SUPPLEMENTARY ONLINE MATERIAL

Evidence for the niche theory in small mammals along an elevational gradient revealed by isotopic signatures

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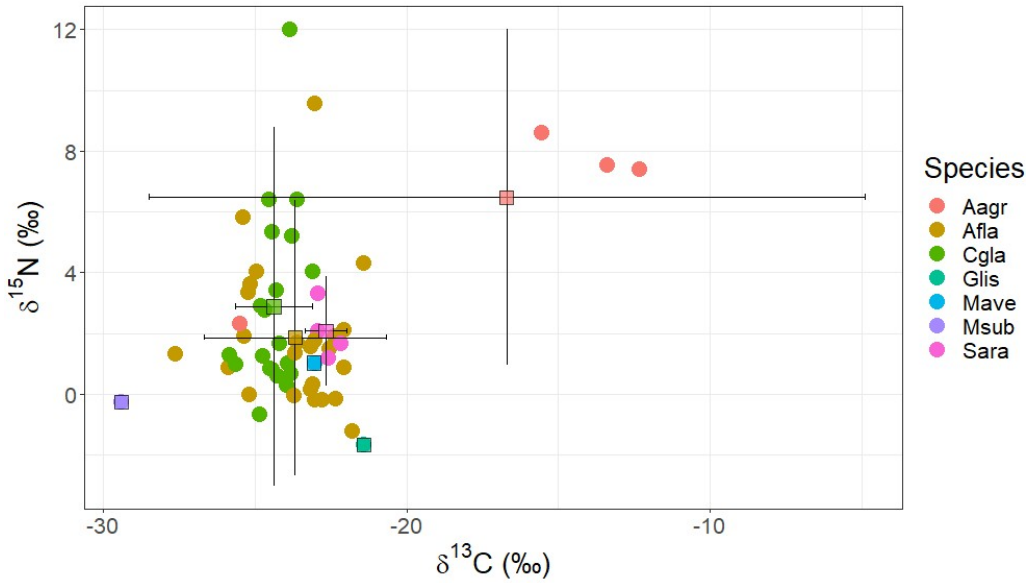

Fig. S1. Position in the isotopic space of the hair samples from the small mammal species from the Southern Carpathians (Romania) over the three years of survey (2022-2024). Squares represent the means and lines represent the 95% confidence intervals. Aagr – *Apodemus agrarius*, Afla – *A. flavicollis*, Cgla – *Clethrionomys glareolus*, Glis – *Glis glis*, Mave – *Muscardinus avellanarius*, Msub – *Microtus subterraneus*, Sara – *Sorex araneus*.

An unexpected result of our study was the position of *Sorex araneus* along the $\delta^{15}N$ axis, similar to or even lower than the rodent species. *Sorex araneus* is the shrew species most commonly found in mountain forests in the Southern Carpathians, and in years of low rodent density it can be the most abundant species in small mammal communities (Benedek & Sîrbu 2019, Benedek et al. 2022). The $\delta^{15}N$ values in the shrew population suggest that it does not occupy a high trophic level, i.e. it is omnivorous. However, categories of small mammal diets are not always useful in explaining variation in $\delta^{15}N$ or $\delta^{13}C$ isotopic ratios. For example, herbivores may have $\delta^{15}N$ values similar to omnivores, either because of their use of plants or microhabitats with high ^{15}N content, or by occasional ingestion of food items different from plants (e.g. fungi, invertebrates) (Shaner & Ke 2022). The lack of knowledge about the biology of species may lead to a failure to accurately categorize their diet (Bubadué et al. 2021). Long considered purely insectivorous, *S. araneus* may be a selective mycophagist, rather than a mere indirect consumer of fungi (Schickmann et al. 2012, Urban 2016). However, it is possible that $\delta^{15}N$ values may not always be a very accurate indicator of trophic position, as they are also affected by many other factors. During particulate N decomposition, the lighter ^{14}N is lost faster than ^{15}N, resulting in a 5 to 10‰ enrichment of ^{15}N in deeper soils (Fry 2006). Therefore, plants with deep roots (trees) have access to the nitrogen in deeper soils and thus will have higher $\delta^{15}N$ values (Kelly 2000, Karasov & del Rio 2007), which, in turn, will be propagated along the food chain. Consequently, exploiting resources that source their nutrients from herbaceous (e.g. leaves, flowers, seeds of herbaceous plants or insects feeding on

these) or woody (e.g. tree seeds, fruits or defoliating insects) plants can shape ^{15}N composition more than trophic position.

Among the uncommon species, *Glis glis* and *Microtus subterraneus* were characterised by the lowest $\delta^{15}N$ values (–1.66 and –0.25 $\delta^{15}N$), indicating their plant-based diets. However, their positions along the $\delta^{13}C$ axis were very distinct, being placed at the two extremities of the main section of the isotopic biplot (–21.42 and –29.42 $\delta^{13}C$), the vole having the lowest and the dormouse the highest values (Fig. S1). In forest ecosystems, the CO_2 resulting from the soil respiration is depleted in ^{13}C, and because it is primarily absorbed by the ground-layer vegetation before mixing with the upper air strata, forests present a vertical $\delta^{13}C$ gradient that increases from the forest floor to the upper part of the tree canopy. This gradient is known as the canopy effect (Medina & Minchin 1980). It explains how locomotion modes (terrestrial, fossorial, scansorial, arboreal) can influence isotopic signatures of species by constraining the exploited resources, through the differential access to them (e.g. using different forest strata) (Bubadué et al. 2021). In our study, it explains the difference in $\delta^{13}C$ between the strictly terrestrial vole and the arboreal dormouse. The position of the second dormouse species, *Muscardinus avellanarius*, in the isospace (–23.06 $\delta^{13}C$ and 1.03 $\delta^{15}C$), suggest a less arboreal habit and a more omnivorous diet (Fig. S1).

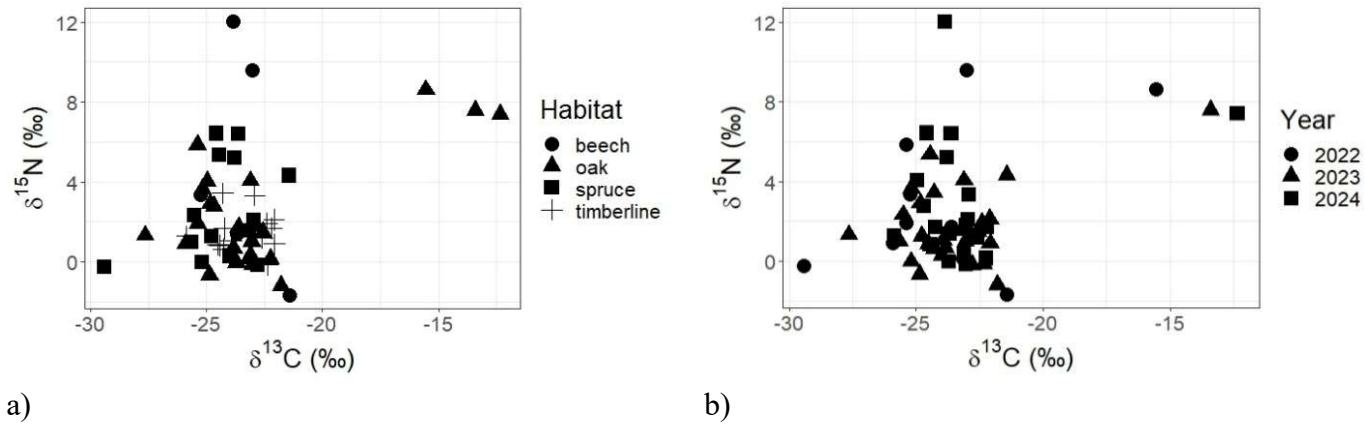

Fig. S2. Position in the isotopic space of the small mammal hair samples from the Southern Carpathians (Romania) over the three years of survey (2022-2024) according to a) forest type and b) year of survey.

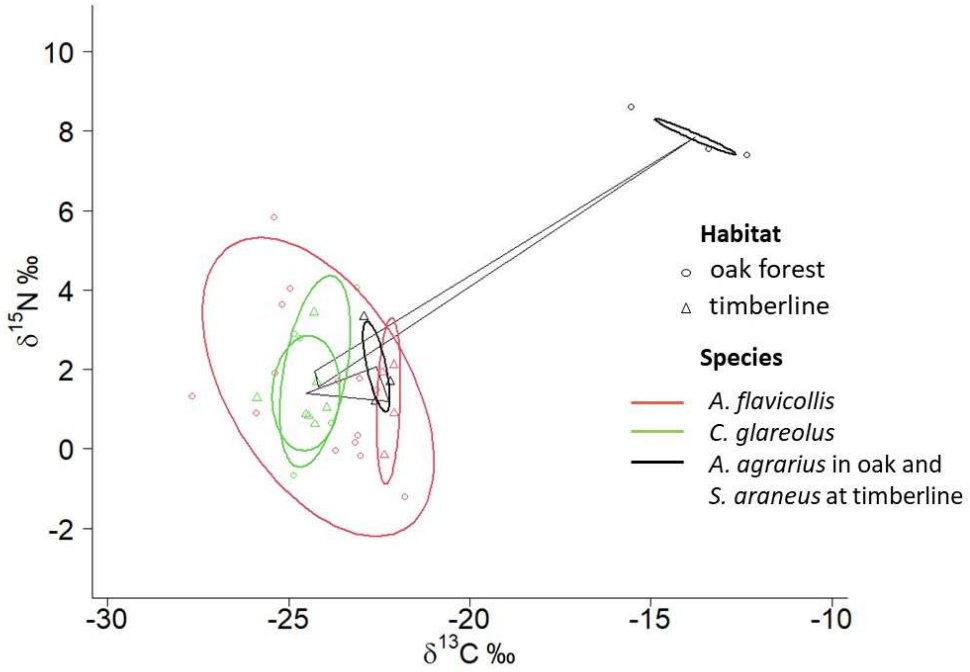

Fig. S3. The convex hulls for the small mammal communities in the oak forest and at the timberline in the Southern Carpathians (Romania) over the three years of survey (2022-2024). The ellipses represent the 95% confidence interval of the species' means of the $\delta^{13}C$ and $\delta^{15}N$ values, corrected for small samples.

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