

Supporting Information to:

Global geographic distribution and host range of *Fusarium circinatum*, the causal agent of pine pitch canker

1. Geo-database

The objective of the geo-database was to collate known records and locations of *Fusarium circinatum* (FC), mainly across Europe, and related survey data such as host, disease intensity and environmental conditions as well as stand management. A certain number of fields were compulsory to allow basic analysis of disease distribution by host species and of how the situation has changed over time. The voluntary fields included more detailed data such as site, stand composition, soil, altitude, host age and height. For example, optional host data could allow tracing the movement of the FC pathogen in a country or continent; the provenance or seed source of the tree(s) (e.g., from a particular seed orchard) would allow the gathering of information on, and subsequent comparison of, the susceptibility of different provenances (see more details in the complete geo-database on the webpage: <http://bit.do/phytoportal>).

We strongly encourage researchers from all over the world, especially from continents and countries which are presently not well covered, to join the FC data collection effort. Please find contact addresses, the template (in Excel) and manual of the FC geo-database on the webpage (<http://bit.do/phytoportal>). The data is uploaded to the interactive map by Mendel University in Brno, Czech Republic.

Table S1. Data fields of the international *Fusarium circinatum* (FC) geo-database (for more information see: <http://bit.do/phytoportal>)^a

Data type	Details
Compulsory fields	
GPS coordinates	WGS 84 standard
Collection, observation or record date	The samples were collected or observation was made from 1945 to 2018
Contact name(s),	Please see contacts on the map active chain symbol at the top-centre: http://bit.do/phytoportal

institution and email address	
Host species	Based on the Farjon [149] (2001) system (see Farjon, A., 2001: World checklist and bibliography of conifers. The Royal Botanic Gardens, Kew, UK)
FC presence	Categories: FC not found, FC present where <i>Fusarium circinatum</i> has been identified by visual and molecular surveys
Sampling site and type of planting	Categories: U = urban greenery/ornamental tree, FP = forest plantation, NR = naturally regenerated forest, A = arboretum, XTP = Christmas tree plantation, N = nursery
Substrate tested	Categories: Entire seedlings, Shoots and branches, Main stem, Roots, Seeds, Cuttings, Other
Identification method	Macroscopic symptoms only, FC spores seen with compound microscope, mycelial morphology, species-specific PCR (conventional and/or real time PCR), sequencing, pyrosequencing
FC eradicated	Categories: Yes, No
Data availability	Categories: Yes, No. This field is to allow data protection, because in some cases information about quarantine organisms cannot be made freely available.
Voluntary fields	
Host	<ol style="list-style-type: none"> 1) source (natural regeneration, seeds, seedlings, mixed, unknown); 2) provenance; 3) origin; 4) age of tree(s) (nursery production, unknown, up to 10 years, 10–30 years, 31–50 years, 51–70 years, 71–90 years, or more than 90 years); 5) height of tree(s), estimation (up to 1 metre, 1–2 metres, 3–5 metres, 6–10 metres, 11–15 metres, 16–20 metres, 21–30 metres, 31 - 40 metres or more than 40 metres); 6) mean stand or tree diameter at breast height; 7) planting or stand density per hectare (less than 1000 stems or seedlings, 1000–3000 stems or more than 3000 stems); 8) other pathogens or microorganisms on the site, the same tree; 9) other stress factor acting on the same site or tree;

	10) additional host comments.
Site	1) site name; 2) estimation of affected area in hectares; 3) stand composition (pure or mixed); 4) soil type (sandy soil, brown earth, peat, bog, other); 5) previous land use (agricultural, forestry, nursery or other); 6) climate data: average temperature and sum of precipitation during the growing season.
Disease	1) percentage of trees affected in stand (single tree, less than 10%, 11–30%, 31–50% or more than 50%, no symptoms); 2) distribution of the disease in the stand (isolated, scattered, clustered, localised, widespread or uniform); 3) severity on the tree level (crown damage less than 5%, 5–10%, 11–25%, 26–50%, or more than 50% crown damage of whole tree, dead tree); 4) historical disease information, the year of the first observation of DNB in the country and published or grey literature source.
Disease management	thinning, pruning, brashing, weed control, fungicidal control in the stand; when (within the previous 2 years, 5 years, 10 years, 20 years) and in what intensity.

^a Data were collected from 41 countries. European countries were Bulgaria, Czech Republic, Cyprus, Estonia, Finland, France, Georgia, Germany, Great Britain, Greece, Hungary, Italy, Latvia, Lithuania, Macedonia, Montenegro, Poland, Portugal, Romania, Russia (including Asian part), Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey (including Asian part) and Ukraine. Non-European countries were Australia, Brazil, Chile, Colombia, Haiti, Israel, Japan, Mexico, New Zealand, Uruguay, South Africa, South Korea, and the USA.

2. GIS and map analyses

ArcGIS server (ESRI) is the basis for the Web Map Application for showing the global distribution of *F. circinatum*. The included geo-database is projected into the WGS 1984 Web Mercator (Auxiliary Sphere) coordinate system. Country data in the form of standardised tables are converted to point vectors (shape files), which are merged to a complex file geo-database and backed up in

parallel on two servers (failover cluster). Cartographic layers in the background of the map application use online ESRI Base Maps (see <http://bit.do/phytoportal>).

3. Statistical analyses

Analysis of environmental parameters was conducted by spatially overlaying localities with positive occurrence of *F. circinatum* with the layers of environmental parameters. Climatic variables were from the dataset of Hijmans et al. [1]. Analysed records represent all positive findings of *F. circinatum*, including localities where the disease was eradicated, but without all nursery findings. Specifically analysed abiotic phenomenon are as follows: elevation, annual average temperature, maximal temperature of the warmest month, minimal temperature of the coldest month, annual average precipitation, maximum precipitation of the wettest month, and minimal precipitation of the driest month.

References

1. Hijmans, R.J.; Cameron, S.E.; Parra, J.L.; Jones, P.G.; Jarvis, A. Very high resolution interpolated climate surfaces for global land areas. *Int. J. Climatol.* **2005**, *25*, 1965–1978.