**Trait functional diversity explains mixture effects on litter decomposition at the arid end of a climate gradient**

Rafaella Canessa\*1,2, Liesbeth van den Brink2, Monica B. Berdugo1, Stephan Hättenschwiler3, Rodrigo S. Rios4,5, Alfredo Saldaña6, Katja Tielbörger2, Maaike Y. Bader1

1Ecological Plant Geography, Faculty of Geography, University of Marburg, Deutschhausstr. 10, 35032 Marburg, Germany; 2Plant Ecology Group, University of Tübingen, Auf der Morgenstelle 5, 72076 Tübingen, Germany; 3CEFE, Univ. Montpellier, CNRS, EPHE, IRD, Montpellier, France; 4Departamento de Biología, Universidad de La Serena, Casilla 554, La Serena, Chile; 5Instituto Multidisciplinario de Investigación en Ciencia y Tecnología, Universidad de La Serena, La Serena, Chile; 6Departamento de Botánica, Facultad de Ciencias Naturales y Oceanográficas, Universidad de Concepción, Casilla 160-C, Concepción, Chile.

\*Corresponding author: Rafaella Canessa; current address: Plant Ecology Group, University of Tübingen, Auf der Morgenstelle 5, 72076, Germany; [rcaness1@uc.cl](mailto:rcaness1@uc.cl)

These data files are published under the terms of the Creative Commons Attribution-NonCommercial License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited and is not used for commercial purposes.

**Journal Name:** Journal of Ecology

**Abstract**

1. Litter decomposition is controlled by climate, litter quality and decomposer communities. Because the decomposition of specific litter types is also influenced by the properties of adjacent types, mixing litter types may result in non-additive effects on overall decomposition rates. The strength of these effects seems to depend on the litter functional diversity. However, it is unclear which functional traits or combination of traits explain litter mixture effects and if these depend on the range of trait values and the ecosystems involved. These uncertainties hamper our ability to predict decomposition in plant communities.

2. We aimed at understanding whether and how functional diversity (measured as functional dispersion, FDis) influences litter decomposition, and how this influence varies among different climates and across decomposition stages. We calculated FDis based on litter traits related to nutrient concentrations or to litter recalcitrance, and tested whether these diversity measures and climatic parameters (soil moisture and temperature) explained litter mixture effects on decomposition.

3. Additive mixture effects (i.e. decomposition of mixtures equalling the mean decomposition of the single litter types) were common in most of the evaluated climates. Non-additive, negative effects were mainly restricted to the driest and warmest sites, and decreased with time. Non-additive effects increased in magnitude with the mixtures’ FDis, with positive effects being related to FDis in nutrient traits and negative effects being related to FDis in recalcitrance traits.

4. *Synthesis*: Litter mixing did not have strong effects on decomposition rates across the studied climatic gradient overall, and the direction and intensity of the mixture effects were context-dependent. The effects were stronger and more negative in the dryer ecosystems. Where effects were found, functional diversity calculated from selected groups of traits (related to nutrients or litter recalcitrance) predicted mixture effects, especially where trait ranges were broad, though much of the variation remains unexplained. We propose that functional diversity metrics based on litter traits that are mechanistically relevant, applied to diverse site-specific litter mixtures in different climates, can help to better understand under which conditions and in which direction litter diversity affects decomposition.

**Key words**

Natural sciences, arid ecosystems, climate gradient, ecosystem functions and services, functional dispersion, litter breakdown, litter decomposition, litter diversity, litter mass loss, litter mixture effect, litter recalcitrance, litterbag, nutrient transfer, plant functional traits

**General description**

The dataset is related to the publication "Trait functional diversity explains mixture effects on litter decomposition at the arid end of a climate gradient" by Canessa et al. 2022 in Journal of Ecology. The study aimed at understanding whether and how functional diversity (measured as functional dispersion, FDis) influences litter decomposition, and how this influence varies among different climates and across decomposition stages. For this, mixture effects in litter decomposition for different local plant litter mixtures were evaluated along a climate gradient in Chile, and related to microclimate parameters (soil temperature and moisture) as well as to the FDis of two sets of litter traits (nutrient and recalcitrance traits).

This dataset provides data on litter decomposition (i.e. mass loss, %) of all individual species and litter mixtures at different decomposition stages, and the litter mixture effects calculated from these. In addition, litter functional traits (C/N, Mg, K, Ca, tannins, total phenolics, lignin and force to punch) and FDis calculations for each litter mixture are provided. Finally, microclimate data for each decomposition site and period are also included.

**General methods**

The dataset represents litter decomposition (i.e. mass loss, %) of 52 plant species, decomposing both individually as well as in litter mixtures (of 2, 4 or 6 litter species combined) in six different study sites along a climate gradient in Chile. Litterbags were set to decompose in the field for 6, 12 and 20 months. For each litterbag, the percentage of litter mass loss was calculated as *(Mf- Mi)*/ *Mi*\* 100, where *Mf* is the final dry mass after decomposition and *Mi*is the initial dry mass.

The litter mixture effect (%), i.e. the percent difference in the observed mass loss of a mixture (*Mo*) relative to the mean of single-species mass loss of all the species that constituted a mixture (*Mp*), was calculated as *(Mo* – *Mp)* / *Mp* \*100 for each mixture. Non-additive mixture effects occurred when the observed mixture mass loss was significantly different from the predicted mixture mass loss. These non-additive effects were positive or negative when the observed mixture mass loss was higher or lower than the predicted mass loss, respectively.

Associated to these decomposition data, the file contains data on plant functional traits for each of the decomposing species. For 30 species, functional traits were retrieved from Canessa et al. (2021). For other species not present in that study, data were measured following the same methodology used in Canessa et al. (2021).

Based on the plant functional traits data, functional dispersion values (FDis, *sensu* Laliberté & Legendre, 2010) for each of the litter mixtures were calculated using two different sets of traits that correlate with litter decomposition generally and that relate to the mechanisms responsible of litter mixture effects. The two calculated indices are (1) “nutrients FDis”, based on a distance matrix using traits that are potentially related to nutrient transfer among litter and thus, may mostly cause positive mixture effects (C/N, Mg, K and Ca); and (2) “recalcitrance FDis”, based on a distance matrix using traits that generally inhibit decomposition, and thus, are expected to produce negative mixture effects (tannins, total phenolics, lignin and Fp).

Additionally, the file contains microclimatic data measured at the six study locations for the different decomposition periods (overall, between June 2017-January 2019). The evaluated parameters include mean soil temperature (MST) and mean soil moisture (MSM).

For more details on the methodology, please refer to the main manuscript associated to this dataset.

**Metadata**

The Excel file contains four sheets:

1. Metadata: Contains the metadata (information about the data presented in the other three sheets).
2. Litter\_species: Contains litter decomposition data of each litter species decomposing alone (single-species mass loss).
3. Funct\_traits: Contains functional trait data of each litter species included in the study.
4. Litter\_mixtures: Contains litter decomposition data for litter mixtures, functional dispersion values for litter mixtures, and microclimate data for each study site and plot.

**Funding Information:**

This study was funded by the German Research Foundation (DFG) in the Priority Program SPP-1803 “EarthShape: Earth Surface Shaping by Biota” (grant BA 3843/6-1 to MYB; TI 338/14-1&2 to KT).

**Related work:**

Canessa, R., van den Brink, L., Saldaña, A., Rios, R. S., Hättenschwiller, S., Mueller, C. W., Prater, I., Tielbörger, K., & Bader, M. Y. (2021). Relative effects of climate and litter traits on decomposition change with time, climate and trait variability. *Journal of Ecology*, 109, 447–458.  <https://doi.org/10.1111/1365-2745.13516>

Canessa, R, van den Brink, L., Saldaña, A., Rios, R. S., Hättenschwiller, S., Mueller, C. W., Prater, I., Tielbörger, K., & Bader, M. Y. (2020), Relative effects of climate and litter traits on decomposition change with time, climate and trait variability, Dryad, Dataset, <https://doi.org/10.5061/dryad.ttdz08kwb>