ARTICLE IN PRESS

Applied Soil Ecology xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Applied Soil Ecology

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

Effect of water table decline on the abundances of soil mites, springtails, and nematodes in the Zoige peatland of eastern Tibetan Plateau

Xue Wei[a,b,c], Rui Cao[d], Xinwei Wu[d,*], Nico Eisenhauer[e,f], Shucun Sun[a,d]

[a] Center for Ecological Studies, Chengdu Institute of Biology, 9 Section 4 Renminnan Rd, Chengdu 610041, China
[b] College of Life Sciences, Sichuan University, 24 South Section 1 Yihuan Rd, Chengdu 610065, China
[c] University of Chinese Academy of Sciences, 19(A) Yuquan Rd, Shijingshan District, Beijing 100049, China
[d] Department of Ecology, College of Life Sciences, Nanjing University, 163 Xianlin Avenue, Nanjing 210023, China
[e] German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Deutscher Platz 5e, 04103 Leipzig, Germany
[f] Institute of Biology, Leipzig University, Deutscher Platz 5e, 04103 Leipzig, Germany

ARTICLE INFO

Keywords:
Climate change
Human activities
Peatland
Qinghai-Tibetan Plateau
Soil fauna
Water table

ABSTRACT

Despite the important role of soil fauna in the decomposition of soil organic matter, the abundance response of soil fauna to environmental changes has been scarcely studied in peatlands, where soil carbon content is exceptionally high. The water table of the Zoige peatland, the largest alpine peatland worldwide, has been declining due to climate change and human drainage in recent decades, which likely induces changes in the abundance of soil fauna. In order to examine the abundance response of soil mites, springtails, and nematodes to water table decline in the Zoige peatland, we conducted an *in situ* field drainage experiment, consisting of low, intermediate, and ambient water table levels for four consecutive years. We measured the abundances of mites, springtails, and nematodes at five soil depths (0–5, 5–10, 10–15, 15–20, and 20–25 cm), for four times in the third and fourth year of the experiment. Results show that the effect of water table decline on the abundance of soil fauna varied among soil animal groups, soil depths, and the sampling times over the course of the experiment. While mites did not respond significantly to the experimental treatments, the abundance of springtails at soil depths of 0–5, 5–10, and 10–15 cm and that of nematodes at a depth of 15–20 cm were significantly higher in the drained treatments than in the undrained one. Moreover, water table decline increased the proportion of herbivorous nematodes in the top soil (0–5 cm) and decreased the proportion of bacterivorous nematodes at soil depths of 0–5 and 5–10 cm, while fungivorous and omnivorous-predaceous nematodes did not respond significantly. Given the demonstrated importance of soil fauna to soil carbon dynamics, the changes in the abundances of soil mites, springtails, and nematodes depicted here indicate that soil fauna should be further studied in relation to the recently reported rapid loss of soil carbon in the Zoige peatland.

1. Introduction

Anthropogenic environmental change is altering the composition and functioning of many ecosystems (Solomon et al., 2007), with peatlands representing one of the most vulnerable and functionally important ones in terms of carbon dynamics and feedbacks to the atmosphere (Sahagian and Melack, 1998). In particular, peatlands around the world are mostly experiencing water table decline (Kettridge et al., 2015), which may significantly decrease the soil carbon storage of peatlands. For example, low water table and associated increased oxygen availability (Straková et al., 2012) can directly enhance the decomposition rate of organic matter (Laiho, 2006). Moreover, it can also change the community composition of soil fauna and increase the abundance of soil fauna to indirectly accelerate the decomposition of soil organic matter in peatlands (Barreto and Lindo 2018; Laiho et al., 2001; Silvan et al., 2000; Vilkamaa, 1981). Thus, exploring the response of peatland soil fauna to water table decline is important to understand the mechanisms underlying peatland carbon dynamics.

Soil fauna has been widely demonstrated to be able to directly consume and fragment large particles of soil organic matter and enhance the diversity and biomass of soil microbes that are responsible for the decomposition of soil organic matter (Barreto and Lindo 2018; Kaneda and Kaneko, 2008; Laiho et al., 2001; Schmidt et al., 2016). However, in contrast to responses of plant communities and greenhouse gases fluxes (Cao et al., 2017a, b; Chimner and Cooper, 2003; Updegraff et al., 2001), the abundance response of soil fauna to water table

* Corresponding author.
E-mail address: wuxw@nju.edu.cn (X. Wu).

https://doi.org/10.1016/j.apsoil.2018.05.006
Received 23 January 2018; Received in revised form 8 May 2018; Accepted 8 May 2018
0929-1393/

Please cite this article as: Wei, X., Applied Soil Ecology (2018), https://doi.org/10.1016/j.apsoil.2018.05.006

Table 1
Results of linear mixed models (LMMs) of the effects of water table (WT), sampling time and their interaction on the abundances of springtails, mites and nematodes, as well as the proportion of different groups of nematodes (herbivores, fungivores, bacterivores, omnivores-predators, and other nematodes) in each soil layer. Degree of freedom (DF) and Sum of squares (SS) values are provided. *, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$.

Soil layer			Mites	Springtails	Nematodes	Relative proportion of different nematode groups				
						Herbivores	Fungivores	Bacterivores	Omnivores-predators	Other nematodes
		DF	SS	SS	SS	SS	SS	SS	SS	SS
0–5 cm	WT	2	0.98	3.69***	1696.46	26.25**	0.67	8.02*	6.42	0.43
	Date	3	2.62*	3.97***	14727.85***	22.88*	35.56***	2.17	1.14	7.85**
	WT*Date	6	0.34	1.24	1332.87	26.06	12.57	8.27	2.65	3.71
	Block	5	4.02**	5.70***	4383.17	19.17	2.2	8.01	7.14	1.26
	Error	55	12.38	9.93	29472.7	139.4	59.32	43.88	66.93	31.65
5–10 cm	WT	2	0.42	4.36***	293.08	22.18*	0.06	1.29	2.52	5.2
	Date	3	10.82***	3.28**	2984.78**	7.97	27.18***	5.6	1.86	26.00***
	WT*Date	6	0.15	0.32	663.61	9.26	11.62	8.36	2.42	3.28
	Block	5	1.66	2.54	2466.68*	5.98	6.83	13.57*	8.32	5.81
	Error	55	7.83	13.29	11023.7	140.56	69.07	56.87	64.45	66.16
10–15 cm	WT	2	0.26	3.32**	35.76	9.37	6.71	2.18	1.81	10.76
	Date	3	6.28***	4.42***	262.44**	43.01**	25.13*	9.2	19.96*	12.18**
	WT*Date	6	0.6	1.39	290.43*	7.43	14.4	13.45	3.25	7.02
	Block	5	0.44	1.82	19.88	27.76	19.57	11.64	11.84	12.6

decline has not been well studied in peatlands. Moreover, results of available peatland studies are idiosyncratic: some studies showed that water table decline increased the abundances and diversity of soil invertebrates in peatlands (Laiho et al., 2001; Silvan et al., 2000; Vilkamaa, 1981; Wasilewska, 1991, 2002, 2006), while some others revealed non-significant effects on the abundance of soil fauna (Krab et al., 2014). One possible explanation for this may be that these previous studies (e.g. Lv et al., 2014; Marx et al., 2016) mostly investigated and compared soil faunal communities between undrained peatlands and drained sites that had previously been peatlands, inducing potential confounding factors (e.g. difference in natural history between sites) that may obscure the interpretation of the effect of water table decline.

The Zoige peatland on the eastern Tibet Plateau, covering 4605 km^2 in area, is the largest alpine peatland in the world (Xiang et al., 2009). It stores 0.48 Pg of soil organic carbon (Chen et al., 2014), accounting for 6.2% and 1‰ of peat soil organic carbon storage in China and in the world, respectively (Cui et al., 2015). Like many other peatlands (Kettridge et al., 2015), the Zoige peatland is now experiencing unprecedented water table decline due to climate change and human activities. On the one hand, the temperature has increased by 0.4 °C per decade, and precipitation has decreased by 22 mm per decade over the past 40 years (Yang et al., 2014). On the other hand, the Zoige peatland has been largely drained for rangelands since the 1970s. Nearly 1000 artificial channels, with a total length of nearly 3000 km, have drained more than 40% of the total area of the Zoige peatland (Dong et al., 2010). These drainage channels must have increased water output from the Zoige peatland (Dong et al., 2010). Consequently, the water table has decreased from several cm to 85 cm below the surface in the Zoige peatland over the past several decades (Xiang et al., 2009). However, the abundance response of soil fauna to water table decline has never been studied in this peatland.

In this study, we explore the response of the abundance of the most dominant groups of soil meso- and microfauna (i.e., soil mites, springtails, and nematodes) to water table decline in the Zoige peatland by conducting an *in situ* field drainage experiment at a homogeneous site. Our experimental treatments are fully controlled and started from the same initial conditions before implementing the experimental treatments. Because the soil moisture of ambient peatlands is usually saturated and the experimental drainage increases soil aeration but does not lead to severe drought effects (Cao et al., 2017a; Wu et al., 2017), we hypothesize that water table decline increases the abundances of mites, springtails, and nematodes (although soil nematodes live in water films) in the Zoige peatland.

2. Materials and methods

2.1. Study site

This study was conducted in Hongyuan County (32°48′N, 102°33′E) of Sichuan Province in the Zoige peatland in the eastern Tibetan Plateau. The elevation is about 3500 m above sea level. The climate is a typical plateau continental zone climate with short-cool summer and long-cold winter. The annual mean temperature is 1.73 °C, with the maximum and minimum monthly means being 11.1 and −9.4 °C in July and January, respectively. The annual mean precipitation is 756 mm, 80% of which occurs between May and August (Cao et al., 2017a).

The Zoige peatland consists of lakes, wide river valleys, and marshy meadows (river terrace marshes), among which the area of marshy meadows is about 492 km^2, occupying 67.2% of the total peatland area (Lang et al., 1999). The peatland site where the study was conducted is mostly dominated by sedge species, including *Carex muliensis*, *Kobresia humilis*, *Scirpus pumilus*, *Blysmus sinocompressus*, *Kobresia setchwanensis* and *Kobresia pygmaea*. Rushes (*Juncus leucanthus* and *Juncus allioides*) are common but with relatively low abundance. Grasses, including *Poa pratensis*, *Deschampsia cespitosa* and *Agrostis matsumurae*, and forb species, including *Chamaesium paradoxum* and *Anemone trullifolia* var. *linearis*, are also abundant (Cao et al., 2017a). Total vegetation cover in midsummer is over 90%. The depth of peat layers in this region ranges from 0.3 to 10 m (Yang et al., 2014). The soil pH ranges between 6.6 and 7.0 (Yang et al., 2014), and the soil carbon and nitrogen concentrations range from 370 to 450 g kg^{-1} and from 13 to 19 g kg^{-1}, respectively, in the top 0–10 cm of the soil (Wu et al., 2017).

2.2. Experimental design and setup

We conducted a field experiment within a homogeneous peatland site to avoid possible confounding factors, such as variations in soil and vegetation conditions. The experiment was set up as a one-factor, three-level block design, with each block containing the ambient, intermediate, and low water table treatments. Each treatment was replicated six times, resulting in a total of 18 plots (Fig. S1).

The water table was manipulated by ditching in the homogeneous