The Web of Life

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The Web of Life (www.web-of-life.es) provides a graphical user interface, based on Google Maps, for easily visualizing and downloading data on ecological networks of species interactions. It is designed and implemented in a relational database management system, allowing sophisticated and user-friendly searching across networks. Users can access the database by any web browser using a variety of operating systems. Data can be downloaded in several common formats, and a data transmission webservice in JavaScript Object Notation is also provided.

1 Introduction

In nature, species do not live in isolation but form large networks of interdependences that are often depicted as a set of nodes (species) connected by links (species interactions). This entangled web of life is increasingly threated by several drivers of global change (Tylianakis et al., 2008, 2010), such as climate warming (e.g., Memmott *et al.*, 2007), habitat loss and fragmentation (e.g., Tylianakis *et al.*, 2007), and invasive species (e.g., Aizen *et al.*, 2008). In this network context, species interactions are a component of biodiversity as important as species themselves (Thompson, 2009). We know we are losing species interactions (Aizen *et al.*, 2012), which may drive ecological communities towards tipping points (Lever *et al.*, 2014). We need, hence, a network thinking to predict future community-wide scenarios (Tylianakis *et al.*, 2008).

Since the 1980s, data on who interacts-with-whom in ecological communities have been compiled, focused mainly on food webs and plant-animal mutualistic networks. Data, however, can be found mainly as appendices or supplementary material in the papers where the authors originally published their work. The Interaction Web DataBase (www.nceas.ucsb.edu/interactionweb/) created in 2003 and hosted by the National Center for Ecological Analysis and Synthesis (NCEAS) at the University of California (USA) is, to our knowledge, the only initiative with the aim of centralizing the available information on ecological networks. However, as far as we know, it is currently

outdated. In addition, because it only provides datasheets, searching options are not implemented. This limits the potential use of the database as a working tool to tackle scientific questions across networks. In addition, if we aim to reach stackeholders and policy makers, an easy way of visualizing the network dataset compiled throughout the world is of paramount importance to capture their attention.

2 Features

We provide the most comprenhensive dataset of plant-animal mutualistic networks to date. In contrast to antagonistic interactions in which one species obtains a benefit at expenses of the other, in plant-animal mutualistic interactions, like those between a plant and a pollinator or between a plant and a seed disperser, both species obtain mutual benefit. Food webs and other ecological interactions such as host-parasite, host-parasitoid, plant-ant, plant-epiphyte, plant-herbivore, and anemone-fish interactions, will be available soon.

2.1 Location map

The user interface is based on Google Maps. Over the map, colored circles indicate where the compiled networks are located. Colors depict the type of ecological interaction. The user can zoom in or out and drag the map.

2.2 Network datasheet

Some basic information about the network can be obtained when the mouse pointer is over one of the colored circles. By left clicking on it, a detailed information about the network is dynamically generated: number of species, number of interactions, network connectance, locality, geographical coordinates, original reference, and a unique network identifier. The network identifier is intended to be adopted by the community of researchers as a unique tag to identify a given network across future studies. The network of interactions is also displayed along the species names (when they are identified). Depending on the data compiled by the researchers, a matrix of ones and zeros (presence/absence of the interaction, respectively) or a matrix of natural numbers indicating the number of visits performed by a pollinator species on a plant species, is displayed. A java script graphical representation using the D3js library is available for a quick visualization of the network.

2.3 Data filtering criteria

Network selection can be filtered directly from the menu bar by selecting the type of interaction (up to now pollination or seed dispersal), type of data (binary: presence/absence of the interactions, or weighted: number of visits), number of species, and number of interactions. The list of networks selected as resulting from the filtering criteria applied is immediately ready for visualization or download. Searchers across networks by species names can be performed from the list of networks selected, which allows a meta-

analysis never accomplished before.

2.4 Data download

Network data can be downloaded from the location map and from the filtering criteria. Species names can also be included. The following file formats are available: comma-separated values (.csv), Excel spreadsheet format (.xls), Pajek format (.net) that can be imported in Gephi as well for visualization, and as Java Script Object Notation (.json). Downloading a large dataset could take some time because a zip file containing each network as a single file, a file for the references, and a readme file, is dynamically generated. A log file tracking the history of changes for the downloaded network dataset (if exists) is also included in the zip file.

3 Implementation

The Web of Life has been designed and implemented in an open-source relational database management system (MySQL). This allows sophisticated and user-friendly searching across networks. It also provides an easy way of incorporating new network data available in the future. In order to minimize spelling mistakes when introducing new data, we do not provide an online interface for data entry, so that users cannot enter and edit their data directly. Users can access the database through any web browser using a variety of operating systems.

4 Conclusion

Biodiversity is much more than a list of species. Interactions among species are the *glue* of biodiversity. If we aim at predicting future community-wide scenarios and anticipating planetary critical transitions, we have to consider the entangled web of interactions among species. Here, we introduce The Web of Life, a database for visualizing and downloading data of species interaction networks. This repository allows scientists to do research within and between networks compiled at different places all over the world.

5 Acknowledgements

We would like to thank Jordi Bascompte's lab members for their suggestions during the design of the web, as well as the authors of the compiled networks for their invaluable effort during the fieldwork. This web service is supported by the European Research Council under the European Community's Seventh Framework Programme (FP7/2007-2013) through an Advanced Grant to Jordi Bascompte (grant agreement 268543). M.A.F. holds a postdoctoral fellowship (JAE-Doc) from the Program "Junta para la Ampliacion de Estudios" co-funded by the Fondo Social Europeo (FSE).

6 References

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Tylianakis, J. M., Laliberté, E., Nielsen, A., and Bascompte, J. (2010). Conservation of species interaction networks. *Biol. Cons.*, 143:2270-2279.

7 Figures

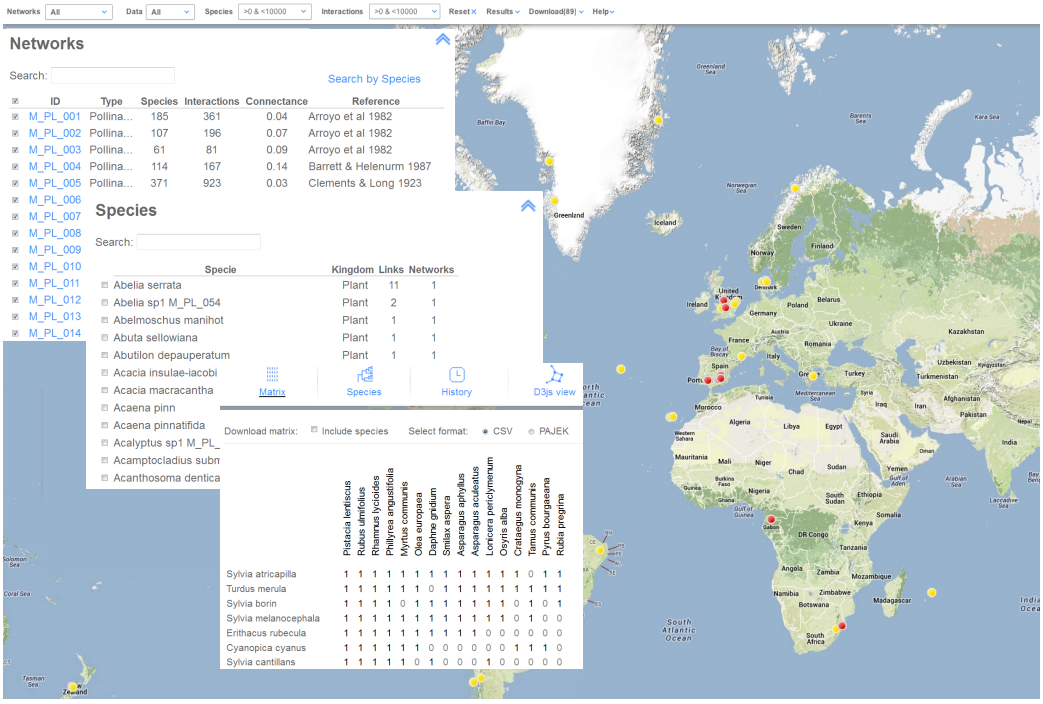


Figure 1: Snapshot of The Web of Life. On top, the menu bar showing the data filtering criteria. Over the map, three pop-up windows are displayed: the network list containing the selected networks, the species list for searching across networks, and an example of a network datasheet showing the presence/absence of mutualistic interactions between plant and animal species (from back to front, respectively).

Web of Life

- What is "web-of-life"?

www.web-of-life.es is a web service that provides a dataset of ecological interactions.

- What can you find?

This web service provides a graphical user interface based on google maps for searching and downloading ecological interaction network matrices of several types, their species names, and other usefull information such as the reference source, the link to the full paper, the geographic localization, etc.

- How does it work and how can you download the data?

The Map

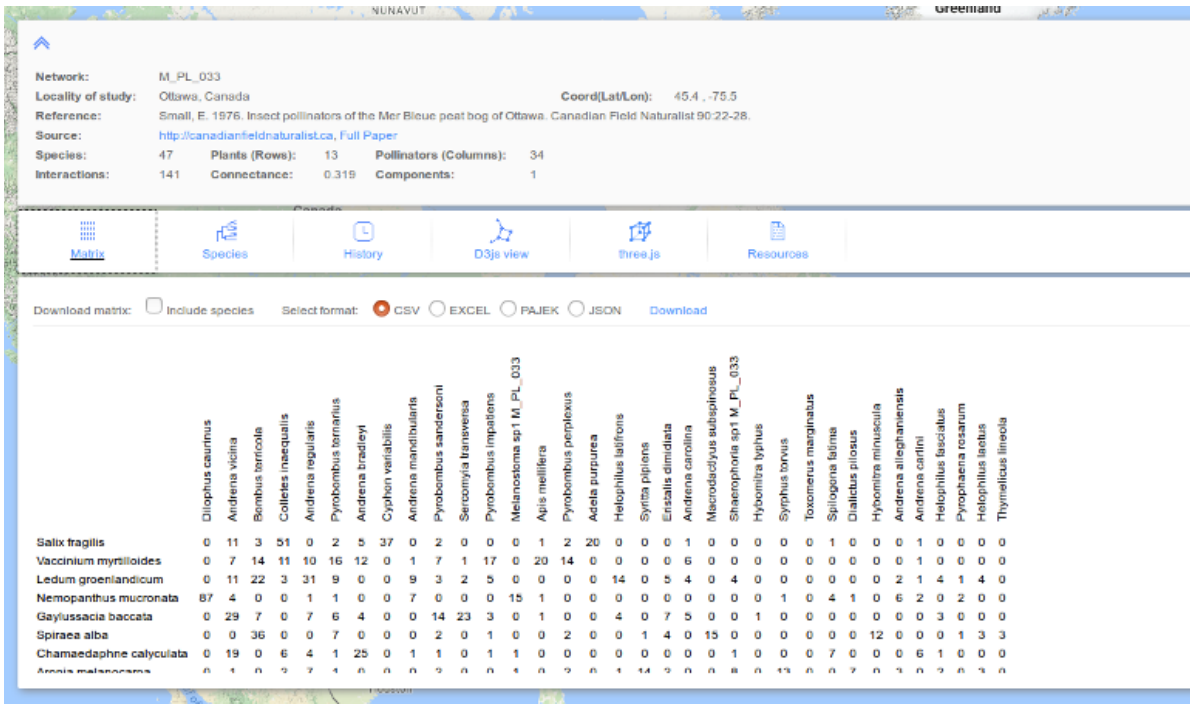
Over the map you can see the markers (circles) where the networks are located. The **color** of the markers inticates the **type of ecological interaction** of the network.

- Host-Parasite.
- Plant-Ant.
- Plant-Herbivore.
- Pollination.
- Seed-Dispersal.

Matrix Datasheet

If you **move the mouse pointer over a marker**, a popup box will show some **basic information about the network**.

If you **left click** on the marker, the **datasheet** window of the network will pop up. There, you will find much more **information** about the network: **unique identifier**, number of species, number of interactions, full reference link, localization coordinates ... and, of course, the **matrix** and the name of the **species**.

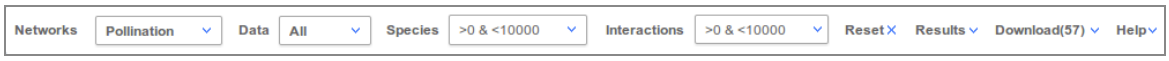


The tab **species** shows a list of the species of the network. You can filter, sort, and download it (see Downloads notes of this section).

You will also find the history records, where all changes will be logged, and graphical representation of the network.

The Menu Bar

On top of the map there is a menu bar:



When the web browser loads the map page, it shows the markers of all networks or a subset of them, depending on the link you clicked of the intro page of the site.

This menu bar **allows you filtering the results** by selecting:

- **Type of networks:** Pollination, Seed Dispersal, Food Webs, Host-Parasite, Host-Parasitoid, Plant-Herbivore, Plant-Ant, and Plant-Epiphyte.
- **Type of data:** binary or weighted.
- **Number of species.**
- **Number of interactions.**

Each time you change some option, the dataset will be filtered, showing over the map only the markers of networks that fit with the selection criteria.

If you want to view a **list of networks** as a result of the filter applied, click on **results**, this will give you more information.

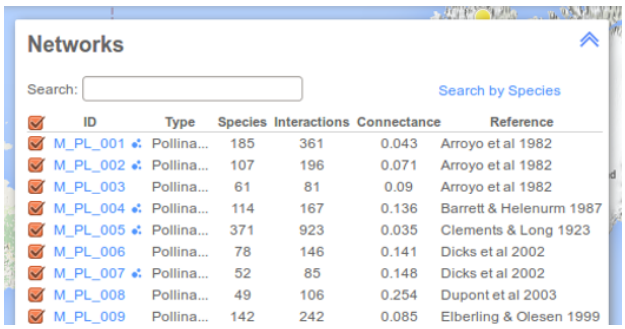
Clicking on **reset** will **erase the actual filter** and will cause showing the entire list of networks and their markers over the map.

The link **help** shows this help page.

The menu link **Donwload** of the menu bar allows you downlading the network matricies of the results list. The number between **brackets** indicates the **number of networks** are in the results list.

Results

The results list shows the **list of networks that fit the selection criteria**. This list include basic information about the networks listed: unique identifier (ID), an icon indicating whether there is more than one component, type of interactions, number of species, number of interactions, connectance, and a short reference. This will be useful to find the networks you are searching.



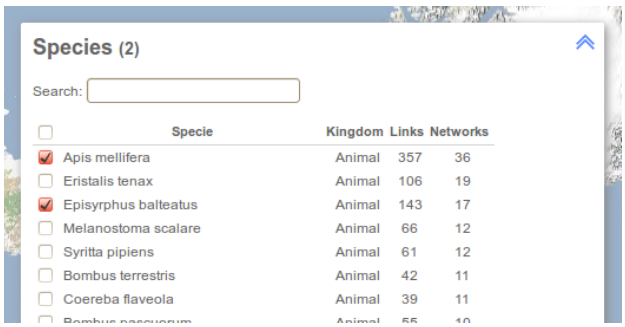
On top, there is a **search box** for filtering this list. While writing on it, any row with field values fitting the value chosen will be shown on the results, and the rest will be hidden. Keep in mind that this does no mean that hidden rows are deleted from the results, they are only hidden. The number between brackets in the Download link will not change.

At the left of each row there is a **checkbox**. By default, all rows have it as checked, and it means that the network will be included in the zip file for downloading. You can check/uncheck any checkbox to indicate exactly what you want to include in the **download** zip file. At the header there is a checkbox for checking or unchecking the full list.

Searching by Species

In addition to filtering criteria, you can find those **networks containing** specific **species**.

By clicking on link **Search by species**, which is located on top right of the networks list, the species list will be shown. All species of all networks of the dataset will be listed on it. Yo can **order** it by any column name, and also you can **filter** the listed species by writing in the search text box.



Once you click on the **checkbox** of any specie the networks list will be filtered, it will only show those networks which fit the selected criteria (type of network, type of data, range of species, range of interactions) and containing the selected specie names.

Note: *The panels/windows are draggable for have a better view.*

Downloads

Note: if you download a large result set, generating the zip file could take some time. Please, be patient.

You can download networks in three different ways:

- Individually from its data sheet.
- As a **zip file** containing the **results set** after filtering.
- As a **zip file** containing only networks with **checked** checkboxes.

The data can be donwloaded in theses formats:

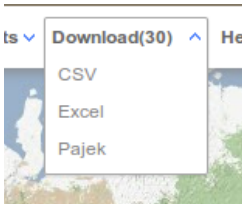
- **CSV:** Comma separated values.
- **XLS:** Excel spreadsheet format.
- **NET:** Pajek network format file. Also used by Gephi.
- **JSON:** data transmission webservice in JavaScript Object Notation.

Individual download format selection:

The options are located on top of the matrix.

Zip file download format selection:

The options are located on menu bar -> Download(n).



The ZIP file

When downloading by clicking the download link at the menu bar, a ZIP file will be **dynamically generated**. It will contain one file per **network** in the chosen format, the **references** of downloaded networks, and a **readme** file. Also, a **log** file per network with the history of **changes** (if exists) will be included in this zip file.

› What is a network ID? What is it for?

Network Identifier

The network identifier is composed by three strings concatenated by the underscore character.

A_B_C

The string "A" begins with a capital letter indicating the main group to which the network belongs:

- Mutualistic: M_
- Antagonistic: A_

The string "B" is composed by one or more uppercase letters indicating the type of interaciton of the network:

Mutualistic:

- Seed Dispersal: SD_
- Pollination: PL_
- Plant-Ant: PA_
- Plant-Herbivore: PH_
- Plant-Epyphit: PE_

Antagonistic:

- Food webs: FW_
- Host-Parasite: HP_
- Host-Parasitoid: HPD_

The string "C" is composed by three numerical digits from 0 to 9. Its value can change from 000 to 999. For a given type of interaction, this number is incremented each time a network is added to the database.

Use

The main purpose of the network identifier is distinguishing any network from each other, using a homogeneous system of reference. Further, we have extended this nomenclature system to non-identified species names, and for specie names with taxonomic errors.

Who is the owner and administers this service?

www.web-of-life.es is a service created by Raúl Ortega, Miguel Angel Fortuna, and Jordi Bascompte, provided by the Bascompte Lab at the Spanish Research Council, focused in the structure and dynamics of ecological networks.

Who support this project?

This project is supported by an **ERC's Advanced Grant** of the European Union.

Who is the author of de data?

www.web-of-life.es (Bascompte Lab) is not the author/owner of the data, but the author/owner of the service. The original work by each scientist should be acknowledged.

The data has been generated from scientific studies. In some cases, there are published in scientific journals. We have then extracted the data from the appendices of the paper or have requested them to the author. In other cases the data has not been published and has been provided by colleagues or by our own research. The Bascompte Lab has cleaned inconsistent species names, grouped rows or columns with repeated species names, and has deleted those which has 0 interactions, for servicing them to you.

What can you do with the data?

The use of this dataset is free, you can **use it** in your projects and **share it** with your collaborators.

If you decide to use this dataset in your projects, you must **mention this web service**:

"This work has used the Web of Life dataset (www.web-of-life.es)".

This does not preclude **citing the author** of individual networks when needed. You will find the references inside the file references.csv.

How can you contribute?

How to contribute

If you have a network that you think could be included in the database, please send us an e-mail, and we'll send you the necessary information. Also we would be happy to know about potential mistakes you spot.

How to contact us?

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