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Short communication

Plateau pikas burrowing activity accelerates ecosystem carbon emission from alpine grassland on the Qinghai-Tibetan Plateau

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ABSTRACT

Pikas (*Ochotona curzoniae*) are common on the Qinghai-Tibetan Plateau (QTP). However, little is known about the effect of their burrowing activity on carbon emissions from alpine grassland ecosystems. In this study, we investigated soil organic carbon (SOC), total nitrogen (TN) density and ecosystem CO_2 flux from the original vegetation and pika piles of three typical alpine grasslands in two climate regions. SOC loss induced by pika activity varied among grassland types. Alpine meadow with high SOC was susceptible to pika activity. Ecosystem CO_2 flux from pika piles with open holes was significantly higher than that from the original vegetation ($P<0.05$, $n=4$). When holes near pika piles were blocked, ecosystem CO_2 flux from pika piles was not significantly different from that of the original vegetation ($P>0.05$, $n=4$). Our results suggested that CO_2 dissipates into pika tunnels and is easily emitted into the atmosphere through pika holes. Due to the large amount of pika holes in alpine grasslands, their significant effect on ecosystem CO_2 flux should not be ignored in future studies.

1. Introduction

Terrestrial ecosystem is an important organic carbon (C) pool on the earth (Post et al., 1990). As one of dominant vegetation types, alpine grassland on the Qinghai-Tibetan plateau (QTP) covers approximately 1.63×10^6 km^2 area in China (Qin et al., 2014). Organic carbon stock in this ecosystem is about 33.52 Pg, which contributes 2.5% to global C pool (Wang et al., 2002). However, about 1/3 of alpine grasslands on the QTP have suffered from quite severe degradation over the last few decades (Li et al., 2011). It is estimated that alpine grassland degradation has led to about 2.95 Pg C loss on the QTP (Wang et al., 2002). In addition to overgrazing (Thomson and Simpson, 2007; Zhang et al., 2014), climate warming and permafrost degradation (Yang et al., 2010), small mammals, especially Plateau pikas (*Ochotona curzoniae*), are deemed to be an important cause of grassland degradation.

Plateau pikas, small diurnal and non-hibernating mammals belong to order lagomorphs, widely distribute in the alpine grassland on the QTP and even were often found in the Loess Plateau of China (Jing et al., 2014). They adversely affect alpine grassland by competing with livestock for scarce food resources, destroying the sod layer and burying vegetation with excavated soil (Smith and Wang, 1991; Pech et al., 2007). On the other hand, plateau pikas are considered a keystone species because of their pivotal role in the community dynamics of high-altitude grasslands on the QTP (Lai and Smith, 2003). They can modify the environment, by enhancing the ability of soil to absorb precipitation, contributing to nutrient cycling and creating microhabitats resulting in increased plant species richness (Smith and Foggin, 1999; Davidson and Lightfoot, 2008).

Although pika burrowing activity was believed to have significant effect on soil organic carbon and ecosystem carbon exchange (Cao et al., 2004; Kato et al., 2004; Li et al., 2009), few quantitative studies exist to investigate this influence on ecosystem carbon emission from alpine grassland on QTP. Typically, these studies compared carbon fluxes with different number of pika burrows (Liu et al., 2013; Peng et al., 2015). However, ecosystem carbon emissions from pika piles have yet to be quantified. What's more, existing studies usually focus on one alpine grassland type (e.g. Li et al., 2009; Liu et al., 2013; Peng et al., 2015). It is desirable to compare multiple types of alpine grassland together to better understand the role of Plateau pikas. Therefore, our objective was to quantify the effect of Plateau pikas burrowing activity on ecosystem CO_2 flux of three typical alpine grasslands in different climate region.

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2. Materials and methods

2.1. Study area and field work

The field work was conducted during the period 14 June–18 September August 2014 in Suli, Qinghai Province (98°18′33.2″ E, 38°25′13.5″ N; 3887 m a.s.l.) and Azi, Gansu Province (101°52′07.9″ E, 33°24′24.1″ N; 3547 m a.s.l.) (Fig. 1a). Suli is in an arid and semi-arid zone with a mean annual precipitation (MAP) of 200–400 mm and mean annual air temperature (MAAT) from −4.0 to −19.4 °C. Azi is in a humid region with a MAP of over 600 mm and MAAT of 1.1 °C.

Three typical alpine grasslands, alpine meadow (AM), steppe meadow (StM) and alpine steppe (AS), were selected in Suli, only one, AM, in Azi. On each grassland type, we set up 3 plots (30 m × 30 m). Four paired subplots (2 m × 2 m) were set up on the original vegetation (Fig. 1c), pika piles with open holes (Fig. 1d) and pika piles with holes blocked (Fig. 1e), respectively on each grassland type. The distance between any two adjacent plots was 5–6 m. Pikas frequently haunted in new pika piles. To avoid their disturbance, we only measured ecosystem CO_2 flux from inactive pika piles.

2.2. Ecosystem CO_2 flux measurement

Ecosystem CO_2 flux was measured using the LICOR-8150 Automated Soil CO_2 Flux System equipped with six LICOR-8100-104 long-term chambers (LICOR, Inc., Lincoln, NE, USA) (Fig. 1b and f). To measure ecosystem CO_2 flux, polyvinyl chloride collars with a 20 cm inner diameter and a 12 cm height were inserted into soil with 3–4 cm exposed to the air. All of the collars were installed at least 24 h before the first measurement to reduce disturbance-induced ecosystem CO_2 effluxes. The rotation measurements of ecosystem CO_2 flux was made alternately among three typical alpine grasslands in Suli and Azi depending on weather conditions. A round-the-clock, i.e., 24 h continuous measurement was conducted at all replicate subplots every half hour from 0:00 to 23:30 h. On each grassland type, there were total 12 subplots (3 treatments × 4 replicates). Therefore, 5 days at least were needed to complete one measurement of ecosystem CO_2 flux on each grassland type.

2.3. Soil sampling

In each plot, three soil samples were taken at depths of 0–10, 10–20, 20–30, 30–40 cm from original vegetation, new and old pika piles. Another three soil samples for each soil depth were collected using stainless steel rings (100 cm^3 in volume) to measure soil bulk density. Soil samples were air-dried, and then hand-sieved through a 2 mm screen to remove roots, litter and stone. Subsamples of the air-dried samples were ground to pass through a 0.25 mm sieve and were then analyzed for soil organic carbon (SOC) and soil total nitrogen (TN). SOC was determined by dichromate oxidation using Walkley-Black acid digestion (Nelson and Sommers, 1982). TN was measured by digestion and then tested by a flow injection analysis system (FIAstar 5000, Foss Inc., Sweden).

2.4. Counts of pika holes

For each 30 m × 30 m plot, we put white belts along the borders and used a quad copter (Phantom 2 Vision +, DJI inc.) with an integrated camera (1.2 mega pixels, fish eye lens) to take pictures at a height of ∼30 m. For pictures taken in air (Fig. 1g), we first used Photoshop to correct distortion due to fish eye lens; then selected the part within white belts for analysis. The pika holes were marked manually with red rectangles to determine their densities (Fig. 1g).

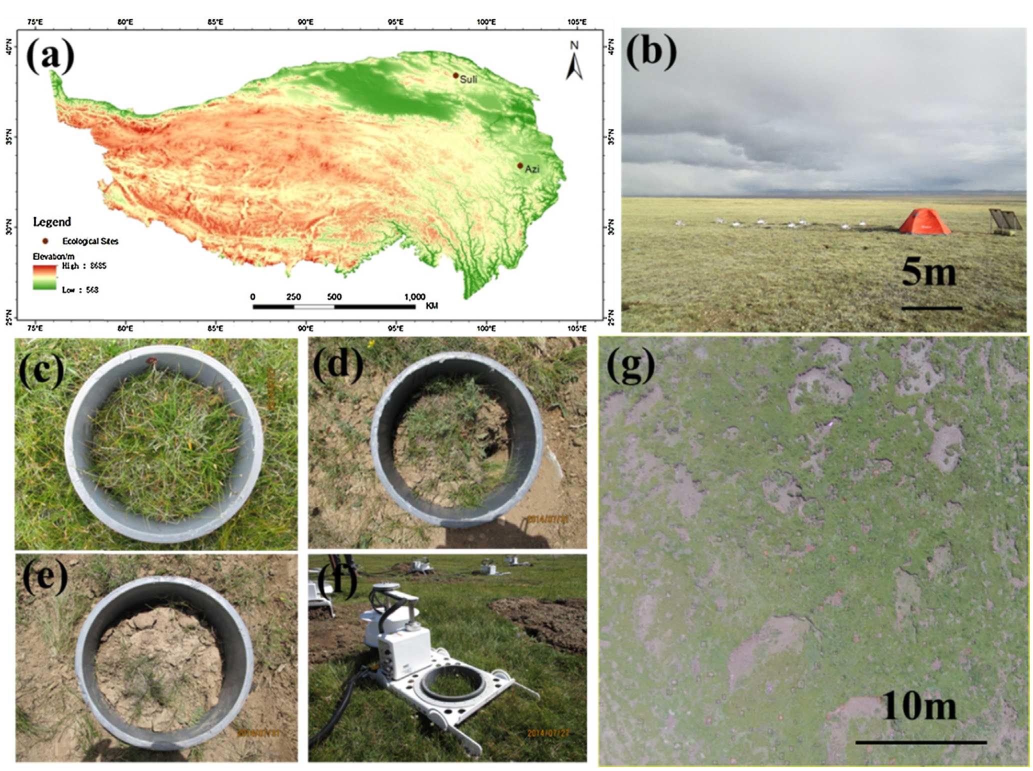

Fig. 1. (a) Location of the study area, (b) observation plot of ecosystem CO_2 flux, (c) observation quadrat of ecosystem CO_2 flux for original vegetation, (d) pika piles with open holes, (e) pika piles with holes blocked, (f) long-term chamber and (g) an aerial photo used to investigate the density of pike holes.