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Effect of pore diameter on the mobility of six collembolan species: an experimental approach using 3D printed soil pore simulation models

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Soil is a complex habitat that host an important diversity of soil organisms. The latter process soil organic matter along trophic chains that play a key role in soil functioning. While important progress has been made to decipher complex trophic interactions in soils, the role of soil animal mobility within the pore space as a determinant of food accessibility, and thus trophic interactions, remains poorly studied. Collembolans are ubiquitous microarthropods playing a pivotal role in soil food webs. We expected that collembolans colonize soil pores of equivalent dimension to their body size (few hundred microns). In these pores, they may hide from predators and access food resources, notably microbes. However, experimental evidences of the range of soil pores accessible to Collembola, and how it affects their mobility are missing. We used self-designed 3D printed physical pore simulation models with pore cylinders of 0.5, 0.75, 1 and 3 mm diameter (and all 4 mm long) to test how the pore diameter affects the mobility of six collembolan species (*Heteromurus nitidus*, *Sinella curviseta*, *Folsomia candida*, *Ceratophysella denticulata*, *Protaphorura fimata* and *Mesaphorura macrochaeta*). For each species, 10 individuals were placed in the soil pore simulation model at moist and dark conditions, and their ability to pass through pores was assessed after 7.5 minutes of incubation. We observed that collembolan mobility increased with pore diameter ($P < 0.001$), but this varied among species ($P < 0.001$). Species with the largest body size, namely *H. nitidus* (body width 0.58 ± 0.29 mm) and *C. denticulata* (body width 0.50 ± 0.12 mm) were particularly restricted with less than 1% of the individuals passing through pore necks of 0.4 mm. As the pore neck diameter increased, passage increased more for *C. denticulata* than for *H. nitidus*. Only 46 ± 20 % of the individuals of *H. nitidus* passed through a pore neck of 1 mm, whereas for *C. denticulata* it was 76 ± 10 %. Across the different pore diameters, *P. fimata* (body width 0.36 ± 0.08 mm) was the least restricted species, with 76 ± 18 % of individuals passing through pores of 0.4 mm diameter. *M. macrochaeta* (body width 0.11 ± 0.07 mm), *S. curviseta* (body width 0.39 ± 0.26 mm) and *F. candida* (body width 0.31 ± 0.09 mm) showed intermediate restriction in mobility with 54 ± 28 %, 43 ± 19 % and 43 ± 28 % of the individuals passing through pore of 0.4 mm diameter, respectively. At a pore diameter of 1 mm, these proportions raised to 84 ± 20%, 79 ± 10% and 95 ± 5%,

respectively. Overall, Collembolan species were able to enter pores 20 ± 37 - 171 ± 33 µm wider than their body width, suggesting different ability to enter narrow pores depending on species. We conclude that the dimension of the pore diameter is a main factor restricting the mobility of collembolans in soil and presumably functions as main determinant of food accessibility.