A large database on functional traits for soil ecologists: BETSI

Sophie Joimel, Johanne Nahmani, Mickael Hedde, A. Auclerc, Beaumelle Léa, Jonathan Bonfanti, Jérôme Cortet, Ganault Pierre, Florence Maunoury-Danger, Pey Benjamin

GLOBAL SYMPOSIUM ON SOIL BIODIVERSITY | FAO HQ | Rome, Italy, 19-22 April 2021

A large database on functional traits for soil ecologists: BETSI

Joimel Sophie[1], Nahmani Johanne[2], Hedde Mickaël[3], Auclerc Apolline[4], Beaumelle Léa[5], Bonfanti Jonathan[2], Cortet Jérôme[2], Ganault Pierre[2], Maunoury-Danger Florence[6], Pey Benjamin[7] & BETSI consortium*

[1]UMR ECOSYS, INRA, AgroParisTech, Université Paris-Saclay, France. Sophie.boulanger-joimel@agroparistech.fr
[2]UMR CEFE, CNRS – Univ. Montpellier – Univ. Paul-Valéry Montpellier 3 – EPHE – IRD, Montpellier, France
[3]Eco&Sols, INRA-IRD-CIRAD-Montpellier SupAgro, France
[4]Laboratoire Sols et Environnement, Université de Lorraine, Inra, LSE, F-54000 Nancy, France
[5]German Centre for Integrative Biodiversity Research (iDiv), Leipzig, Germany
[6]Université de Lorraine, CNRS, LIEC, F-57000 Metz, France
[7]EcoLab, Université de Toulouse, CNRS, Toulouse, France

Abstract summary

Functional approaches are gaining considerable traction in ecology. Expanding the functional trait-based conceptual framework to soil organisms has been slowed by the lack of standardized semantic and methods. The Biological and Ecological Traits of Soil Invertebrates database (BETSI, https://portail.betsi.cnrs.fr/) is a European database dedicated specifically to soil organisms' traits. This open database now gathers 129 185 entries on 44 413 species and 56 traits coming from about 2000 literature references and is linked to a thesaurus defining each trait. In this presentation, we will give an overview of the database and of its multiple associated research projects. With more than 20 articles, four PhD thesis conducted on various taxonomic groups and land uses/soil types, and multiple collaborative projects, e.g. on soil invertebrates feeding preferences or earthworm distribution in France, the database offers many opportunities to improve our knowledge on the functional facet of soil biodiversity. Most publications using or citing BETSI aimed to clarify the relationships between functional traits and habitat or environmental stressors. We will further highlight the main perspectives and future directions on functional traits research in soil ecology in order to advance the monitoring and conservation of soil biodiversity.

Keywords: functional traits, soil fauna, database, standardisation, cooperation

Introduction

The functional approach provides quantitative and generic predictions in order to understand how organisms interact, respond and affect their environment. Moreover, in the era of Big Data and FAIR principles (Data need to be Findable, Accessible, Interoperable, Reusable), there is growing interest and need for data integration and accessibility in order to facilitate scientific networking, discovery and innovation (Jones *et al.*, 2006; Wilkinson *et al.*, 2016). Consequently, many databases on various taxa's functional traits were created: plants

(TRY database (Kattge *et al.*, 2011)), fungi ('FUNGuild' (Nguyen *et al.*, 2016)), the 'Reptile Trait Database' (Grimm *et al.*, 2014) or the 'Coral Trait Database' (Madin *et al.*, 2016). As soils host a quarter of our planet's biodiversity and provide a variety of ecosystem services, it is crucial to expand the functional trait-based conceptual framework to soil organisms.

Currently, existing databases for functional traits of soil fauna focus on single taxonomic groups (Antbase: AntBase.net, Carabidae of the World: Carabid.org, ColTrait for Collembola, DriloBASE: taxo.drilobase.org) or on soil invertebrates but with no trait data (Burkhardt *et al.*, 2014). Until now however, no single database gathered functional traits of soil invertebrates across taxonomic groups. BETSI, a database dedicated to soil invertebrates' functional traits in Europe was created to fill this gap. The aim of the present presentation is to describe the functioning, the innovations, the current and potential future uses of BETSI.

BETSI database functioning

The BETSI database currently gathers data on 13 traits (morphological traits and ecological preferences) for 9 taxonomic groups: Arachnida (Aranae), Chilopoda, Coleoptera, Collembola, Diplopoda, Hymenoptera (Formicidae), terrestrial Isopoda, Oligochaeta and Orthoptera. With 129 185 entries on 44 413 species and 56 traits coming from about 2000 reference, BETSI is currently the largest database on functional traits of soil fauna.

BETSI is designed to host different types of trait data inputs - in their definitions and in their trait values - and is able to provide the users with harmonized trait data outputs. Indeed, to ensure semantic homogeneity on traits or ecological preferences, BETSI query trait or ecological preferences names from a controlled vocabulary organized into a hierarchy: the thesaurus for soil invertebrate trait-based approaches (T-SITA) http://t-sita.betsi.cnrs.fr/BETSI_vizIndex.jsp (Pey *et al.*, 2014). The T-SITA reflects the consensus of a community of soil zoologists on trait and ecological preference semantic properties (Pey *et al.*, 2014). To date, the T-SITA gathers 298 definitions for traits and ecological preferences.

Moreover, traits in BETSI were split into attributes by a fuzzy coding approach (Pey *et al.*, 2014). Attributes were not always exclusive, but may present affinity scores for each trait of one functional trait. Such data transformation allows values to be computed for functional traits derived from a variety of sources, mainly arising from identification keys.

An interface to the BETSI database is available at the following address (https://portail.betsi.cnrs.fr/, Figure 1).

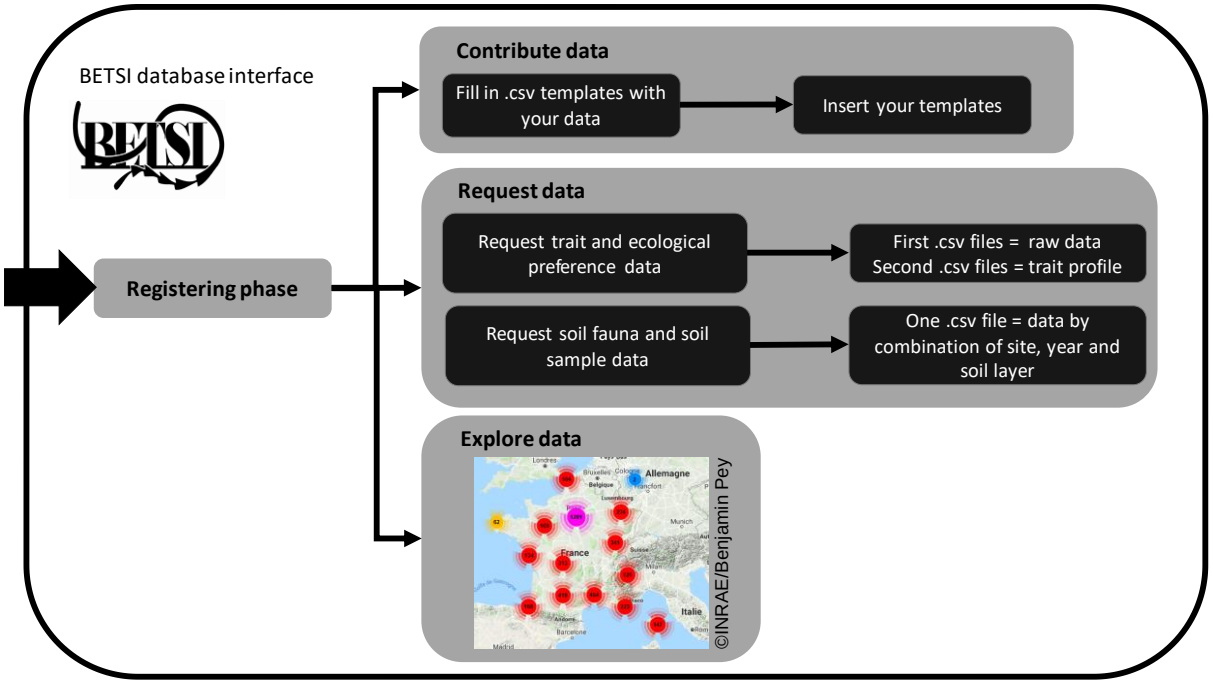

Figure 1: General workflow of user interaction with BETSI

Current uses and opportunities

BETSI allowed the publication of more than 20 articles, four PhD thesis conducted on various taxonomic groups and land uses/soil types or ecological gradients, and collaborative projects on soil invertebrates feeding preferences, or earthworm distribution in France (Figure 2). These studies mainly focused on Collembola (44 percent), and on macrofauna (41 percent), particularly on spiders, ground beetles and earthworms. Until now, the BETSI database contains information on a restricted number of traits on few - but highly representative - European taxonomic groups of soil invertebrates, and Orthoptera due to time constraints. However, new members and collaboration promise increase knowledge on other important group such as gastropods, ants or nematodes. BETSI is supported by an international research open network (www.reseau-tebis.fr) that has been gathering in a 3-days congress every year in a French research institution since 2014.

References	Soil fauna groups	Areas of study	Subject areas	Land uses	Citing	Using
Aubert et al. 2018	All groups	-	Ecology	Forest	x	
Bonfanti et al. 2018	Collembola	Europe	Ecology	-		x
Brousseau et al. 2018	All groups	-	Ecology	-	x	
Hedde et al. 2018	Macrofauna	France	Ecological rehabilitation	Urban/Industrial		x
Joimel et al. 2018a	Collembola	France	Ecology	Urban		x
Joimel et al. 2018b	Collembola	France	Ecotoxicology	Urban		x
Seibold et al. 2018	All groups	-	Ecology	-	x	
Vincent 2018	**Collembola, Macrofauna**	**France**	**Ecological rehabilitation**	**Urban/Industrial**		**x**
Vincent et al. 2018	Collembola, Macrofauna	France	Ecological rehabilitation	Urban/Industrial		x
Wong et al. 2018	All groups	-	Ecology	-	x	
Abgrall et al. 2017	Collembola	France	Ecology	Wetland	X	
Maisto et al. 2017	Mesofauna	Italy	Ecotoxicology	Forest, Urban, Arable land	x	
Milano 2017	**Collembola**	**France**	**Ecology/ Management**	**Urban**		**x**
Cameron et al. 2016	Earthworms	World	Ecology	-	x	
Marliac et al. 2016	Spiders	France	Agricultural management/Ecotoxicology	Orchard		x
Pelosi et al. 2016	Earthworms	France	Agricultural management	Arable Land		x
Burrow 2015	**Collembola**	**France**	**Ecological restauration**	**Urban/Industrial**		**x**
Hedde et al. 2015	Ground beetles	France	Agricultural management/Ecotoxicology	Orchard		x
Henneron et al. 2015	Macrofauna	France	Agricultural management	Arable Land		x
Joimel 2015	**Collembola**	**France**	**Land disturbance**	**Urban**		**x**
Mazzia et al. 2015	Spiders	France	Agricultural management/Ecotoxicology	Orchard		x
Santorufo et al. 2015	Collembola	Italy	Land disturbance	Forest, Arable Land, Urban, Industrial		x
Duflot et al. 2014	Ground beetles	France	Landscape ecology	Forest, Arable Land, Grassland		x
Pelosi et al. 2014	Earthworms	France	Agricultural management	Arable Land		x
Pey et al. 2014a	All groups	-	Ecology	-	x	
Pey et al. 2014b	All groups	-	Ecology	-	x	
Salmon et al. 2014	Collembola	Europe	Environmental gradient	Forest, Arable Land, Grassland		x
Santorufo et al. 2014	Collembola	Italy	Land disturbance/ Ecotoxicology	Urban		x
Hedde et al. 2013a	Macrofauna	France	Agricultural management/Ecotoxicology	Urban/Industrial		x
Hedde et al. 2013b	Macrofauna	France	Agricultural management/Ecotoxicology	Urban/Industrial		x
Santorufo 2013	**Micro-arthropods**	**Italy**	**Land disturbance**			**x**
Hedde et al. 2012	Macrofauna	France	Soil disturbance/ Ecotoxicology	Urban/Industrial		x

Figure 2: Review of the literature using or citing BETSI database. In bold are theses

Most publications using or citing BETSI aimed to clarify the relationships between functional traits and habitat or environmental stressors (Hedde *et al.* 2012). They focused on environmental stressors such as soil contamination by metals (Joimel *et al.*, 2018), uses of pesticides in relation with agricultural management, changes in agricultural practices such as tillage (Pelosi *et al.*, 2014), or effects of land use. BETSI also incorporates behavioural traits, making it possible to study biotic interactions. Moreover, BETSI gathers enough data to explore functional biogeography questions (Bonfanti *et al.*, 2018).

Functional traits can also be used to help understanding the impacts of biodiversity on ecosystem processes and services (Wood *et al.*, 2015). For instance, a clear theoretical framework using traits exits for linking plant diversity to ecosystem processes (Lavorel et Garnier,, 2002). However such a framework is not adapted to soil invertebrates whose dynamics and effects on ecosystem processes are driven by a multitude of complex interactions (mainly trophic) (Gravel, Albouy and Thuiller, 2016). In this context, a new framework has recently emerged, reinterpreting foodweb interactions via the prism of functional traits (Gravel, Albouy and Thuiller, 2016). As BETSI already hosts many traits used in the functional foodweb description for soil invertebrates, it could be the cornerstone of the storage of trait data used in these approaches.

Conclusions

BETSI is designed to be a collaborative and an interactive database that already offers great opportunities for trait-based approach in soil ecology. BETSI has been evolving over the years thanks to its support by the TEBIS network of soil biodiversity researchers.

Most of data are represented by information available in synoptic books (species level data) rather than by actual measurements (individual level data). We aim to continue data collection to enhance data on functional traits of soil organisms.

Within the on-going European COST Action EUdaphobase that aims to improve soil biodiversity monitoring and conservation, the functional trait-based framework has been identified as a crucial approach. A pan-European soil-biology data warehouse hosting data on species traits and distribution, will improve the potential of functional trait approaches to assess soil biodiversity response to global changes at broad scales.

Acknowledgements

We would like to thanks all members of the TEBIS network and BETSI consortium.

References

Burkhardt, U., Russell, D.J., Decker, P., Döhler, M., Höfer, H., Lesch, S., Rick, S., *et al.* 2014. The Edaphobase project of GBIF-Germany—A new online soil-zoological data warehouse. *Applied Soil Ecology,* 83: 3-12.

Bonfanti, J., Hedde, M., Joimel, S., Krogh, P.H., Violle, C., Nahmani, J., Cortet, J., 2018. Intraspecific body size variability in soil organisms at a European scale: Implications for functional biogeography. *Functional Ecology*, *32*(11): 2562-2570.

Grimm, A., Ramírez, A.M.P., Moulherat, S., Reynaud, J. & Henle, K. 2014. Life-history trait database of European reptile species. *Nature Conservation*, 9: 45-67.

Gravel, D., Albouy, C. & Thuiller, W. 2016. The meaning of functional trait composition of food webs for ecosystem functioning. *Philosophical Transactions of the Royal Society B: Biological Sciences,* 371(1694)

Hedde, M., van Oort, F., Lamy, I., 2012. Functional traits of soil invertebrates as indicators for exposure to soil disturbance. *Environmental Pollution*, 164: 59-65.

Jones, M.B., Schildhauer, M.P., Reichman, O.J. & Bowers, S. 2006. The New Bioinformatics: Integrating Ecological Data from the Gene to the

Biosphere. *Annual Review of Ecology Evolution and Systematics*, 37: 519-544.

Joimel, S., Capiaux, H., Schwartz, C., Hedde, M., Lebeau, T., Guern, C.L., Nahmani, J., *et al.* 2018. Effect of Geogenic Lead on Fungal and Collembolan Communities in Garden Topsoil. *Pedosphere* 28, 215–226.

Kattge, J., Diaz, S., Lavorel, S., Prentice, C., Leadley, P., Bonisch, G., Garnier, E., *et al.* 2011. TRY - a global database of plant traits. *Global Change Biology*, 17(9): 2905-2935.

Lavorel, S. & Garnier, E. 2002. Predicting changes in community composition and ecosystem functioning from plant traits: revisiting the Holy Grail. *Functional Ecology*, 16(5): 545-556.

Madin, J.S., Anderson, K.D., Andreasen, M.H., Bridge, T.C.L., Cairns, S.D., Connolly, S.R., Darling, E.S., *et al.* 2016. The Coral Trait Database, a curated database of trait information for coral species from the global oceans. *Scientific Data*, 3: 160017.

Nguyen, N.H., Song, Z., Bates, S.T., Branco, S., Tedersoo, L., Menke, J., Schilling, J.S. & Kennedy, P.G. 2016. FUNGuild: An open annotation tool for parsing fungal community datasets by ecological guild. *Fungal Ecology*, 20: 241-248.

Pelosi, C., Pey, B., Hedde, M., Caro, G., Capowiez, Y., Guernion, M., Peigné, J., Piron, D., Bertrand, M. & Cluzeau, D., 2014. Reducing tillage in cultivated fields increases earthworm functional diversity. *Applied Soil Ecology,* 83: 79–87.

Pey, B., Laporte, M.-A., Nahmani, J., Auclerc, A., Capowiez, Y., Caro, G., Cluzeau, D., *et al.* 2014. A Thesaurus for Soil Invertebrate Trait-Based Approaches. *PLoS ONE*, 9(10): e108985.

Wilkinson, M.D., Dumontier, M., Aalbersberg, Ij.J., Appleton, G., Axton, M., Baak, A., Blomberg, N., *et al.* 2016. The FAIR Guiding Principles for scientific data management and stewardship. *Scientific Data*, 3: 160018.

Wood, S.A., Karp, D.S., DeClerck, F., Kremen, C., Naeem, S. & Palm, C.A. 2015. Functional traits in agriculture: agrobiodiversity and ecosystem services. *Trends in Ecology & Evolution*, 30(9): 531-539.