Trophic niche shift of soil microarthropods associated with soil disturbance: an evaluation using carbon and nitrogen stable isotope measurements

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Organic layers on soil surface is the vertically heterogeneous habitat and one of the important endmembers; i.e. their source of energy and nutrients, for soil fauna. The vertical heterogeneity of soil organic matter is primarily ascribed to decomposition process from plant litter to different matters so called fumus and humin. Perturbations of the organic layers by diffluence and localization are the mechanisms which ecosystem disturbances result in changes to species compositions of soil fauna. On the other hand, effects of the disturbances to biological interactions between predator and prey; food web structures, are little described. In this study, we aimed to elucidate response of diets of soil microarthropods to ecological disturbances and compared carbon and nitrogen stable isotope ratios of them between those from litter removal plots and those from control plots.

Litter removal manipulation was conducted in Kamigamo Experimental Station, Kyoto, Japan on July 12th, 2019. For simplification of experimental conditions, we selected a Japanese cypress (*Chamaecyparis obtusa*) monoculture plantation for the manipulation. Litter manipulation plot was comprised of three 4 m x 4 m quadrates settled in one-line, and two 2 m x 4 m quadrates on both sides of the litter removal plot were defined as control plot. All quadrates were split into 2 m x 2 m subplots, and at least two soil cores were sampled from every subplot for the extraction of soil microarthropods. Tullgren apparatus was used for the extraction. The extracted microarthropods were identified to order or suborder and stable isotope ratios of carbon and nitrogen (δ^{13}C and δ^{15}N) were measured for the following taxa; Oribatida (detritivore), Collembola (detritivore), Prostigmata (Predator or microbivore), and Gamasida (predator). Part of the soil cores were used for the δ^{13}C and δ^{15}N measurements of the following four collembola species; *Tetracanthella sylvatica*, *Tomocerus varius*, *Folsomia octoculata*, and *Isotoma carpenteli*. Organic layers on soil surface is also sampled from every subplot, and separated into litter, fumus, upper humin, and lower humin for the isotope measurements. For the samples less than 0.2 mg in dried weight, reduced-volume quartz tube was used for the combustion furnace. To test the effect of manipulation and sample type on the δ^{13}C or δ^{15}N values, ANOVA-like GLMM considering effect of plot as block factor, were conducted for each of soil organic layer, three Acari suborders with Collembola, and four Collembola species. Goodness of fit was evaluated by AIC, and in case singular fit was returned, block random factor was removed and GLM was re-selected. Post-hoc test was also conducted by model selection of GLMM for every sample type.

Based on the models, effect of litter removal was selected for δ^{13}C, δ^{15}N of Collembola species and δ^{15}N of Acari suborders and Collembola. δ^{15}N of organic layers were slightly different between manipulated plots and control plots, although the effects were not consistent between the sample types: δ^{15}N of litter layer was increased, while δ^{15}N of humus was decreased by litter removal. Collembola species living in the deeper organic layer showed in higher δ^{13}C and δ^{15}N than surface-living species, as shown in previous studies. Gamasida in the manipulated plot showed on average 1.7‰ higher δ^{15}N values than those from control plot. These results indicate that predators approached to prey in deeper organic layers. Collembola species sampled in manipulated plot showed up to 0.5‰ lower $\delta^{13}C$ values and up to 0.7‰ higher $\delta^{15}N$ values than controlled plot. A surface-dwelling Collembola (*Tomocerus varius*) showed predominantly different isotope $\delta^{13}C$ and $\delta^{15}N$ values between treatments, which suggested shift to phytophagy of the species. On the other hand, litter removal little affected the isotope values of Collembola as a whole. Based on the effect of litter removal on $\delta^{13}C$ of some Collembola species, phytophagous-oriented diet shift was suggested. On the other hand, no-effects of $\delta^{13}C$ and $\delta^{15}N$ values might be explained by compensatory change of species composition of collembola against the diet shift of some species (i.e., decrease of surface-dwelling species, which had low $\delta^{13}C$ and $\delta^{15}N$ values).

Keywords: soil microarthropods, food web, carbon and nitrogen stable isotope ratios

