

High-level diversity of tailed phages, eukaryote-associated viruses, and virophage-like elements in the metaviromes of Antarctic soils

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Abstract

The metaviromes of two distinct Antarctic hyperarid desert soil communities have been characterized. Hypolithic communities, cyanobacterium-dominated assemblages situated on the ventral surfaces of quartz pebbles embedded in the desert pavement, showed higher virus diversity than surface soils, which correlated with previous bacterial community studies. Prokaryotic viruses (i.e., phages) represented the largest viral component (particularly Mycobacterium phages) in both habitats, with an identical hierarchical sequence abundance of families of tailed phages (Siphoviridae>Myoviridae>Podoviridae). No archaeal viruses were found. Unexpectedly, cyanophages were poorly represented in both metaviromes and were phylogenetically distant from currently characterized cyanophages. Putative phage genomes were assembled and showed a high level of unaffiliated genes, mostly from hypolithic viruses. Moreover, unusual gene arrangements in which eukaryotic and prokaryotic virus-derived genes were found within identical genome segments were observed. Phycodnaviridae and Mimiviridae viruses were the second-most abundant taxa and more numerous within open soil. Novel virophage-like sequences (within the Sputnik clade) were identified. These findings highlight high-level virus diversity and novel species discovery potential within Antarctic hyperarid soils and may serve as a starting point for future studies targeting specific viral groups.

Introduction

Antarctica is the coldest, driest place on Earth (1). Exposed soil areas comprise approximately 0.4% of the continent's surface and are mainly located in coastal areas, particularly on the Antarctic peninsula and in the McMurdo Dry Valleys (2). These mineral soils are exposed to a range of "extreme" abiotic factors, including very low temperatures, high soil salinity, low water availability and nutrient levels, high levels of UV radiation, and strong, cold winds descending from glaciers or mountain tops (katabatic). Due to these conditions, the most morphologically distinct soil communities (i.e., type I, II, and III hypoliths) are associated with lithic surfaces (3, 4). Hypolithic

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