

Leaf nitrogen and phosphorus stoichiometry of natural plant community and restorable plant community in the northern Qinghai-Tibet Plateau, China

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Introduction

The human engineering activities (highway, railway, cable, gas line and high line construction) has a negative impact on the alpine grassland ecosystem in the Qinghai-Tibet Plateau (QTP), and the natural restoration of plant community in land used for engineering construction is an important part of the rehabilitation of the degraded alpine grassland ecosystem. Previous studies have shown that the plant species and community diversity relationship in natural plant community and restorable plant community vary with the elevation (Guo *et al.* 2007) and restoration duration of land for engineering construction is more than 20 years at present (Ma *et al.* 2004). Understanding the mechanisms of plant species replacement in the process of plant restoration is important to restore the land used for engineering construction. The ecological stoichiometry is considered as an effective tool to disclose the inter-specific competition process and determine the succession trend (Güsewell 2004; Güsewell 2005; Yin *et al.* 2010). However, the stoichiometry relationship between natural plant community and restorable plant community is not well known yet. The objective of this study is to investigate the nitrogen (N) and phosphorus (P) stoichiometry of natural plant community and restorable plant community and its changes with elevation.

Methods

Study sites and field sampling

A field survey was conducted in late July 2012 along the Qinghai-Tibetan Highway from Kunlunshan (35°33.44'N, 94°04.15'E) to the southern Tanggulashan Pass (33°07.12'N, 90°52.67'E) in the northern QTP, China. The study area ranges from 4300 to 5100 m.a.s.l and experiences a cold and arid plateau continental climate, with mean annual temperature of -1.3 ~ -4.1°C. The vegetations of survey transect are dominated by *Carex moorcroftii* meadow and *Stipa purpurea* steppe. Based on elevation, six survey sites were designed along Qinghai-Tibetan Plateau Highway from north to south, followed by Xidatan, Budongquan, Wudaoliang, Hoh Xil, Fenghuoshan Mountains Pass and Wuli. At each survey site, four plots with the size of 10 m x 10 m were selected for natural plant community

and restorable plant community, respectively. Four subplots with the size of 0.5 m x 0.5 m for each plot were randomly used to harvest the plant samples. After clipping the above-ground parts at the soil surface, newly mature leaves were selected and collected, and then these leaves were sun-dried in the field, and oven-dried at 65°C for 48h when carrying back laboratory. Dry leaves were finely ground in a Wiley mill and screened by a 40-mesh screen.

N and P content and data statistics

Total N concentration was analysed calorimetrically by Kjeldahl acid-digestion method with a Foss autoanalyzer (AN3001) and total P concentration was measured by Vanadium-Ammonium Molybdate Colorimetric Method. Data were analysed with SPSS13.0, in which the bivariate correlation (Pearson's r) was used to analyse the correlation between N, P and N:P ratio and two-tailed Student's t -test was used to compare N,P stoichiometry.

Results

The average values of leaf N, P concentrations and N:P ratios at the community level were 17.36 ± 3.44 mg/g, 1.41 ± 0.38 mg/g and 12.98 ± 3.90 mg/g, respectively. The variability in leaf P [coefficient of variation (CV) = 0.27] was near that in N:P ratio (CV=0.30) across all observations, and the variability in leaf N (CV=0.20) was lower than those in leaf P and N:P ratio. Leaf P concentrations were negatively correlated with leaf N:P ratio ($Y_{N:P} = -7.25X_P + 23.23$, $R^2 = 0.50$, $P < 0.01$), while N and N:P ratio had no significant correlation, implying that the variation in N:P ratio was primarily determined by leaf P.

This study showed that the N concentration of restorable community in alpine steppe was higher than that in alpine meadow (Table 1). For alpine steppe, the N concentration of restorable community was higher than that of natural community; however, the N concentration was not significantly different between restorable community and natural community for alpine meadow. The P concentration and the N:P ratio were not significantly different between alpine steppe and alpine meadow. The mean leaf N:P ratios of natural plant communities and restorable plant community were 12 and 14, indicating the grassland plants in this

Table 1 . Statistical characteristics of leaf N,P concentrations and N:P ratios of Alpine steppe and Alpine meadow at the community level in the grassland of northern QTP (Mean \pm SD) (mg/g). Different lowercase letters in same list represented statistical significant differences ($P=0.05$). Xidatan and Hoh Xil belong to alpine steppe, and the other sites are alpine meadow.

Vegetation types	Community types	N (mg/g)	P (mg/g)	N:P
Alpine steppe	Natural community	16.02 \pm 0.57 b	1.48 \pm 0.24 a	11.12 \pm 2.11 a
	Restorable community	20.43 \pm 4.69 a	1.48 \pm 0.67 a	15.22 \pm 3.79 a
Alpine meadow	Natural community	16.53 \pm 0.38 b	1.37 \pm 0.07 a	12.38 \pm 2.10 a
	Restorable community	17.35 \pm 3.86 b	1.40 \pm 0.32 a	13.38 \pm 6.38 a

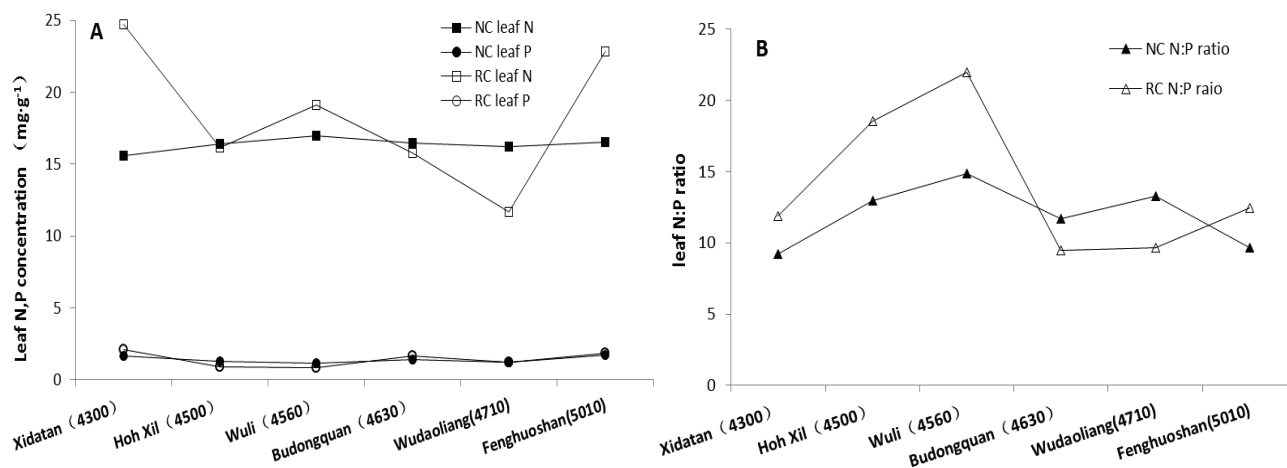


Figure 1. The spatial variations of N, P concentration (A) and N:P ratio(B) with elevation. NC, natural community; RC, restorable community.

region suffers from N-deficient.

The spatial variations of N, P concentration and N:P ratio with elevation at community level had no evident and consistent tendency (Figure 1).

Conclusion

The variation in N:P ratios is primarily determined by leaf P. The grassland of the northern QTP suffered from N-deficient overall, and the N:P ratios was not different between natural community and restorable community. The degree of N limitation for natural plant community was more severe than that for restorable community. The N, P stoichiometry characteristics was not different between alpine steppe and alpine meadow.

This study suggests that the spatial variations of N, P concentration and N:P ratio with elevation at community level had no evident and consistent tendency, indicating the altitude-induced

temperature difference has no impact on N, P stoichiometry in the northern Qinghai-Tibet Plateau, China.

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