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Research article

The research culture collection of Italian wood decay fungi: a tool for different studies and applications

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Abstract
A section of 512 strains from 106 species of wood decay fungi (WDF) collected in Italy is included within MicUNIPV, the reseach culture collection of the University of Pavia (Italy). The number of detained strains has been continuously updated since 2010, when this core collection started. The strains are representative of the remarkable variety in habitat, climate and land use in Italy, including 59 different plant hosts, either living or dead, as well as different degradation stages and modes. Polyporales, Hymenochaetales and Corticiales are the main wood-decay orders included in this core collection. Few examples of rare or strictly localized species in Italy are *Ganoderma pfeifferi*, *G. valesiacum*, *Hericium flagellum*, *Perenniporia meridionalis* and *Punctularia strigosozonata*. Besides these ones, *Laricifomes officinalis* especially rises conservation issues. The wide taxonomic and ecological spectrum provides with a variety of subjects for different studies in both systematics and applied mycology, as well as for exchanges with other mycologists and private partners in research projects.

Keywords
Culture collection, fungal strain, wood-decay fungi, biodiversity, conservation *ex situ*

Introduction

Culture collections of fungal strains are important tools in mycology. They are sources of quality-certified, axenic material to periodically refresh and indefinitely reproduce on demand. Axenic strains improve the quality of molecular analyses to explore the barcode regions, infer phylogeny, evolution and genomic scaffolds, and reduce the variability when studying metabolic pathways, gene expression, omics such as proteomics or metabolomics, or target metabolites. Axenic conditions are also necessary in the first stages of cultivation and in spawn generations especially (Stamets, 2011).

The increasing evidence that "fungal strain matters" (Dresch et al., 2015) suggests to introduce different conspecific strains in the same study: intra-specific variability can in fact result in different growth rates (that strongly affect biomass production), optimal temperature, substrate preference, synthesis of desired metabolites, etc. Despite to now poorly and broadly conceptualized, ecotypization is also part of this variability, either advantageously or not for applications (Barros et al., 2020a,b).

Culture collection also allow the *ex situ* conservation of species typically related to degradative successions where coenoses are gradually extincted in their own site as the substrate has been degraded and the environmental conditions have changed. Culture collections can overcome the problem of strain availability and support the biodiversity conservation (Lonsdale et al., 2008; Moose et al., 2019; Wainhouse and Boddy, 2022). Methods such as low temperature storage and cryopreservation ensure strain viability, purity and avoid genetic changes (https://wfcc.info/guideline). These methods are particularly suitable to preserve mycelia in species which typically don't produce resting spores or other resistant propagules in pure culture (Homolka, 2014).

Since 1980, the WFCC (World Federation for Culture Collections) has been providing quality standards which are now the main global reference for culture collections (https://wfcc.info/guideline), such as for the partners and sub-contributors of the European network MIRRI (Microbial Resource Research Infrastructure, https://www.mirri.org/). Since 2010, the Laboratory of Mycology of the Department of Earth and Environmental Sciences (University of Pavia, Italy) has set up a section of its Fungal Research Culture Collection (MicUNIPV) dedicated to wood decay species with a special, but not exclusive, focus on Basidiomycota.

Categorization of WDF is often tricky and ambiguous; this broadly defined category embraces almost all the orders in Agaricomycetes and several taxa in Tremellomycetes and Dacrymycetes, as well as in subphylum Pezizomycotina in Ascomycota (Hibbett et al., 2014; Zanne et al., 2020).

The main selection criterion of this work is to achieve WDF strains from as many species as possible representing different localities, hosts, climates and environments/habitats (Girometta et al., 2020; Cartabia et al., 2022; Buratti et al., 2023a). Aim of this work is to present the Italian strains of wood-decayer Basidiomycota included in MicUNIPV, highlighting the critical taxonomic issues of some species and the different applications.

Materials and Methods

Field sampling

Sporomata were manually collected in field and preserved in paper bags until processing in laboratory. If necessary, specimens of the host plant were collected to check the identity. Each strain is provided with the following data according to the current protocols of the MicUNIPV section for wood decay fungi (WDF-MicUNIPV hereafter): local toponym; municipality; province; coordinates (for selected specimen series); host plant; collection date; legit; revidit; determinavit; isolavit; general notes on the habitat features and habitat category if applicable (https://www.wfcc.info/guideline; http://vnr.unipg.it/habitat/cerca.do). Topographic metadata have been retrieved, verified or cross-checked on institutional webGIS facilities, such as Geoportale Nazionale (http://www.pcn.minambiente.it/viewer/), Geoportale della Lombardia (https://www.geoportale.regione.lombardia.it/), Geoportale del Piemonte (https://www.geoportale.piemonte.it/) and Geoportale della Regione Emilia Romagna (https://geoportale.regione.emilia-romagna.it/). Parks and Natural Reserves authorized the sampling upon limitations.

Identification and isolation in pure culture

Macro and micro-morphological identification of original sporomata was performed by the joint collaboration of the DSTA-Unipv Laboratory of Mycology, the DLS-Unisi Laboratory of Mycology and the reference expert Dr. Annarosa Bernicchia. Zeiss Axioplan and Nikon Labophot II were used for stereo- and optical microscopy respectively. The following handbooks were used: Breitenbach and Kränzlin (1994); Bernicchia (2005); Bernicchia and Gorjón (2010); Ryvarden and Melo (2017); Bernicchia and Gorjón (2020). Most strains were isolated as follows: a small piece of context (about 10 mm^3) was drawn from a fresh surface and inoculated in Petri plate containing MEA (2% ME, 1.5% agar) or PDA (potato-dextrose-agar, 3.9%) (Biokar Diagnostics, Oxoid, VWR) with or without chloranphenicol 50 ppm. DRBC (dextrose-bengal rose-agar with chloranphenicol) (Biokar Diagnostics) was used for specimens suspected of microbial contamination. The described protocol allowed the isolation of strains in the dikaryon stage.

Due to the high contamination and failure rate, isolation in pure culture from basidiospores was attempted in a few selected cases only (e.g. corticioids): spores were gently brushed from the hymenial surface or a spore print and suspended in sterile water; bulk and diluted suspensions were splitted in Petri plate (about 1 mL / 177 cm^2) and incipient colonies were transplanted in new plates. This protocol mostly results in monokaryotic mycelia, although unexpected dikaryotization can occur as well, due to clusters of co-germinating spores or unpredictable irregularity of nuclear state in basidiospores. In both the protocols, plates were incubated in dark at 24-25 °C in thermostat (Biolog) until full colonization and in no case longer than 4 weeks in order to avoid dehydration. Colonies were subsequently examined for both macroscopic and microscopic features in order to discard contaminated copies and confirm the identification. Further confirmation of identity based on molecular barcode was performed as described in Girometta et al. (2020) and Buratti et al. (2023a).

Long-term conservation of strains in pure culture

Each strain received a MicUNIPV code and has been conserved by the following methods:

a) parafilm-sealed Petri plates, usually containing MEA as above (culture medium always reported on the plate), stored at 3-4 °C in dedicated fridges; fridges have periodically disinfected by NaClO solution; cultures have been periodically checked for dehydration and contamination and never left older than 4 years before refresh transplantation;

b) tubes containing mycelium-colonized paper discs in water-glycerol at -80 °C as described in Cartabia et al. (2022).

Results and Discussion

To date, the WDF-MicUNIPV has comprehensively achieved 690 strains from Italy, Spain, Poland, Switzerland and North Macedonia. The 55 Spanish strains are shared with the Salamanca University, that also detains the corresponding exsiccata as described in Buratti et al. (2023). Further 96 strains are shared with research fungal collections of Mogu S.r.l (MRFC) (Cartabia et al., 2021; Cartabia et al., 2022). The two mentioned sub-collections will not be discussed in the present work. The remaining core is made of 512 WDF Italian strains from 106 different species collected in 32 administrative provinces and growing on at least 59 plant species (substrates were not identified in some samples). The overall prospect of strains in WDF-MicUNIPV and its distribution within the current administrative frame of Italian Provinces (http://www.pcn.minambiente.it/viewer/) are respectively reported in Table 1 and Figure 1. All the fungal taxa follow the Mycobank Database nomenclature (www.mycobank.org, accessed on February 25th, 2024), whereas plant nomenclature was checked on Plants of the World Online (https://powo.science.kew.org/).

Consistently with Pavia location, the main provider provinces are placed in Lombardia, Piemonte and Emilia-Romagna regions. Yet, rare and/or featuring species were found in Toscana (e.g. most *Hericium erinaceus* strains), Valle d'Aosta/Vallée d'Aoste (5 strains of *Laricifomes officinalis* and the only strain of *Ganoderma valesiacum*), Sardegna (*Phellinus rimosus* and *Phellinus eryngii*), Sicilia (*Punctularia strigosozonata*) and Abruzzo (*Ganoderma pfeifferi* from the only known Italian site). Despite in different proportion, this collection reflects the environmental complexity of Italy, summarized in the phytoclimate concept. The higher ranks of Blasi et al. (2014) point out 2 Divisions (Temperate and Mediterranean) and 6 Provinces: the latter are all represented in WDF-MicUNIPV, as shown by the wide host spectrum (Fig. 2).

Besides the plant hosts reported in Figure 2, the following plants respectively hosted 2 strains: *Cedrus atlantica*; *Cistu*s sp.; *Platanus* sp.; *Tilia* sp.; or 1 strain: *Acer negundo*; *Acer* sp.; *Ailanthus altissima*; *Alnus glutinosa*; *Arbutus unedo*; *Cedrus libani*; *Cercis siliquastrum*; *Chamaecyparis* sp.; *Fraxinus excelsior*; *Ginkgo biloba*; *Laburnum* sp.; *Ostrya carpinifolia*; *Pinus* sp.; *Prunus cerasifera*; *Pterocarya fraxinifolia*; *Punica granatum*; *Quercus castaneifolia*; *Quercus pubescens*; *Sambucus nigra*; *Sorbus aucuparia*; *Ulmus pumila*; *Rosa* sp. Host distribution reflects the local frequency of the host itself. *Quercus robur* is the commonest oak in Po Plain and low Apennines, whereas *Q. cerris* dominates sunny sides at higher altitude. *Populus nigra* is very common in Po Plain and along Apennine streams, whereas *P. alba* and *P. tremula* are pioneer freatophytes vicariant based on the altitude (Blasi and Biondi, 2017). The number of isolated strains per substrate also depends on the selective search due to the contingent research purpose, such as in *Fomitiporia mediterranea*, an emergent necrotrophic pathogen for *Vitis vinifera* in Pavia and Piacenza vineyards, and *Laricifomes officinalis*, in Europe exclusively growing on *Larix decidua* (Bernicchia and Gorjón, 2020; Girometta et al., 2021).

Practices in forestry affect the continuous renewal of the dead wood resource, that would otherwise gradually end as wood decay fungi typically fit the definition of degradative (eterotrophic) succession (Bullini et al., 1998; Blaser et al., 2013; Juutilainen et al., 2014). For example, coppicing in chestnut standings gives excellent substrates for *Fistulina hepatica*, *Omphalotus olearius* and *Grifola frondosa* (amongst others), as well as stumps in oak thinnings do for some *Ganoderma* and *Trametes* species (Bernicchia and Gorjón, 2020; Girometta et al., 2020).

Table 1 – Comprehensive prospect of strains per fungal species in WDF-MicUNIPV. (*) = the species is meant *sensu lato*.

Species	Family	Order	Strain sum
Abortiporus biennis (Bull.) Singer	Meruliaceae	Polyporales	6
*Antrodia albida** (Fr.) Donk	Fomitopsidaceae	Polyporales	1
Armillaria mellea (Vahl) P. Kumm.	Physalacriaceae	Agaricales	9
Auricularia auricula-judae (Fr.) Quél.	Auriculariaceae	Auriculariales	4
Auricularia mesenterica (Gray) Pers.	Auriculariaceae	Auriculariales	4
Bjerkandera adusta (Willd.) P. Karst.	Phanerochaetaceae	Polyporales	6
Cerrena unicolor (Bull.) Murrill	Cerrenaceae	Polyporales	1
Chondrostereum purpureum (Pers.) Pouzar	Schizophyllaceae	Agaricales	2
Coprinellus domesticus (Bolton) Vilgalys	Agaricaceae	Agaricales	1
Coprinellus micaceus (Bull.) Vilgalys, Hopple & Jacq. Johnson	Agaricaceae	Agaricales	1
Coriolopsis gallica (Fr.) Ryvarden	Polyporaceae	Polyporales	1
Coriolopsis trogii (Berk.) Domanski	Polyporaceae	Polyporales	4
Cyanosporus caesius (Schrad.) McGinty	Postiaceae	Polyporales	2
Cyclocybe cylindracea (DC.) Vizzini & Angelini	Strophariaceae	Agaricales	11
Daedaleopsis confragosa (Bolton) J. Schröt.	Polyporaceae	Polyporales	4
Daedaleopsis tricolor (Bull.) Bondartsev & Singer	Polyporaceae	Polyporales	3
Desarmillaria tabescens (Scop.) R.A. Koch & Aime	Physalacriaceae	Agaricales	2
Dichomitus campestris (Quél.) Domanski & Orlicz	Polyporaceae	Polyporales	2
Dichomitus squalens (P. Karst.) D.A. Reid	Polyporaceae	Polyporales	1
Fistulina hepatica (Schaeff.) With.	Fistulinaceae	Agaricales	7
Flammulina velutipes (Curtis) Singer	Physalacriaceae	Agaricales	8
Fomes fomentarius (L.) Fr.	Polyporaceae	Polyporales	22
Fomitiporia hartigii (Allesch. & Schnabl) Fiasson & Niemelä	Hymenochaetaceae	Hymenochaetales	2
Fomitiporia mediterranea M. Fisch.	Hymenochaetaceae	Hymenochaetales	61
Fomitiporia robusta (P. Karst.) Fiasson & Niemelä	Hymenochaetaceae	Hymenochaetales	1
Fomitiporia rosmarini (Bernicchia) Ghobad-Nejhad & Y.C. Dai	Hymenochaetaceae	Hymenochaetales	1
Fomitopsis betulina (Bull.) B.K. Cui, M.L. Han & Y.C. Dai	Fomitopsidaceae	Polyporales	3
Fomitopsis marianiae (Bres.) Spirin, Vlasák & Cartabia	Fomitopsidaceae	Polyporales	1
Fomitopsis pinicola (Sw.) P. Karst.	Fomitopsidaceae	Polyporales	27
Fomitopsis quercina (L.) Spirin & Miettinen	Fomitopsidaceae	Polyporales	5
Fuscoporia contigua (Pers.) G. Cunn.	Hymenochaetaceae	Hymenochaetales	1
Fuscoporia torulosa (Pers.) T. Wagner & M. Fisch.	Hymenochaetaceae	Hymenochaetales	3
Ganoderma adspersum (Schulzer) Donk	Ganodermataceae	Polyporales	17
Ganoderma applanatum (Pers.) Pat.	Ganodermataceae	Polyporales	4
Ganoderma carnosum Pat.	Ganodermataceae	Polyporales	1
Ganoderma lucidum (Fr.) P. Karst.	Ganodermataceae	Polyporales	7
Ganoderma pfeifferi Bres.	Ganodermataceae	Polyporales	1
Ganoderma resinaceum Boud.	Ganodermataceae	Polyporales	10
Ganoderma valesiacum Boud.	Ganodermataceae	Polyporales	1
Gloeophyllum abietinum (Bull.) P. Karst.	Gloeophyllaceae	Gloeophyllales	1
Gloeophyllum odoratum (Wulfen) Imazeki	Gloeophyllaceae	Gloeophyllales	1
Granulobasidium vellereum (Ellis & Cragin) Jülich	Cyphellaceae	Agaricales	1
Grifola frondose (Dicks.) Gray	Grifolaceae	Polyporales	6
Gymnopilus penetrans (Fr.) Murrill	Strophariaceae	Agaricales	2
Hapalopilus rutilans (Pers.) Murrill	Phanerochaetaceae	Polyporales	2
Hericium coralloides (Scop.) Pers.	Hericiaceae	Russulales	2

Hericium erinaceus (Bull.) Pers.	Hericiaceae	Russulales	5
Hericium flagellum (Scop.) Pers.	Hericiaceae	Russulales	3
Heterobasidion abietinum Niemelä & Korhonen	Bondarzewiaceae	Russulales	1
Heterobasidion annosum (Fr.) Bref.	Bondarzewiaceae	Russulales	2
Hexagonia nitida Durieu & Mont.	Polyporaceae	Polyporales	1
Hirschioporus abietinus (Pers. ex J.F. Gmel.) Donk	Trichaptaceae	Hymenochaetales	1
Hirschioporus fuscoviolaceus (Ehrenb.) Donk	Trichaptaceae	Hymenochaetales	1
Hypholoma fasciculare (Huds.) P. Kumm.	Strophariaceae	Agaricales	4
Hypholoma lateritium (Schaeff.) P. Kumm.	Strophariaceae	Agaricales	3
Inocutis tamaricis (Pat.) Fiasson & Niemelä	Hymenochaetaceae	Hymenochaetales	3
Inonotus hispidus (Bull.) P. Karst.	Hymenochaetaceae	Hymenochaetales	6
Irpex lacteus (Fr.) Fr.	Irpicaceae	Polyporales	6
Irpiciporus pachyodon (Pers.) Kotl. & Pouzar	Meripilaceae	Polyporales	1
Kuehneromyces mutabilis (Schaeff.) Singer & A.H. Sm.	Strophariaceae	Agaricales	1
Laetiporus montanus Cerný ex Tomsovský & Jankovský	Laetiporaceae	Polyporales	3
Laetiporus sulphureus (Bull.) Murrill	Laetiporaceae	Polyporales	6
Laricifomes officinalis (Vill.) Kotl. & Pouzar	Laricifomitaceae	Polyporales	24
Lentinus substrictus (Bolton) Zmitr. & Kovalenko	Polyporaceae	Polyporales	1
Lentinus tigrinus (Bull.) Fr.	Polyporaceae	Polyporales	5
Lenzites betulinus (L.) Fr.	Polyporaceae	Polyporales	1
Lenzites warnieri Durieu & Mont.	Polyporaceae	Polyporales	7
Lycoperdon pyriforme Schaeff.	Lycoperdaceae	Agaricales	3
Mensularia hastifera (Pouzar) T. Wagner & M. Fisch.	Hymenochaetaceae	Hymenochaetales	1
Mensularia nodulosa (Fr.) T. Wagner & M. Fisch.	Hymenochaetaceae	Hymenochaetales	2
Mensularia radiata (Sowerby) Lázaro Ibiza	Hymenochaetaceae	Hymenochaetales	4
Meripilus giganteus (Pers.) P. Karst.	Meripilaceae	Polyporales	3
Neolentinus schaefferi (Weinm.) Redhead & Ginns	Gloeophyllaceae	Gloeophyllales	2
Omphalotus olearius (DC.) Singer	Omphalotaceae	Agaricales	3
Oudemansiella mucida (Schrad.) Höhn.	Physalacriaceae	Agaricales	2
Panellus stipticus (Bull.) P. Karst.	Mycenaceae	Agaricales	5
Perenniporia fraxinea (Bull.) Ryvarden	Polyporaceae	Polyporales	30
Perenniporia meridionalis Decock & Stalpers	Polyporaceae	Polyporales	2
Perenniporia ochroleuca (Berk.) Ryvarden	Polyporaceae	Polyporales	1
Phaeolus schweinitzii (Fr.) Pat.	Phaeolaceae	Polyporales	3
*Phellinus alni** (Bondartsev) Parmasto	Hymenochaetaceae	Hymenochaetales	2
*Phellinus igniarius** (L.) Quél.	Hymenochaetaceae	Hymenochaetales	4
Phellinus rimosus (Berk.) Pilát	Hymenochaetaceae	Hymenochaetales	1
Phellinus tremulae (Bondartsev) Bondartsev & P.N. Borisov	Hymenochaetaceae	Hymenochaetales	13
Phellinus tuberculosus (Baumg.) Niemelä	Hymenochaetaceae	Hymenochaetales	13
Pholiota adiposa (Batsch) P. Kumm.	Strophariaceae	Agaricales	1
Pholiota populnea (Pers.) Kuyper & Tjall.-Beuk.	Strophariaceae	Agaricales	5
Picipes melanopus (Pers.) Zmitr. & Kovalenko	Polyporaceae	Polyporales	2
Pleurotus eryngii (DC.) Quél.	Pleurotaceae	Agaricales	2
Pleurotus ostreatus (Jacq.) P. Kumm.	Pleurotaceae	Agaricales	13
Polyporus varius Fr.	Polyporaceae	Polyporales	1
Porodaedalea pini (Brot.) Murrill	Hymenochaetaceae	Hymenochaetales	1
Punctularia strigosozonata (Schwein.) P.H.B. Talbot	Punctulariaceae	Corticiales	1
Pycnoporus cinnabarinus (Jacq.) P. Karst.	Polyporaceae	Polyporales	3

Schizophyllum commune Fr.	Schizophyllaceae	Agaricales	8
Scytinostroma hemidichophyticum Pouzar	Lachnocladiaceae	Russulales	1
Spongipellis spumea (Sowerby) Pat.	Meripilaceae	Polyporales	1
Spongiporus balsameus (Peck) A. David	Postiaceae	Polyporales	1
Steccherinum semisupiniforme (Murrill) Miettinen	Steccherinaceae	Polyporales	1
Terana coerulea (Lam.) Kuntze	Phanerochaetaceae	Polyporales	2
Trametes gibbosa (Pers.) Fr.	Polyporaceae	Polyporales	4
Trametes hirsuta (Fr.) Lloyd	Polyporaceae	Polyporales	3
Trametes pubescens (Schumach.) Pilát	Polyporaceae	Polyporales	5
Trametes suaveolens (L.) Fr.	Polyporaceae	Polyporales	2
Trametes versicolor (L.) Lloyd	Polyporaceae	Polyporales	12
Xylodon quercinus (Pers.) Gray	Hyphodontiaceae	Hymenochaetales	1

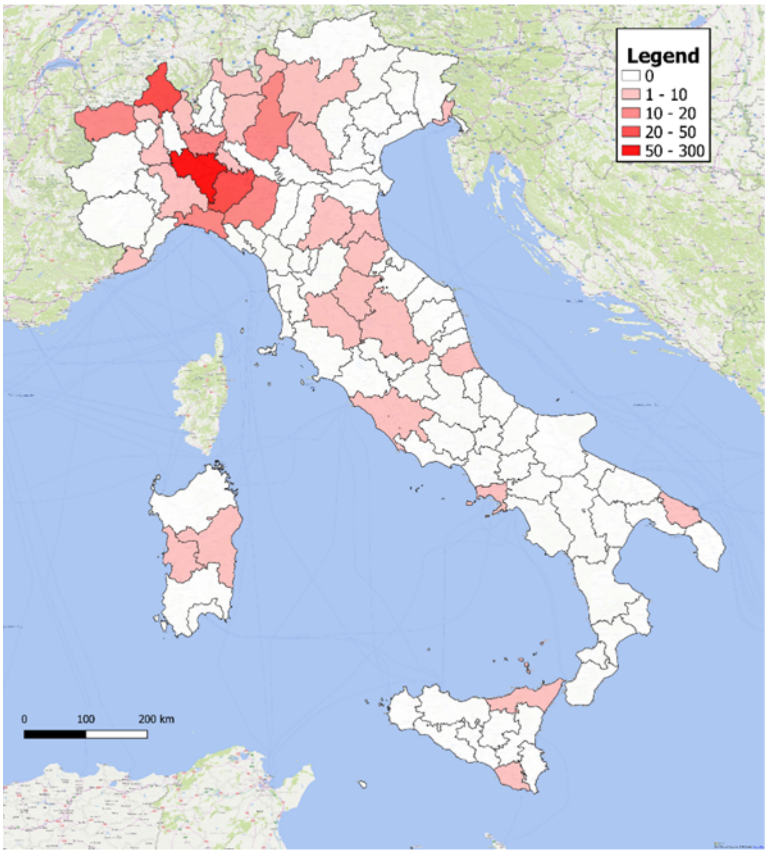

Fig. 1. – Density of fungal strains in WDF-MicUNIPV per Italian Province. Graphic elaboration by QGIS 3.22.10 Białowieża. See http://www.pcn.minambiente.it/viewer/ for the updated Province nomenclature.

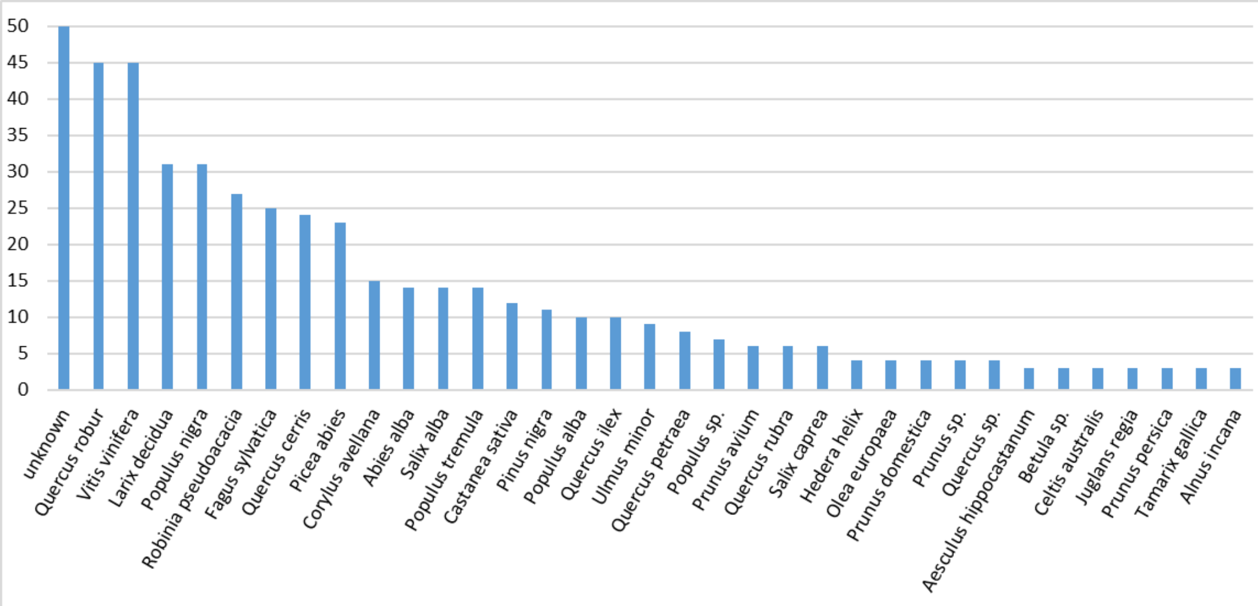

Fig. 2. – Number of strains in WDF-MicUNIPV per each plant substrate. The cutoff limit in this graph was set at 3 strains per host. Excluded hosts are listed in the text.

The amount of available dead wood and/or decaying hosts introduces a "bias" in the host representativeness since this could be the consequence of either the natural abundancy (e.g. poplars, most oaks and beech) or high mortality in native species, e.g. due to the Dutch elm disease by species in *Ophiostoma* Syd. & P. Syd. spp. (Santini et al., 2005; Tonon et al., 2005; Lonsdale et al., 2008). Non-native hosts may also turn in high mortality due to local factors. Several non-managed standings of black Austrian pine and red spruce have been experiencing population decline resulting in high amounts of dead or decaying wood for *F. pinicola* especially (Mariotti et al., 2015; Ardenghi and Polani, 2016). Strains of *F. pinicola* were isolated from either the basidiome or colonized wood, since this species can invade the whole stem massively and possibly excluding other fungal species. Mortality in the highly invasive North-American neophyte *Robinia pseudoacacia* has been showing complex responses to climate change (Motta et al., 2009; Nola et al., 2020). Several fungal species are found on this plant, whose role as a reservoir for both true saprotrophs and necrotrophs (like emerging pathogens *Perenniporia fraxinea* and *Fomitiporia mediterranea*) is to be furtherly investigated. Noteworthy, WDF-MicUNIPV owns 30 strains of *P. fraxinea*, part of whom functional to clarify the spreading modes (Sillo et al., 2016). *Perenniporia fraxinea* is also a still poorly explored species with concern to its biotechnological potential, e.g. for enzyme production, biotransformation of agroindustrial wastes and bioremediation (Sturini et al., 2017; Buratti et al., 2023b). Moreover, its taxonomic position is debated as Zhao et al. (2013) proposed to accommodate it in genus *Vanderbylia* D.A. Reid, that is currently rejected by Mycobank, despite accepted by Index Fungorum (www.indexfungorum.org). *Perenniporia meridionalis* enzyme spectrum is markedly shifted towards lignin degradation and manganese peroxydases (Doria et al., 2014). This is a rare and perhaps overlooked polypore, still poorly known to applied mycology.

Tracking the host and growth site allows to analyze the species ecological niche to reconcile the main species concepts in critical taxonomical groups (Blonder et al., 2018; Xu et al., 2020). Hymenochaetaceae and Polyporaceae are the main Families in WDF-MicUNIPV (Fig. 3). Several new genera have been proposed in recent years in Hymenochaetaceae to resolve the polyphyly problems in *Phellinus sensu lato* and *Inonotus sensu lato*; strains in WDF-MicUNIPV can furtherly contribute to the debate as well as to explore the strengths and limits of the ecological species concept (Bernicchia and Gorjón, 2020). Analogous ideas may concern *Ganoderma* (Ganodermataceae), "the most difficult genus of all polypores" (Ryvarden and Melo, 2017), and laccate species especially. Besides the medicinal species *G. lucidum*, the WDF-MicUNIPV owns a strain of *G. pfeifferi* from the only known Italian station, as well as one strain of *G. valesiacum*, very rare in the Italian Alps and hosted by larch only – see the sub-collection described in Cartabia et al. (2022) for a further strain. *Ganoderma applanatum* and *G. adspersum* respectively show distribution shifted North- and South of Alps, and sympatry in North Italy. On the other hand, the WDF-MicUNIPV conserves 22 strains of *Fomes fomentarius* that is apparently *sensu stricto* with respect to the cryptic lineages of *F. inzengae* (Ces. & De Not.) Cooke (Peintner et al., 2019). Two species in *Hirschioporus* Donk (*H. abietinus* and *H. fuscoviolaceus*) are represented here. This genus has recently been segregated from *Trichaptum* Murrill in the monotypic Hirschioporaceae Y.C. Dai, Yuan Yuan & Meng Zhou by Wang et al. (2023), still rejected by Index Fungorum. *Trichaptum* concept is marginally discussed in Wang et al. (2023), who overlook the suggestions by Seierstad et al. (2021) about complexity and compatibility issues in *Trichaptum sensu lato*. Italian strains, excluded to now, could therefore contribute to this open debate.

Climate change has been challenging the adaptation and life cycles of a wide part of organisms in any environment (Bellard et al., 2012; Habibullah et al., 2022). Further studies on strains in pure culture may contribute to explore the possible adaptations affecting WDF distribution, niche, reproduction and impact on the host plants. *Lenzites warnieri* has been apparently increasing its occurrency northward; WDF-MicUNIPV owns 7 strains clustered in both the lowlands and hilly belt of Pavia and Piacenza provinces.

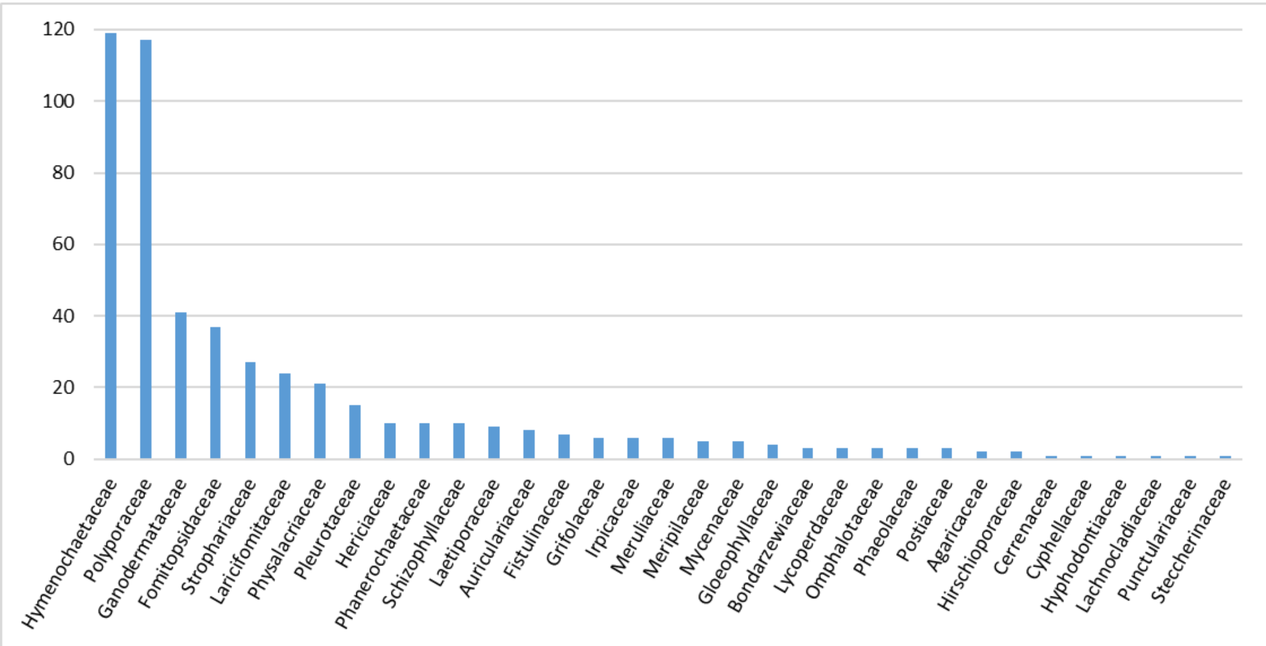

Fig. 3. – Number of strains per Family in WDF-MicUNIPV.

Although most strains in WDF-MiUNIPV come from broadly-defined polypores, few corticioids are also included, such as *P. strigosozonata*, a very rare species in Europe with only a few growth stations in Italy in Ferrara, Cagliari and Ragusa provinces (Bernicchia and Gorjón, 2010). Several current and potential applications can be found in literature concerning most species in WDF-MicUNIPV. This collection includes 5 Italian strains of *H. erinaceus* whose characterization is continuously in progress along with *H. coralloides* and *H. flagellum*. Although *H. erinaceus* is one of the most famous medicinal species in the world, its wide distribution area (basically following *Quercus* distribution) suggests to explore the possible variability in bioactivity and metabolites among different populations (Rossi et al., 2018; Cesaroni et al., 2019; Corana et al., 2019; Ratto et al., 2019; Roda et al., 2021; Roda et al., 2022). This means to implement the specific and subspecific strain profiles to tune the applications in nutraceutics and rationalize the clinical and/or pre-clinical treatments (Goppa et al., 2023).

Besides any processing, *Hericium* species are directly edible, as well as *G. frondosa* and *F. velutipes* but unlikely tenacious *Ganoderma* species such as *G. lucidum* and the poorly known *G. valesiacum*. The latter has also been proposed for the *Endangered* status by The Global Fungal Red List Initiative – GFRLI (https://redlist.info/en/iucn/welcome) due to the very peculiar trophic niche and uncertain distribution. Analogously, *L. officinalis* is both a well-known medicinal species and an instable resource to be protected, now granted the "Endangered" status by the GFRLI. The University of Pavia detains, as far as known, the widest strain set from 4 different Provinces in Western and Central Alps thanks to a 12-years old selective research (Girometta et al., 2021). This is an example of *ex situ* conservation of local genetic resources.

Strains in WDF-MicUNIPV have been also involved in research about mycomaterials and new strategies for wastewater depuration (Cartabia et al., 2021; Buratti et al., 2022). Currently, selected strains are under examination in research projects financiated by the NextGenerationEU program (Project NODES – Spoke 2, based on the Italian frame). The main topic is the re-use of waste materials for mycoremediation solutions in circular economy. Long-term conservation and maintainance is the major challenge for WDF-MicUNIPV too; notwithstanding, future perspective include new strain sets to increase the coverage of WDF taxa, such as in the poorly known, wide compound of so-called corticioid fungi. The bridgehead work of Buratti et al. (2023b) including the Spanish strain sub-collection has assessed a valid methodology in this way.

Conclusions

The Italian core of the WDF-MicUNIPV research culture collection includes a wide variety of fungal species representative of all the ecoregional provinces in Italy and many different plant hosts from both North Italy and Mediterranean region. These strains allow to have ready-to-use pure material for several pure and applied purposes, from taxonomy issues to industrial mycology. To now, selected strains have allowed to win and/or take part to the following peer-reviewed, funded projects: MATER (Fondazione Cariplo and Regione Lombardia); CE4WE (Regione Lombardia); NODES (European Union – NextGenerationEU) as well as to explore applications in mycoremediation by Project MicoDEP in collaboration with CAP Holding and A2A Ciclo Idrico (now A2A Life Company). Characterization and metabolite profiling of medicinal species is ongoing to valorize the potential of Italian strains of popular mushrooms (*Hericium erinaceus*) as well as to explore poorly known species such as *Hericium flagellum* and *Perenniporia fraxinea* and the ancient medicinal polypore *Laricifomes officinalis*.

Taxonomically critical groups in Hymenochaetaceae are currently addressed with a particular focus on genera *Fomitiporia* Murrill and *Phellinus* Quél. *sensu stricto*, along with the non-Italian strains in MicUNIPV. Further strains may also contribute to resolve the debate about the *Antrodia albida* species complex, whose cryptic components have not been concordantly accepted yet; in Italy, this issue particularly concerns the sibling species *A. serpens* (Fr.) P. Karst., that is currently rejected by both Mycobank and Index Fungorum. Possible strategies to define the ecotype concept in polypores (*Fomes fomentarius* and *F. inzengae*) are also in progress.

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