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Methane oxidation and methanotrophs: resistance and resilience against model perturbations

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Biodiversity is claimed to be essential for ecosystem functioning. However, most experiments on biodiversity and ecosystem functioning (BEF) have been made on higher plants, while only few studies have dealt with microbial communities. Overall microbial diversity may be very high, and general functions like aerobic carbon mineralization are assumed to be supported by highly redundant communities. Therefore, we focused on methane oxidation, a microbial process of global importance mitigating methane emissions from wetland, rice fields, and landfills. We used a rice paddy as our model system, where >90% of potentially emitted methane may be oxidized in the oxic surface layer. This community is presumed to consist of 10-20 taxa more or less equivalent to species. We focused on the ability of methanotrophs to recover from a disturbance causing a significant die-off of all microbial populations. This was simulated by mixing native with sterile soil in two ratios (1:4 and 1:40). Microcosms were incubated and the temporal shift of the methanotrophic communities was followed by pmoA-based Terminal Restriction Length Polymorphism (T-RFLP), qPCR, and a pmoA-based diagnostic microarray. We consistently observed distinctive temporal shifts between Methylocystaceaea and Methylococcacea, a rapid population growth leading to the same or even higher cell numbers as in microcosms made from native soil alone, but no effect on the amount of methane oxidized. The ratio of different methanotrophs changed with treatment, while the number of taxa stayed nearly the same. Overall, methanotrophs showed a remarkable resilience compensating for die-offs. It has to be noted, however, that our experiment focused on methanotrophs adapted to and living at high methane fluxes. Quite different, methanotrophs living in upland soils do not mitigate methane emissions, but are the only biological sink to atmospheric methane. These microbes are severely substrate limited, and will be much more susceptible to perturbations.