
	C2	Pre	0.75 ± 0.08	0.79 ± 0.02	0.13 ± 0.70	0.0041	0.0056	4.96 ± 2.18
		Post	0.52 ± 0.16	0.91 ± 0.01	0.35 ± 0.96	0.012	0.026	7.20 ± 3.87

Table 2: Average regrowth rate in cm day^{-1} per treatment and cycle

Cycle	Treatment 1	Treatment 2	*P* value
C1	0.23 ± 0.16	0.10 ± 0.08	0.069
C2	0.08 ± 0.08	0.16 ± 0.07	0.02

Regrowth rates (

Table *2*) revealed a treatment × cycle interaction. In cycle 1, lightly grazed paddocks recovered faster (0.23 ± 0.16 cm day^{-1} in T1 vs. 0.10 ± 0.08 cm day^{-1} in T2, $P = 0.069$). In cycle 2 the ranking reversed, with T2 regrowing twice as fast (0.16 ± 0.07 cm day^{-1} vs. 0.08 ± 0.08 cm day^{-1}, $P = 0.02$). This crossover suggests compensatory photosynthesis and enhanced nutrient return triggered by the heavier, yet conservative, defoliation (Ye et al., 2020). Twice as many lambs in T2 also redistributed faecal nutrients more evenly, further stimulating second-cycle growth.

Conclusion

Moderate grazing intensity removed more biomass than low intensity. Still, it maintained similar spatial heterogeneity in the short term due to selective foraging and dung avoidance. It also led to faster regrowth in the second cycle. This suggests moderate grazing as an efficient strategy to optimize forage use and animal performance under favorable weather and soil conditions. Integrating spatial metrics into pasture management could help improve the timing of grazing rotations and avoid overgrazing. Further work should assess seasonal dynamics and forage quality to confirm these results in broader contexts and over longer periods of time.

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