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Measuring ecosystem functioning of soil mega-aggregates produced by soil/litter mix-feeding animals

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Some soil animals are soil/litter mix-feeders. They are known to produce long-lasting soil structures (e.g. casts and molting chamber), and these structures will modify resource availability and environmental conditions for plants and soil organisms. Good examples are epigeic Megascolecid earthworms (Uchida et al., 2004) and Xystodesmid millipeds (Toyota et al., 2006), both found in Japan. In this study we examined chemical, physical and biological properties of soil focusing on multi-functioning of aggregates made by these animals.
Since 2003, we manipulated densities of epigeic earthworms in a field encloser (35 m2) (three replications) at a cool temperate forest in Japan. At a no-worm (NW) treatment, all the worms have been collected every year by hand. At the same place, we prepared a control treatment in an encloser (Closed control; CC) and outside the encloser (Open control; OC). We examined surface soil and plant growth after 5-years field manipulation of oak dominated forest. Growth of two Liliaceae forest floor herbs; Smilacina japonica and Polygonatum odoratum, and oak (Quercus crispula) seedlings and canopy oak trees were recorded.
Reduction of aggregates after elimination of earthworms was observed in a field condition. The manipulation site showed decreased soil pH, Ca, Mg, and P concentration and total carbon storage was also reduced.
There was a negative significant correlation between casts abundance and soil NH4-N, and a positive significance was observed between casts abundance and growth of S. japonica, and oak seedlings. Radial growth of canopy oak trees was decreased at NW treatment compared to CC and OC. Leaf N contents of oak seedling at NW were significantly lower in NW, but canopy oak trees did not show any difference in leaf-N. Although S. japonica and P. odoratum were both found in a same forest floor, S. japonica is known as nutrient limited plants in spring, whereas P. odoratum is light limited. Oak seedlings are depending early growth on their seed nutrient, and the canopy oak trees seem to be nutrient limited. Thus in this forest, the nutrient condition mediated by earthworm activity was a strong factor influencing plant species-specific growth and this correlation was clear when we used the cast abundance as an independent factor but it was not clear when we used the worm abundance or biomass for explanation variables.
In laboratory incubations, fresh casts of earthworm Metaphire hilgendorfi contained higher NH4-N which was mostly nitrified within 4-weeks. The 4-weeks aged casts of the earthworm and millipede Parafontaria laminata emitted significantly more N2O whereas the modified soil had strong CH4 acidification capacity. Therefore the animal effects on greenhouse effect gas should be evaluated for CO2, N2O and CH4 at the same time.
We then confirmed that megaaggregates, probably cast origin, tended to contain more carbon than fine soil. Combining our data from various study sites in Japan, the amount of carbon contained in megaaggregates (> 2 mm) in 0-5 cm layer ranged from 200 to 1000 g C per m2. Animal feeding activities maintained substantial amount of surface soil aggregates.
Therefore, the activity of soil/litter mix feeders can be linked to the carbon dynamics by evaluating worm's soil engineering effect.