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Nematode communities response to long-term grazing disturbance on Tibetan plateau

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ABSTRACT

Grazing by herbivores plays a key role in grassland ecosystems, but its effects on soil fauna biodiversity are not clear in alpine meadow ecosystems, especially on the Tibetan plateau. We investigated the effects of long-term grazing disturbance of varying intensities (low disturbed site, medially disturbed site, and seriously disturbed site) on ecosystem biodiversity and functional process using soil nematode communities. Soil physicochemical characteristics and plant communities were also measured to explore the relationships between soil nematode communities structure and key environment variable. Soil samples were collected in May, June, August, and October, 2013. The abundance of total nematode communities, plant feeders and bacterivores increased with the grazing intensity increase, and predators decreased with grazing intensity increase. Low disturbed site has the lowest abundance of fungivores. Grazing disturbance has no significant influence on abundance of omnivores ($P > 0.05$). Species richness was highest on seriously disturbed site and lowest on low disturbed site. MI and SI decreased as grazing intensity increase. The highest NCR was found in low disturbed site and the lowest in medially disturbed site. The highest EI was found in medially disturbed site and the lowest in low disturbed site. Principal component analysis (PCA) showed that nematode communities could be separated by three different grazing disturbance intensity sites. Redundancy analysis (RDA) showed that *Helicotylenchus*, *Acrobeloides* and *Labronema* were positively correlated with higher plant communities diversity. *Filenchus* was positively correlated with forbs biomass. Some omnivores such as *Eudorylaimus* and *Aporcelaimus* was positively correlated with soil moisture and rich nutrient resources, meanwhile, *Enchodelus* and *Coomansus* was positively correlated with biomass of sedges and grasses. *Anaplectus* and *Prismatolaimus* significantly correlated with soil moisture, nutrient resources and biomass of sedges and grasses. This study revealed that grazing herbivores can change composition, structure and diversity of soil nematode communities, and then reflect radical shift in below-ground soil faunal biodiversity and processes in alpine meadow on the Tibetan plateau.

1. Introduction

Grazing by herbivores is the primary form of disturbance on grassland and has a wide range of effects on ecosystem biodiversity and process across the world [1,2]. On the Tibetan plateau grassland, the effects of grazing on plant communities [3–6] and soil physicochemical properties [7–9] have been investigated, however, few studies have yet been carried out on the impacts of the grazing on diversity of soil fauna in this alpine regions, although soil fauna plays an important role in process of ecosystem [10]. The Tibetan plateau comprises one quarter of China's total land area, and is the largest and highest plateau on earth [11] and plays a vital role in physical environment and ecosystem function because of its unique geographical features [5]. The unique properties of alpine grassland mean that grazing may have different consequences for soil biota communities compared to the others terrestrial environments. It is critical to observe the impacts of grazing on abundance and

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diversity of soil faunal could enlarges our knowledge to ecological links between biodiversity and ecosystem functioning.

Tibetan plateau grassland is widely used for Tibetan sheep and yak grazing. In addition to providing livestock revenue, grazing is used as a management tool for conservation of ecosystem biodiversity and improvement of grassland function. Herbivores have been found to change ecosystem process through changes to the plant community and the abiotic environment [3–5,7–9]. In general, herbivore grazing regulates the soil faunal by two main ways: First, grazing can alter litter decomposition rates by decreasing or enhancing the nutritional quality of plant tissue. Second, herbivores can return much decomposable nutrients from animal wastes, such as urine, dung, and insect frass, but these nutrients have a heterogeneous distribution both in space and time [12]. An increased grazing intensity has been reported to enhance microbial biomass [13], then increased the number of soil faunal [14]. However browsing damage under infertile grassland will reduce above and below ground biomass over time due to soil resource depletion [2]. Soil abiotic properties changes induced by grazing such as bulk density, water content and temperature also affects the microbial activity and nutrient cycling processes, then alters the changes in soil faunal communities [15].

Among soil fauna, soil nematodes represent one of the most abundant groups of soil fauna in terrestrial ecosystems, and their special characteristics make them as an ideal bioindicators for below-ground ecosystem [16,17]. Soil nematode communities include genera at most trophic levels, and play critical roles in controlling organic matter decomposition, nutrient cycling and thus in the availability of plant nutrients [16]. At the end of the last century, nematode families were classified along colonizer-persister (cp) continuum [18]. According to these conceptual advances, nematode faunal analyses were modified and include the maturity index (MI) [18], the development of an enrichment-structure weighting system [19], and nematode channel ratio (NCR) [16]. These particular indices of analysis of soil nematode community promote bioassessment studies using nematodes as indicators.

Many studies that focus on the effects of grazing on soil nematode were carried out on different ecological system. For example, in subtropical pastures, the effects of grazing have been found that varied among nematode genera. Grazing could decrease colonizer bacterivores and some herbivores such as *Criconematidae* and increase persistent bacterivores such as *Euteratocephalus* and *Prismatolaimus*. At the same time, grazing also resulted in a more structured nematode community [12]. Grazing might show little or no effect on nematode community parameters, but total abundance was higher on ungrazed semi-natural steppe grassland [20]. The number of nematode which generally positively related to microbial biomass in sub-montane ecosystem [14] may also do not show a peak at intermediate grazing intensity [13]. In a semiarid steppe, abundance of soil nematodes increased with increase grazing intensity [21]. The variable results obtained on different grassland types make it difficult to predict impacts of grazing on soil nematode communities, hence, more research needs to carry out in alpine grassland.

The study was carried out by comparing different sites along the three herbivore grazing disturbance intensities on the Tibetan plateau meadow. We assumed that seriously grazing disturbance would decrease the abundance and biodiversity of nematode communities. Further, the main aim of this study was to: 1) determine whether the abundance and structure of nematode communities are affected by grazing disturbance, 2) evaluate the relationships between environment variable and soil nematodes communities.

2. Materials and methods

2.1. Experimental site

The study was carried out at the Alpine Meadow and Wetland Ecosystem Research Station of Lanzhou University, located on Maqu, Gansu, China on the eastern Tibetan plateau (N35°58′, E101°53′, 3500 m a. s. l.). The local climate is featured by strong solar radiation with short, cool summers, and long, cold winters. The area has more than 270 frost days and 2580 h of sunshine per year. The mean annual temperature and precipitation are 1.2 °C (range from 11.7 °C in July to −10 °C in January) and 620 mm per year (over the last 35 years), respectively. The soil type is alpine meadow soil [3], and parent materials are from a variety of sources including glacial, alluvial, residual, and residual slope deposits. The plant community is mainly Tibetan alpine meadow type and is dominated by sedges, grasses, and other forbs species.

2.2. Experimental design and sample sites

Our interviews with local people revealed that this alpine meadow has been managed by the same herders with similar grazing management for at least 15 years. Soil samplings and assessments of plant communities characteristic were carried out in three sites, including low disturbed site, medially disturbed site, and seriously disturbed site, which represents a grazing disturbance gradient. In 1999, two paddocks of grassland were fenced out at the center of grassland (the first rectangular fence, 450 m × 250 m; the second rectangular fence, 200 m × 100 m) that had a uniform vegetation cover, plant species composition, and soil properties (Fig. 1).

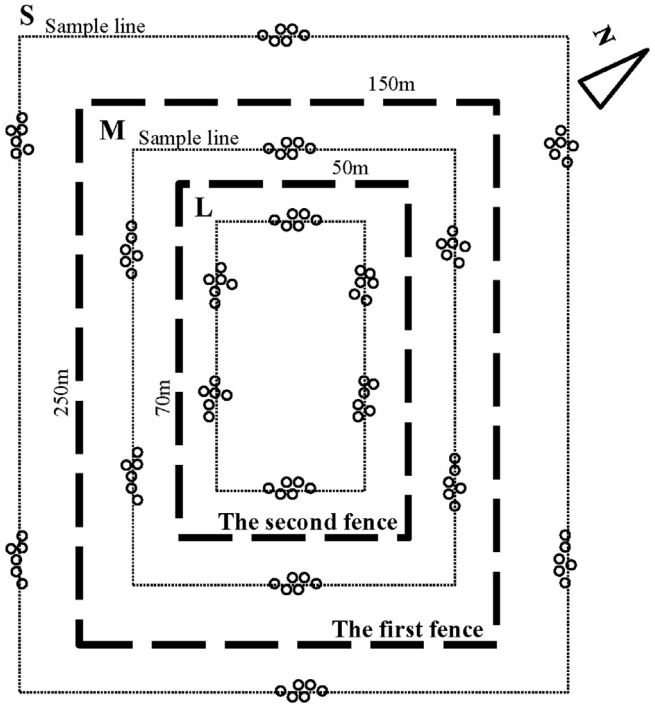

Fig. 1. For seriously disturbed site, soil samples were taken outside the first fence and 10 m away from the rectangular fence. For medially disturbed site, soil samples were taken between the first fence and the second fence. For low disturbed site, soil samples were taken inside the second fence and 10 m away from the rectangular fence. Abbreviations of sites names: S, seriously disturbed site; M, medially disturbed site; L, low disturbed site.