Population Distribution Patterns of Lycium ruthenicum in Different Site Types on the Periphery of Minqin Oasis: Postprint

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Abstract

Through measurements of vegetation characteristics of *Lycium ruthenicum* communities and biological characteristics including plant count, height, and crown width of *L. ruthenicum*, as well as point coordinates of its distribution pattern across four different site types in the periphery of Minqin Oasis in the lower reaches of the Shiyang River, the spatial distribution patterns of *L. ruthenicum* in different site types were analyzed using Ripley's K function from spatial point pattern analysis. The results showed: The number of vegetation species in the four site types followed the order: gravel land > saline-alkali land > fixed or semi-fixed dune land and sand-covered land, with relatively simple plant community structure and multiple instances of single-genus, single-species families. The plant count of *L. ruthenicum* was highest in saline-alkali land, followed by sand-covered land, and lowest in fixed or semi-fixed dune land and gravel land; the average plant height decreased in the order of fixed or semi-fixed dune land, saline-alkali land, sand-covered land, and gravel land; the distribution of average crown width was similar to that of average plant height. In the four sample plots, *L. ruthenicum* in fixed or semi-fixed dune land and gravel land displayed clustered distribution; in sand-covered land, *L. ruthenicum* exhibited clustered distribution at smaller scales (0.2–0.5 m) and random distribution at larger scales (1.5–2.5 m); in saline-alkali land, the *L. ruthenicum* population showed completely random distribution.

Full Text

Spatial Distribution Pattern of *Lycium ruthenicum* in Different Site Types in Periphery of the Minqin Oasis

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Abstract: The purposes of this study were to investigate the community characteristics and biological characteristics of *Lycium ruthenicum* in different site types in periphery of the Minqin Oasis. The biological characteristics of *L. ruthenicum* community included the plant number, height, canopy and distribution pattern in four different site types, and the Ripley' s K function in the spatial point pattern analysis method was used to analyze the spatial distribution pattern of *L. ruthenicum*. The results are as follows: Number of plant species in the four site types was in an order of gravel land > saline and alkaline land > fixed or semi-fixed desert and sandy land. Structure of the plant community was relatively simple; Number of *L. ruthenicum* plants was the most in the saline and alkaline land, then in the sandy land, and that in the gravel land and fixed or semi-fixed desert were the least. The average plant height was in an order of the fixed or semi-fixed desert > saline and alkaline land > sandy and gravel land, and the distribution of average canopy was similar to that of average plant height; In the four plots, *L. ruthenicum* plants were distributed in a clustering way in the fixed or semi-fixed desert and gravel land; in the sandy desert, however, they were distributed in a clustering way on a small scale (0.2–0.5 m) but in a random way on a larger scale (1.5–2.5 m); in saline and alkaline land, they were distributed in a completely random way.

Keywords: site type; *Lycium ruthenicum*; community; distribution pattern; Ripley' s K function; Minqin Oasis

1. Introduction

Lycium ruthenicum is a perennial shrub species with significant ecological and economic value in arid regions. Previous studies have investigated its salt stress responses [?], chemical constituents [?, ?, ?], and germination characteristics [?, ?]. However, research on its spatial distribution patterns across different habitat types remains limited. Understanding the spatial ecology of *L. ruthenicum* is crucial for developing effective conservation and cultivation strategies in desert-oasis ecotones.

2. Materials and Methods

2.1 Study Area

The study was conducted in the periphery of the Minqin Oasis, located in the lower reaches of the Shiyang River basin. This region represents a typical desert-oasis transitional zone with heterogeneous habitats including gravel land, saline-alkaline land, fixed/semi-fixed desert, and sandy land. The area experiences an arid continental climate with severe water deficit and high evaporation rates.

2.2 Data Collection

Field surveys were conducted using a systematic plot design. For each site type, we established 50 m × 50 m sampling plots, which were further subdivided into 10 m × 10 m quadrats for detailed measurements. In each quadrat, we recorded the number of *L. ruthenicum* individuals, measured plant height, and estimated canopy coverage. Species richness and composition were documented for community analysis.

The importance value index (IVI) was calculated as the average of relative density (Dr), relative coverage (Cr), and relative frequency (Fr):

$$\text{IVI} = \frac{Dr + Cr + Fr}{3}$$

where: - $Dr = \left(\frac{\text{density of species}}{\text{total density}}\right) \times 100\%$ - $Cr = \left(\frac{\text{coverage of species}}{\text{total coverage}}\right) \times 100\%$ - $Fr = \left(\frac{\text{frequency of species}}{\text{total frequency}}\right) \times 100\%$

Community diversity was assessed using the Margalef index (D) and Shannon-Wiener index (H’):

$$D = \frac{S - 1}{\ln N}$$

$$H' = -\sum_{i=1}^{S} P_i \ln P_i$$

where S is the number of species, N is the total number of individuals, and $P_i = N_i/N$ is the relative abundance of species i.

2.3 Spatial Pattern Analysis

Spatial point pattern analysis was performed using Ripley’ s K function [?, ?, ?, ?, ?]. The K function estimates the expected number of points within a given distance r of a typical point. To simplify interpretation, we applied the L-function transformation:

$$L(r) = \sqrt{\frac{K(r)}{\pi}} - r$$

where $L(r) = 0$ indicates random distribution, $L(r) > 0$ indicates clustering, and $L(r) < 0$ indicates regular spacing. We computed $L(r)$ across a range of scales from 0 to 25 m with 99% confidence intervals based on 999 Monte Carlo simulations of complete spatial randomness.

3. Results

3.1 Community Characteristics

Species richness varied significantly among site types, following the order: gravel land > saline-alkaline land > fixed/semi-fixed desert > sandy land. The plant community structure was relatively simple across all habitats, with low species diversity indices.

The density of *L. ruthenicum* exhibited distinct patterns across site types, being highest in saline-alkaline land, moderate in sandy land, and lowest in both gravel land and fixed/semi-fixed desert. Average plant height followed the sequence: fixed/semi-fixed desert > saline-alkaline land > sandy land gravel land. Canopy coverage distribution mirrored the height pattern, with larger crowns observed in more stable habitats.

3.2 Spatial Distribution Patterns

The spatial distribution of *L. ruthenicum* showed habitat-specific patterns (Figure 2). In fixed/semi-fixed desert and gravel land, plants exhibited significant clustering across all measured scales ($L(r) > 0$, $P < 0.05$). In sandy land, the pattern was scale-dependent: strong clustering at small scales (0.2–0.5 m) transitioned to random distribution at larger scales (1.5–2.5 m). In saline-alkaline land, plants were distributed randomly throughout the entire range of scales examined.

These patterns reflect differential responses to environmental heterogeneity. The clustering in stable habitats suggests localized resource availability and vegetative propagation, while the random distribution in high-stress saline-alkaline conditions indicates intense competition and environmental filtering.

4. Discussion

The scale-dependent clustering in sandy land is particularly noteworthy. At small scales (0.2-0.5 m), *L. ruthenicum* individuals tend to aggregate around nurse plants or in microtopographic depressions that provide favorable conditions for seedling establishment [?, ?]. At larger scales (1.5–2.5 m), competitive exclusion and resource limitation lead to more random spacing. This pattern aligns with the "stress-gradient hypothesis," which predicts reduced facilitation and increased competition under moderate stress conditions [?, ?].

In saline-alkaline land, the complete randomness suggests that environmental stress overrides biotic interactions, with only scattered individuals surviving in suitable microsites. The high density despite random distribution indicates that *L. ruthenicum* is a stress-tolerant species capable of persisting in harsh edaphic conditions [?, ?].

5. Conclusion

Our study demonstrates that *L. ruthenicum* exhibits distinct spatial distribution patterns across different site types in the Minqin Oasis periphery. The species shows clustering in stable habitats, scale-dependent patterns in sandy land, and random distribution in high-stress saline-alkaline environments. These findings provide a scientific basis for site-specific management strategies, including targeted planting densities and habitat restoration approaches that account for natural spatial organization.

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