Ecological Engineering 102 (2017) 509–518

Contents lists available at ScienceDirect

Ecological Engineering

journal homepage: www.elsevier.com/locate/ecoleng

Relationships between plateau pika (*Ochotona curzoniae*) densities and biomass and biodiversity indices of alpine meadow steppe on the Qinghai–Tibet Plateau China

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ARTICLE INFO

Article history:
Received 23 March 2016
Received in revised form 6 February 2017
Accepted 18 February 2017
Available online 6 March 2017

Keywords:
Pika density
Biomass components
Diversity indices
Soil moisture
Alpine meadow steppe

ABSTRACT

Variations of plant biomass and plant species diversity in relation to plateau pika densities in alpine meadow steppe of the Qinghai-Tibet Plateau China were investigated. Peak above- and below-ground biomass, botanical composition, and soil moisture were measured and from these species and functional diversity indices were calculated with reference to pika burrow densities, biomass and soil moisture. Biomass components generally decreased with increased pika burrow density. Biomass of sedges and forbs increased whereas aboveground biomass of grasses first increased and then decreased as burrow density increased. There were positive linear relationships between aboveground biomass and both species and functional group richness and diversity, and also between soil moisture and these indices. These results are relevant to considerations of whether plateau pika is a pest or is a key species in maintaining the ecological stability and biodiversity of its indigenous habitat.

1. Introduction

Maintaining diversity of alpine meadow grasslands is a major challenge that has received international attention because of its contribution to global biodiversity. The Three Rivers Headwaters Region (TRHR) (Fig. 1a and b) in the Qinghai–Tibet Plateau, China, a typical component of Eurasian plateau meadow steppe (4000 m above sea level on average) is ecologically fragile and particularly sensitive to environmental disturbance (Fan et al., 2010). Grasslands are the principal ecosystem and steppe meadow is the widely distributed type in this region.

Plateau pika (*Ochotona curzoniae*) is a small burrowing lagomorph (weighing approximately 120–170 g for females and 150–210 g for males) endemic to the TRHR in Qinghai province (Fig. 1c) (Zhang et al., 1998; Smith and Foggin, 1999; Bagchi et al., 2006). They are considered to be important ecosystem modifiers and have disproportionate effects on ecosystem productivity and biodiversity (Smith and Foggin, 1999; Lai and Smith, 2003; Zhang et al., 2003). Previous work reports that the activity of pika decreased plant species richness and productivity (Shi and Yu, 2010).

It has been estimated that over 58% of the available grassland area of the region is moderately or severely degraded (Liu et al., 2008). Seriously degraded grassland in TRHR is named "black-soil-patch" which occupies 32.1% of the area of degraded grassland (Chen, 2005). It has been estimated that activity of the plateau pika is the cause of about 50% of the "black-soil-patch" area (Li and Sun, 2009) (Fig. 1d).

However the definition of grassland degradation and methods for its assessment in the region has been questioned in a recent review by Harris (2010). Harris specifically concludes that the case for plateau pika being a cause of grassland degradation is "generally weak". It is better regarded as "an indicator than a cause of rangeland degradation". Although there have been programs to reduce pika numbers by poisoning, these have been unsuccessful. This ineffectiveness control method was indicated in a study by Pech et al. (2007) showed that plateau pika are able to rapidly increase their population numbers in one breeding season and decrease their numbers had no apparent effect on forage production.

The highest values of plant biodiversity and productivity have been most frequently recorded as occurring at moderate intensities of disturbance (Huston, 1979). Other studies have also supported the assumption that maximum functional richness and diver-

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http://dx.doi.org/10.1016/j.ecoleng.2017.02.026
0925-8574/

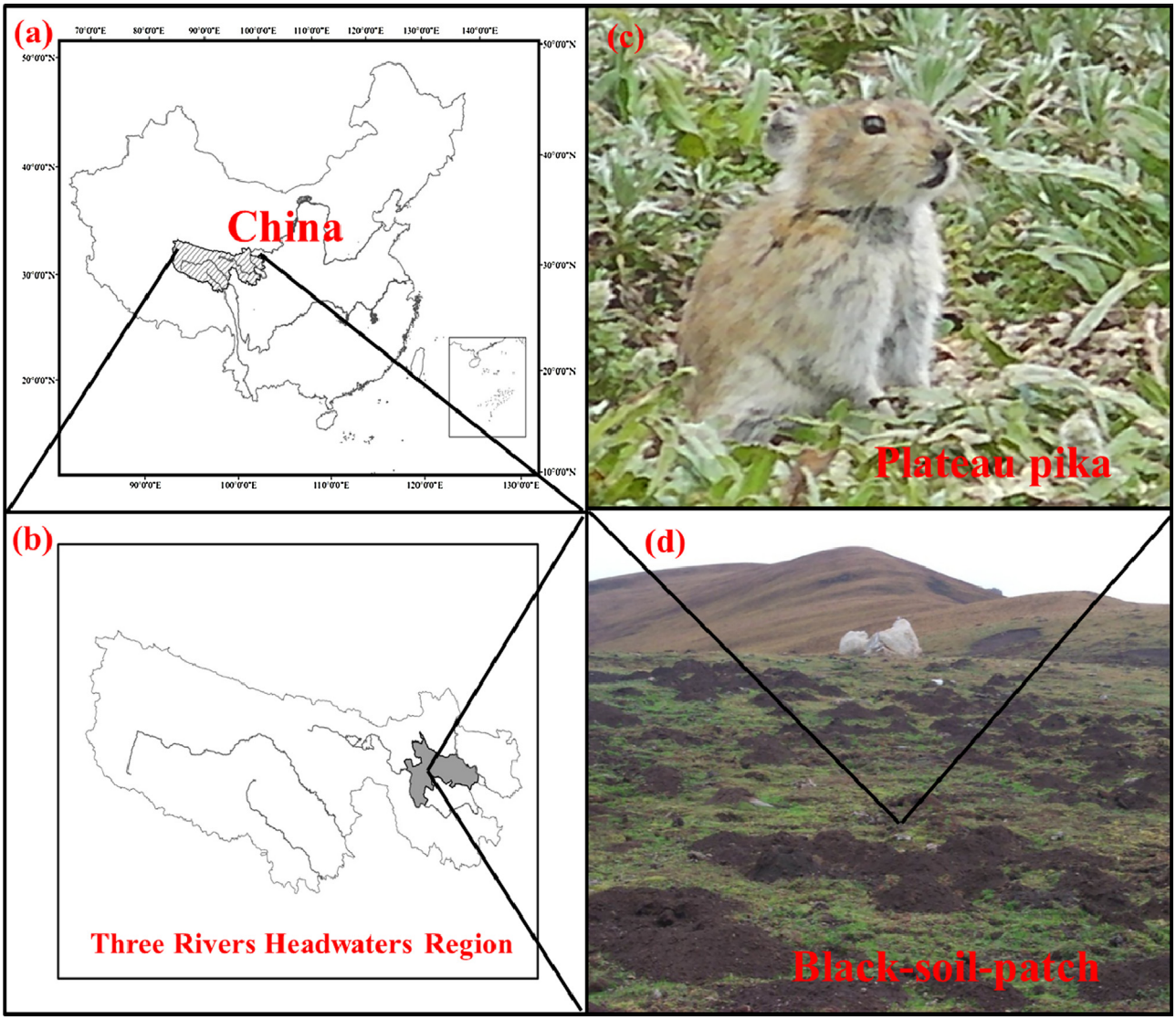

Fig. 1. (a) Location of the study area on the Qinghai-Tibet Plateau, China, showing the courses of the Huang He (Yellow), Yangtze and Lantsang-Mekong rivers, (b) Three Rivers Headwaters Region (TRHR), (c) plateau pika (*Ochotona curzoniae*), and (d) alpine meadow with high pika burrow numbers, named black-soil-patch.

sity occur at moderate disturbance (Biswas and Mallik, 2010). In particular, moderate disturbance by grazing has been shown to increase the biodiversity and productivity of many ecosystems (McNaughton, 1979). To date there has been limited detailed investigation of the relationships between the activity of pika on the biodiversity and productivity of the alpine meadow steppe of TRHR (Sun et al., 2010).

There is a growing consensus that functional diversity is likely to be the component of biodiversity most relevant to ecosystem function (Hooper and Vitousek, 1997; Tilman et al., 1997; Diaz and Cabido, 2001; Naeem and Wright, 2003; Reich et al., 2004; Wright et al., 2006). Functional group richness (FGR) can then be used as an approximation of functional diversity in an ecosystem (Wright et al., 2006). It is generally assumed that functional richness and species diversity show similar responses to disturbance. However, these relationships have been rarely tested in natural systems (Naeem, 2002). Particularly for alpine meadow steppe, because of its remoteness and harsh environment, species diversity has been studied in relatively few instances (Wang et al., 2006a). The influences of disturbance by pika on response patterns of plant functional richness and diversity indices and on differences between species and functional diversity still remains unclear.

Community diversity affects ecosystem processes, for example increased plant species diversity has been found to increase community biomass production (Naeem et al., 1996; Tilman et al., 1996; Roscher et al., 2004, 2005). Several studies have shown that disturbance of grassland ecosystems in Asia-Euro steppe and American prairie by burrowing animals increased plant species richness (Dmitriev, 1985; Whicker and Detling, 1988; Huntly and Reichman, 1994). There is little direct evidence for the effect of plateau pika on species richness (Smith and Foggin, 1999) or functional diversity in TRHR meadow steppe.

The shifts in community composition (functional groups) depends on either the intensity of pika activity (including their foraging, burrowing and deposition of excreta) or on inherent properties of the steppe meadow community it inhabits. The classic and commonly used classification scheme for plant functional groups in herbaceous plant communities is grass, non-legume forbs, and legumes (GFL) (Tilman et al., 1997; Hector et al., 1999; Naeem et al., 1999; Reich et al., 2001). This classification has been widely used in studies of natural grassland ecosystems and in manipulative experiments of grassland plant diversity (Tilman et al., 1997; Naeem and Wright, 2003). As the sedge genus *Kobresia* is the major dominant of vegetation on the Qinghai-Tibet Plateau (Wang et al., 2006a; Yang