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The effect of environmental factors on plant species diversity and productivity

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Key words: Bayinbuluk grassland, Shannon-Weiner index, Tianshan mountain, CCA ordination

Introduction The analysis of species-environment relationships is a central issue in plant ecology (Antoine, 2000). Productivity is an important index for studying ecosystem function and determining conservation measures. Many studies have focused on the impact of environmental factors on plant species distribution and composition (Campagne 2006). In this paper, we discuss the effects of environmental factors on grassland productivity, species diversity and species diversity-productivity relationships using plant and environmental data from alpine grasslands.

Materials and methods Bayinbuluk grassland is a typical alpine cold grassland (82° 27' -86° 17' E, 42° 18' -43° 34' N) on the southern slope of the Tianshan mountain region, Xinjiang Province, China. In 2006, nine sites (10 m × 10 m) were selected from typical vegetation types at 100 m vertical intervals along an elevation gradient. At each site, seven 1 m × 1 m quadrats were sampled for grass species in late July. Grass species frequency, height and cover were recorded. Aboveground biomass in each 1 m² plot was clipped, sun-dried and weighed. Three soil samples were collected at each site. Soils were analyzed for organic matter, pH, soluble calcium, soluble bicarbonate, and water content. HOBO Pro RH/TEMP Data Loggers installed at each site recorded air relative humidity and temperature during the growing season. Soil compaction was measured with a soil compaction meter.

Results Thirty-five indigenous species in 29 genera and 15 families were identified. Values of the Shannon-Weiner index varied from 2.02 to 2.40. Species richness was negatively related to pH (-0.805), Ca⁺² (-0.81), soil compaction (-0.755), air temperature (-0.742), total salinity (-0.733), and HCO₃²⁻ (-0.73) and was positively related to relative humidity (0.77) and soil water content (0.671). Aboveground biomass was negatively related to pH (-0.699), Ca⁺² (-0.794), and soil compaction (-0.739) and positively related to relative humidity (0.754). A positive relationship was found ($R^2 = 0.1847$, $P < 0.001$) between species richness and productivity across the 63 plots. CCA ordination showed that the first axis (Eigenvalue=0.704) accounted for 66.4% of the variation in environmental factors. Correlation between the first axis and species-environmental variables was 0.993. The second axis (Eigenvalue=0.349) explained 21.9% of the variation. Axis 1 was correlated to air temperature, relative humidity, HCO₃²⁻, total salinity, pH, and Ca⁺².

Conclusions Mittelbach (2001) found hump-shaped and positive species richness-productivity relationships at continental scales. Our results are consistent with the positive relationships. The study scale and environmental heterogeneity may effect the species richness-productivity relationships. Ca⁺², pH, soil compaction and relative humidity impacted species richness and productivity in Bayinbuluk grasslands. The results of CCA ordination showed there are high correlations between axis 1 and air temperature, relative humidity, HCO₃²⁻, total salinity, pH value, and Ca⁺².

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