

LIU Dianfeng, LIAN Bin, WU Chunhao and Peijun GUO, 2017. A Comparative Study of Gut Microbiota Profiles of Earthworms Fed in Three Different Substrates. *Acta Geologica Sinica* (English Edition), 91(supp. 1): 153-154.

Earthworms' Transcriptome and Gut Microbiota Response to Mineral Weathering

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1 Introduction

Earthworms are an important component of soil macrofauna, dominating the biomass of soil invertebrates (Kodama et al., 2014; Plum and Filser, 2005). They are known as the "engineers of ecosystem", and have a significant impact on biological, chemical and physical processes of the soil ecosystem through their activities (Edwards, 2004; Zhang et al., 2007). Numerous studies have shown that earthworms have a significant role in promoting soil mineral weathering (Carpenter et al., 2007, 2008; Liu et al., 2011; Suzuki et al., 2003; Zhu et al., 2013). Earthworms' gene expression and gut microbiota must make some changes during weathering minerals.

Earthworms' gene expression may change after eating minerals that are at different stages of weathering in order to use effectively mineral elements. The change in gene expression in turn may affect the secretion and chemical composition of digestive fluids, and even affect the behavior of earthworms. So, deciphering gene expression in earthworms feeding on different matrices helps understanding how earthworms regulate their physiological activities and their transcriptome responses to mineral weathering.

As a special earthworm "organ", gut microbes play an important role in biogeochemical processess of soil elements (Edwards and Fletcher, 1988; Sruthy et al., 2013). Earthworms swallow great quantities of soil. When soil minerals pass through earthworm's gut, gut microbes may degrade them to some extent besides mechanical grinding action of guts, corrosion of digestive juice, etc.(Basker et al., 1994; Carpenter et al., 2007; Needham et al., 2004). However, there is poor knowledge about the response of gut microbiota to the passed minerals.

This article characterizes the response of the

earthworms' transcriptome and gut microbiota to the passed nutrient-poor minerals.

2 Earthworms' Transcriptome and Gut Microbiota Changes during Mineral Weathering

2.1 Transcriptome responses of earthworms to mineral weathering

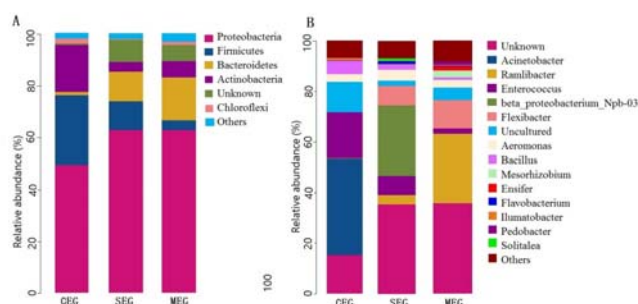
In order to discern these mechanisms, we studied the transcriptome of earthworms cultured in three matrices: soil, potassium-bearing rock powder (PBRP) or decomposed wheat straw (DWS) using RNA-seq. Results indicate that culture matrices affected clearly gene expression in earthworms. There were pronounced transcriptomic differences between earthworms in the soil and those in the DWS. Similar pronounced differences were also seen between earthworms in the PBRP and those in the DWS. There were less differences between earthworms in the PBRP and those in the soil. Similar differential expression patterns were observed also in genes related to the digestive system. The differential genes are in many functions, suggesting that adaptation of earthworms to matrices involve very complex molecular mechanisms. The weathering of mineral by earthworms is the results of regulation of many genes and many metabolic pathways. The digestive system of earthworms adapts very differently to nutrient rich organic matter, compared to nutrient-poor minerals. The adaptation involves salivary, gastric acid and pancreatic secretion.

2.2 Gut microbiota responses of earthworms to mineral weathering

To characterised the gut microbiota of earthworms and explore these microorganisms that can weather minerals, we compared the bacterial communities harboured in the intestines of earthworms fed on soil, compost soil and mineral powders, by using high-throughput sequencing

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with barcoded primers targeting the V3 to V4 regions of the bacterial 16S rRNA gene. It was found that there were 24 phyla (338 genera) in the guts of earthworms. In general, the microbial communities of the earthworms' gut were dominated by Proteobacteria, Firmicutes, Actinobacteria, Chloroflexi and Bacteroidete (Fig.1). However, the abundance of each phylum was significantly different between samples from three feeding substrates, which indicated that feeding substrates had significantly influence on the gut microbiota of earthworms. Among dominant bacteria, Proteobacteria and Bacteroidetes were higher at the phylum level, and Ramlibacter, Flexibacter, Mesorhizobium, Ensifer and Pedobacter were higher at the genus level in the gut of the earthworms fed on soil and mineral powders than the gut of those fed on compost soil. These microorganisms may help earthworms survive in the substrates shortage of nutrients by weathering minerals and releasing elements from minerals.



Acknowledgements

This work was supported by National Natural Science Foundation of China (U1204405 and 41373078).

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