

Article

# An Italian Research Culture Collection of Wood Decay Fungi

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**Abstract:** One of the main aims of the University of Pavia mycology laboratory was to collect wood decay fungal (WDF) strains in order to deepen taxonomic studies, species distribution, officinal properties or to investigate potential applications such as biocomposite material production based on fungi. The Italian Alps, Apennines and wood plains were investigated to collect Basidiomycota basidiomata from living or dead trees. The purpose of this study was to investigate the wood decay strains of the Mediterranean area, selecting sampling sites in North and Central Italy, including forests near the Ligurian and Adriatic seas, or near the Lombardy lakes. The isolation of mycelia in pure culture was performed according to the current methodology and the identity of the strains was confirmed by molecular analyses. The strains are maintained in the Research Culture Collection MicUNIPV of Pavia University (Italy). Among the 500 WDF strains in the collection, the most interesting isolates from the Mediterranean area are: *Dichomitus squalens* (basidioma collected from *Pinus pinea*), *Hericium erinaceus* (medicinal mushroom), *Inocutis tamaricis* (white-rot agent on *Tamarix* trees), *Perenniporia meridionalis* (wood degrader through Mn peroxidase) and *P. ochroleuca*. In addition, strains of species related to the Mediterranean climate (e.g., *Fomitiporia mediterranea* and *Cellulariella warnieri*) were obtained from sites with a continental-temperate climate.

**Keywords:** wood decay fungi (WDF); culture collection; fungal strain; host; Italy; morphological and molecular identification

## 1. Introduction

Wood decay fungi provide an extraordinary model both for pure and applied research, as well as a food or medicinal mushroom resource.

From an ecological point of view, wood decay fungi have a fundamental role, since they are important degraders of lignocelluloses. Heterogeneity in degradation strategies consists in different enzymatic pools, conditions for secretion and catalysis, alternative non-enzymatic pathways and strategy-switch depending on environmental conditions [1,2]. Consistently, wood decay fungi shift from necrotrophism to pure saprotrophism, sometimes at an intraspecific level.

Systematic revisions based on multi-locus or genomic approach have revealed an extremely complex scenario concerning both biochemical features and morphology. Similar degradation strategies and similar morphologies are widespread, even among phylogenetically distant taxa, whereas the

same taxonomic group may include species displaying different strategies and different morphologies. As a whole, wood decayers appear to be a pivotal model in the study of the evolutionary relationships of both Dikarya and extra-Dikarya taxa [3–5]. Consistently, the incipient molecular-based biogeography of wood decayers seems to display distribution patterns strongly affected by preferred host species (trees or shrubs), which are apparently followed throughout [6].

Wood decay fungi include several edible species as well as species reported to be the source of bioactive compounds, related to either primary (e.g.,  $\beta$ -glucans) or secondary metabolism (terpenoids, phenolics, acids, superior alcohols, etc.). Structural diversity, occurrence and distribution among taxa, synthesis stimulation factors and correlation to growth stage, bioactivity pathways, standardization of products and crude extracts are the main current topics under investigation [7–9].

Due to their relatively easy reproduction in culture, several other applications are being developed on wood decay fungi: degradation of organic pollutants and bioremediation [10]; pretreatment of biomasses for production of sugars and bioethanol [11,12]; production of enzymes for industrial purposes, namely Mn peroxidases, laccases, cellulases and hemicellulases [13]; and bioadsorption and bioaccumulation of metal ions either in living or dead biomass [14–16].

Last but not least, necrotrophic wood decay means a loss of harvest in forestry and woody cultures, whereas in public and private green areas it means destabilization and consequently risk for people and objects [17].

Culture collections are an important reference, since availability and exchange of authenticated, quality-guaranteed pure cultures are increasingly needed by researchers at an international level [18,19]. Above all, tests on different species and strains (at intraspecific level) are required since biochemical differences are often not negligible [20–22].

Actually, only a few research centers can afford to structure their culture collection in conformity to international guidelines provided by the World Federation for Culture Collections (WFCC) [23,24]. The strains maintained in many universities or research centers can be considered an important source of experimental material, even without a WFCC certification. Since small uncertified collectors are geographically widespread, their contribution may be significantly representative of local ecosystems and biodiversity [25].

The Mycology Laboratory at the Botanical Garden of Pavia University (Italy) has a long tradition of the isolation, identification and preservation of fungal strains in various areas of mycology. This is supported by the numerous publications from the middle of the last century [26] up to now. Currently, the fungal strains collection is named MicUNIPV and each working group preserves and enriches the collection.

Although the definition of ecotypes is usually hard, a remarkable intraspecific variability is well documented in several fungal species and it may be particularly true for rare species, whose populations are supposed to be more isolated [27]. This highlights the value of Italian territory for fungal biodiversity and the great potentiality for research [28].

Italy has a wide variety of climates and morphologies, both due to its remarkable latitudinal range (about 13°) and structural-topographic complexity, including the presence of four different seas and two main mountain chains. According to the official maps of MATTM (Ministero dell'Ambiente e della Tutela del Territorio e del Mare), 28 different phytoclimatic classes are recognized, five of which are specifically referred to as Mediterranean [29], also taking into account the biogeographic reference map suggested by Rivas-Martínez [30]. Nevertheless, the pluri-millennial stratification of human impact has made it difficult to distinguish between actual and potential ecosystem features. As a consequence, the classification and mapping of either Italian ecoregions or phytoclimates provide a tool for the comprehension of biodiversity instead of a strict map of biodiversity itself [31].

The present article reports the results obtained by the researchers of the Laboratory of Mycology in DSTA-University of Pavia (Italy) who continuously collect new cultures of wood decay fungi, focusing on fungal biodiversity of species related to the Mediterranean area and climates.

## 2. Materials and Methods

### 2.1. Sampling Sites and Field Work

Basidiomata were mostly (but not exclusively) collected in North and Central Italy. Sampling stratification was selectively applied, i.e., specific areas have been more frequently and strictly examined than others and sampling effort was not equal among different species [32]. The different environments examined are resumed hence:

- (a) highly-fragmented marginal woodlands and shrublands placed into an agricultural landscape, particularly referring to vegetation surrounding the hydrographic network, including major lakes;
- (b) mountain continuous woodlands and shrublands, both managed and unmanaged;
- (c) woody cultures (e.g., poplar plantations and vineyards), tree rows and hedges in agricultural landscape;
- (d) urban and suburban environments (tree rows, parks, private and public gardens).

Environments a, c, and d are mostly related to basal altitudinal belt and upper hill altitudinal belt in Po Plain, Apennines and Prealps (lower mountain thermal belt), as well as Adriatic, Tirrenian and Ligurian coasts; Environment b is mostly related to the lower and upper montane belt in the North and Central Apennines.

The basidiomata were completely or partially harvested by knife, gently brushed to eliminate debris and stored in paper bags until laboratory operations. The collecting sites were geolocalized, and the host species and general features were detected.

### 2.2. Experimental Procedures

Basidiomata identification was carried out by macro and micro-morphological analysis [6,33,34]; stereo and light microscopy were performed by Zeiss Axioplan and Zeiss Stemi 2000-C.

According to Stalpers [35] and Gams et al. [36], as well as Stamets [37], isolation of mycelia in pure culture was obtained in sterile conditions by inoculating small portions of the basidioma context into Petri dishes containing MEA medium and antibiotic (malt extract 2% + agar 1.5% + cloramphenicol 50 ppm). The incubation was carried out at 24 °C in the dark and each strain growth was checked constantly for a month. Based on the above, all the mentioned strains are to be regarded as dikaryotic.

Besides the morphological checks, molecular identifications of isolates were carried out on mycelia cultured in liquid medium (malt extract 2%). DNA was extracted from lyophilized mycelia by Nucleospin Plant II kit (Macherey-Nagel). Amplification by Polymerase Chain Reaction (PCR) used the primer pair ITS1 (19bp) and ITS4 (20bp)—that is, Internal Transcribed Spacer of ribosomal DNA; this region has been widely used for different fungal taxa [38,39]. PCR protocol exploited Dream Taq Mastermix (Promega) and was performed in a thermocycler, as reported in Table 1.

**Table 1.** Thermocycling protocol for PCR.

| Step | Aim              | T (°C) | Duration | Cycle Repetitions |
|------|------------------|--------|----------|-------------------|
| I    | Denaturation     | 95     | 5 min    | 35                |
|      | Denaturation     | 95     | 30 s     |                   |
| II   | Annealing        | 50     | 45 s     |                   |
|      | Elongation       | 72     | 1 min    |                   |
| III  | Final elongation | 72     | 10 min   |                   |

The qualitative checking of DNA (5 µL/sample) was performed both after extraction and amplification by DNA run (30 min, 100 V) on electrophoretic gel (1% agarose). SYBR Safe-DNA Gel Stain (Invitrogen) was used as an intercalant; GeneRuler 1kb (Thermo Scientific, Waltham - USA) was used as a ladder; BlueJuice (Invitrogen) was used as a gel loading buffer. The imaging was performed by Gel Doc (Biorad, Berkeley, CA, USA).

ExoSAP-IT (Applied Biosystems, Foster City, CA, USA) was used for the purification of amplification products. According to the suggested protocol, the sample/ExoSAP ratio was 5:2  $\mu$ L; the reaction was carried out in a thermocycler in two steps—15 min at 37 °C and 15 min at 80 °C.

The sequencing was ordered to Macrogen (The Netherlands). Sequence analysis was performed by Sequencher 5.0 Demo. The sequences were finally matched with the ones available in the molecular identification facility of Mycobank [40].

Strains in pure culture were stored by different methods:

- (a) on malt extract agar (MEA) in a Petri plate at 3 °C;
- (b) in a glass tube corked with cotton at room temperature;
- (c) colonized paper discs in demineralized water at 4 °C;
- (d) at  $-80$  °C in glycerol (selected strains only).

Periodic checking and refreshment of cultures was performed to avoid contamination and devitalization.

The strains are maintained in the Fungal Research Culture Collection (MicUNIPV) of Department of Earth and Environmental Sciences of University of Pavia (Italy); each strain is included in a private database with all the information regarding sampling sites, data of collection and ecological notes.

### 3. Results and Discussion

MicUNIPV includes species related to plant pathology, soil, extreme environments, fresh and marine water, monuments and cultural heritage. As previously mentioned, different working groups within the Laboratory of Mycology (DSTA-University of Pavia) are engaged in the management, preservation and improvement of each MicUNIPV section. The section regarding wood decay species has up to now achieved 500 strains belonging to 110 different species [41–43]. The broad focus on wood decay led us to include in this section species related to different applications such as nutraceuticals, forest pathology, wood degradation and biocomposite materials.

The distribution of most species exceeds the Mediterranean area; nevertheless, several of them also display wide spatial gaps among stations and clear heterogeneity in host preference depending on the geographic location of the population.

Here, we present the species that have a distribution strongly related to the Mediterranean region and/or Southern Europe and/or warm climates, according to Ryvarden and Melo [6] and Bernicchia [33,34,44]. The species related to the Mediterranean diversity are reported in Table 2 and the most peculiar are discussed below.

**Table 2.** Selected Italian strains from MicUNIPV related to the Mediterranean area. Phytoclimate class as in [29].

| Mic UNIPV ID | Species                         | Authors                       | Locality                  | Municipality                 | Host                          | Phytoclimate Class                                 |
|--------------|---------------------------------|-------------------------------|---------------------------|------------------------------|-------------------------------|----------------------------------------------------|
| D.con.1      | <i>Daedaleopsis confragosa</i>  | (Bolton) J. Schröt.           | Dormelletto               | Dormelletto (NO)             | <i>Unidentified broadleaf</i> | mesotemperate/humid supratemperate                 |
| D.con.2      | <i>Daedaleopsis confragosa</i>  | (Bolton) J. Schröt.           | Pian Porcino              | Bagno di Romagna (FC)        | <i>Unidentified broadleaf</i> | hyperhumid supratemperate/ultrahyperhumid          |
| D.q.1        | <i>Daedalea quercina</i>        | (L.) Pers.                    | R.N. Bosco Giuseppe Negri | Pavia (PV)                   | <i>Quercus robur</i>          | humid supratemperate/subhumid                      |
| D.q.2        | <i>Daedalea quercina</i>        | (L.) Pers.                    | Cono di Volo Malpensa     | Gallarate (VA)               | <i>Quercus rubra</i>          | mesotemperate/humid supratemperate                 |
| D.q.3        | <i>Daedalea quercina</i>        | (L.) Pers.                    | Fosso dell'Oca            | Rovescala (PV)               | <i>Quercus petraea</i>        | humid supratemperate/subhumid                      |
| D.sq.1       | <i>Dichomitus squalens</i>      | (P. Karst.) D.A. Reid         | Pineta di San Vitale      | Ravenna (RA)                 | <i>Pinus pinea</i>            | supratemperate/humid-subhumid mesotemperate        |
| D.sq.2       | <i>Dichomitus squalens</i>      | (P. Karst.) D.A. Reid         | Ispra, Lungolago          | Ispra (VA)                   | <i>Cedrus sp.</i>             | mesotemperate/humid supratemperate                 |
| D.tric.1     | <i>Daedaleopsis tricolor</i>    | (Bull.) Bondartsev and Singer | Rio Bardonezza            | Santa Maria della Versa (PV) | <i>Prunus avium</i>           | humid supratemperate/subhumid                      |
| Des.t.1      | <i>Desarmillaria tabescens</i>  | (Scop.) R.A. Koch and Aime    | RNIS Bosco Siro Negri     | Zerbolò (PV)                 | <i>Quercus robur</i>          | humid supratemperate/subhumid                      |
| Fm.i.1       | <i>Fomitopsis iberica</i>       | Melo and Ryvarden             | Via Montello              | Varese (VA)                  | <i>Corylus avellana</i>       | humid supratemperate/hyperhumid                    |
| Fm.i.2       | <i>Fomitopsis iberica</i>       | Melo and Ryvarden             | Villa Baragiola           | Varese (VA)                  | <i>Abies alba</i>             | humid supratemperate/hyperhumid                    |
| Fm.i.3       | <i>Fomitopsis iberica</i>       | Melo and Ryvarden             | Via Tasso                 | Varese (VA)                  | <i>Cedrus deodara</i>         | humid supratemperate/hyperhumid                    |
| Fm.i.4       | <i>Fomitopsis iberica</i>       | Melo and Ryvarden             | Via S. Francesco          | Inarzo (VA)                  | <i>Betula pendula</i>         | humid supratemperate/hyperhumid                    |
| Fm.i.5       | <i>Fomitopsis iberica</i>       | Melo and Ryvarden             | Villa Toeplitz            | Varese (VA)                  | <i>Fagus sylvatica</i>        | humid supratemperate/hyperhumid                    |
| Fm.i.6       | <i>Fomitopsis iberica</i>       | Melo and Ryvarden             | Villa Mylius              | Varese (VA)                  | <i>Fagus sylvatica</i>        | humid supratemperate/hyperhumid                    |
| Fm.m.1       | <i>Fomitiporia mediterranea</i> | M. Fisch.                     | RNIS Bosco Siro Negri     | Zerbolò (PV)                 | <i>Quercus robur</i>          | humid supratemperate/subhumid                      |
| Fm.m.2       | <i>Fomitiporia mediterranea</i> | M. Fisch.                     | RNIS Bosco Siro Negri     | Zerbolò (PV)                 | <i>Quercus robur</i>          | humid supratemperate/subhumid                      |
| Fm.m.3       | <i>Fomitiporia mediterranea</i> | M. Fisch.                     | RNIS Bosco Siro Negri     | Zerbolò (PV)                 | <i>Hedera helix</i>           | humid supratemperate/subhumid                      |
| Fm.m.4       | <i>Fomitiporia mediterranea</i> | M. Fisch.                     | Rio Bardonezza            | Santa Maria della Versa (PV) | <i>Robinia pseudoacacia</i>   | humid supratemperate/subhumid                      |
| Fm.m.5       | <i>Fomitiporia mediterranea</i> | M. Fisch.                     | Comiso                    | Ragusa (RG)                  | <i>Cistus sp.</i>             | mesomediterranean/subhumid-dry thermomediterranean |
| Fm.m.6       | <i>Fomitiporia mediterranea</i> | M. Fisch.                     | Cono di Volo Malpensa     | Gallarate (VA)               | <i>Quercus rubra</i>          | mesotemperate-humid supratemperate                 |
| Fm.m.7       | <i>Fomitiporia mediterranea</i> | M. Fisch.                     | R.N. Torbiere del Sebino  | Provaglio d'Isèo (BS)        | <i>Corylus avellana</i>       | mesotemperate-humid supratemperate                 |
| Fm.m.8       | <i>Fomitiporia mediterranea</i> | M. Fisch.                     | Villa Augusta             | Varese (VA)                  | <i>Fagus sylvatica</i>        | humid supratemperate - hyperhumid                  |
| Fm.m.9       | <i>Fomitiporia mediterranea</i> | M. Fisch.                     | Olgiate Comasco           | Olgiate Comasco (CO)         | <i>Actinidia chinensis</i>    | mesotemperate-humid supratemperate                 |

Table 2. Cont.

| Mic UNIPV ID | Species                         | Authors         | Locality                           | Municipality                   | Host                    | Phytoclimate Class                          |
|--------------|---------------------------------|-----------------|------------------------------------|--------------------------------|-------------------------|---------------------------------------------|
| Fm.m.10      | <i>Fomitiporia mediterranea</i> | M. Fisch.       | Pradone nord                       | Rovescala (PV)                 | <i>Vitis vinifera</i>   | humid supratemperate - subhumid             |
| Fm.m.11      | <i>Fomitiporia mediterranea</i> | M. Fisch.       | Pradone nord                       | Rovescala (PV)                 | <i>Vitis vinifera</i>   | humid supratemperate - subhumid             |
| Fm.m.12      | <i>Fomitiporia mediterranea</i> | M. Fisch.       | Pradone nord                       | Rovescala (PV)                 | <i>Vitis vinifera</i>   | humid supratemperate - subhumid             |
| Fm.m.13      | <i>Fomitiporia mediterranea</i> | M. Fisch.       | Pradone nord                       | Rovescala (PV)                 | <i>Vitis vinifera</i>   | humid supratemperate - subhumid             |
| Fm.m.14      | <i>Fomitiporia mediterranea</i> | M. Fisch.       | Pradone nord                       | Rovescala (PV)                 | <i>Vitis vinifera</i>   | humid supratemperate - subhumid             |
| Fm.m.15      | <i>Fomitiporia mediterranea</i> | M. Fisch.       | Pradone nord                       | Rovescala (PV)                 | <i>Vitis vinifera</i>   | humid supratemperate - subhumid             |
| Fm.m.16      | <i>Fomitiporia mediterranea</i> | M. Fisch.       | Pradone nord                       | Rovescala (PV)                 | <i>Vitis vinifera</i>   | humid supratemperate - subhumid             |
| Fm.m.17      | <i>Fomitiporia mediterranea</i> | M. Fisch.       | Unipv_polo scientifico via Ferrata | Pavia (PV)                     | <i>Salix alba</i>       | humid supratemperate - subhumid             |
| G.adsp.1     | <i>Ganoderma adspersum</i>      | (Schulzer) Donk | Orto Botanico                      | Pavia (PV)                     | <i>Quercus sp.</i>      | humid supratemperate - subhumid             |
| G.adsp.2     | <i>Ganoderma adspersum</i>      | (Schulzer) Donk | R.N. Bosco Giuseppe Negri          | Pavia (PV)                     | <i>Populus nigra</i>    | humid supratemperate - subhumid             |
| G.adsp.3     | <i>Ganoderma adspersum</i>      | (Schulzer) Donk | R.N. Bosco Giuseppe Negri          | Pavia (PV)                     | Unidentified broadleaf  | humid supratemperate - subhumid             |
| G.adsp.4     | <i>Ganoderma adspersum</i>      | (Schulzer) Donk | Parco della Vernavola              | Pavia (PV)                     | <i>Alnus glutinosa</i>  | humid supratemperate - subhumid             |
| G.adsp.5     | <i>Ganoderma adspersum</i>      | (Schulzer) Donk | RNIS Bosco Siro Negri              | Zerbolò (PV)                   | Unidentified broadleaf  | humid supratemperate - subhumid             |
| G.adsp.6     | <i>Ganoderma adspersum</i>      | (Schulzer) Donk | Rio Bardonezza                     | Rovescala (PV)                 | <i>Quercus robur</i>    | humid supratemperate - subhumid             |
| G.adsp.7     | <i>Ganoderma adspersum</i>      | (Schulzer) Donk | Madonna del Bocco                  | Santa Margherita Staffora (PV) | <i>Quercus cerris</i>   | supratemperate - humid mesotemperate        |
| G.adsp.8     | <i>Ganoderma adspersum</i>      | (Schulzer) Donk | Morina                             | Rovescala                      | <i>Quercus petraea</i>  | humid supratemperate - subhumid             |
| G.adsp.9     | <i>Ganoderma adspersum</i>      | (Schulzer) Donk | RNIS Bosco Siro Negri              | Zerbolò (PV)                   | <i>Quercus robur</i>    | humid supratemperate - subhumid             |
| G.adsp.10    | <i>Ganoderma adspersum</i>      | (Schulzer) Donk | RNIS Bosco Siro Negri              | Zerbolò (PV)                   | <i>Populus nigra</i>    | humid supratemperate - subhumid             |
| G.adsp.11    | <i>Ganoderma adspersum</i>      | (Schulzer) Donk | RNIS Bosco Siro Negri              | Zerbolò (PV)                   | <i>Quercus robur</i>    | humid supratemperate - subhumid             |
| G.adsp.12    | <i>Ganoderma adspersum</i>      | (Schulzer) Donk | Ca' del Bosco                      | Nibbiano Val Tidone (PC)       | <i>Quercus cerris</i>   | humid supratemperate - hyperhumid           |
| G.adsp.13    | <i>Ganoderma adspersum</i>      | (Schulzer) Donk | Montebolone                        | Pavia (PV)                     | <i>Cedrus atlantica</i> | humid supratemperate - subhumid             |
| G.adsp.14    | <i>Ganoderma adspersum</i>      | (Schulzer) Donk | Cascina Scova                      | Pavia (PV)                     | Unidentified broadleaf  | humid supratemperate - subhumid             |
| G.adsp.15    | <i>Ganoderma adspersum</i>      | (Schulzer) Donk | Ticino                             | Torre d'Isola (PV)             | <i>Quercus sp.</i>      | humid supratemperate - subhumid             |
| G.adsp.17    | <i>Ganoderma adspersum</i>      | (Schulzer) Donk | unknown                            | Bologna (BO)                   | Unidentified broadleaf  | supratemperate/humid mesotemperate-subhumid |
| G.car.1      | <i>Ganoderma carnosum</i>       | Pat.            | Foreste Casentinesi                | Poppi (AR)                     | <i>Abies alba</i>       | hyperhumid supratemperate/ultrahyperhumid   |

Table 2. Cont.

| Mic UNIPV ID | Species                       | Authors                                    | Locality                         | Municipality                 | Host                        | Phytoclimate Class                                                       |
|--------------|-------------------------------|--------------------------------------------|----------------------------------|------------------------------|-----------------------------|--------------------------------------------------------------------------|
| G.pf.1       | <i>Ganoderma pfeifferi</i>    | Bres.                                      | Prati di Tivo                    | Pietracamela (TE)            | <i>Fagus sylvatica</i>      | supratemperate/hyperhumid<br>mesotemperate/humid                         |
| H.e.1        | <i>Hericium erinaceus</i>     | (Bull.) Pers.                              | Colle Ciupi                      | Siena (SI)                   | <i>Quercus ilex</i>         | subhumid mesotemperate/humid                                             |
| H.e.2        | <i>Hericium erinaceus</i>     | (Bull.) Pers.                              | Castello di Belcaro              | Siena (SI)                   | <i>Quercus ilex</i>         | subhumid mesotemperate/humid                                             |
| H.e.3        | <i>Hericium erinaceus</i>     | (Bull.) Pers.                              | Strada per Castello di Belcaro   | Siena (SI)                   | <i>Quercus ilex</i>         | subhumid mesotemperate/humid                                             |
| H.e.4        | <i>Hericium erinaceus</i>     | (Bull.) Pers.                              | Strada per Castello di Belcaro   | Siena (SI)                   | <i>Quercus ilex</i>         | subhumid mesotemperate/humid                                             |
| H.e.5        | <i>Hericium erinaceus</i>     | (Bull.) Pers.                              | Colle Val d'Elsa                 | Colle Val d'Elsa (SI)        | <i>Quercus ilex</i>         | subhumid mesotemperate/humid                                             |
| I.t.1        | <i>Inocutis tamaricis</i>     | (Pat.) Fiasson and Niemelä                 | Apani                            | Brindisi (BR)                | <i>Tamarix gallica</i>      | thermomediterranean/mesomediterranean/dry<br>inframediterranean/subhumid |
| I.t.2        | <i>Inocutis tamaricis</i>     | (Pat.) Fiasson and Niemelä                 | Ostia Lido                       | Roma (RM)                    | <i>Tamarix gallica</i>      | subhumid mesomediterranean                                               |
| L.s.1        | <i>Laetiporus sulphureus</i>  | (Bull.) Murrill                            | RNIS Bosco Siro Negri            | Zerbolò (PV)                 | <i>Quercus robur</i>        | humid supratemperate - subhumid                                          |
| L.s.2        | <i>Laetiporus sulphureus</i>  | (Bull.) Murrill                            | RNIS Bosco Siro Negri            | Zerbolò (PV)                 | <i>Quercus robur</i>        | humid supratemperate - subhumid                                          |
| L.s.3        | <i>Laetiporus sulphureus</i>  | (Bull.) Murrill                            | RNIS Bosco Siro Negri            | Zerbolò (PV)                 | <i>Quercus robur</i>        | humid supratemperate - subhumid                                          |
| L.s.4        | <i>Laetiporus sulphureus</i>  | (Bull.) Murrill                            | RNIS Bosco Siro Negri            | Zerbolò (PV)                 | <i>Quercus robur</i>        | humid supratemperate - subhumid                                          |
| L.s.5        | <i>Laetiporus sulphureus</i>  | (Bull.) Murrill                            | Pietragavina                     | Varzi (PV)                   | <i>Castanea sativa</i>      | supratemperate - hyperhumid mesotemperate -<br>humid                     |
| L.s.6        | <i>Laetiporus sulphureus</i>  | (Bull.) Murrill                            | Cono di Volo Malpensa            | Gallarate (VA)               | <i>Quercus sp.</i>          | mesotemperate-humid supratemperate                                       |
| L.w.1        | <i>Cellulariella warnieri</i> | (Durieu and Mont.) Zmitr. and V. Malysheva | R.N. Bosco Giuseppe Negri        | Pavia (PV)                   | <i>Quercus robur</i>        | humid supratemperate - subhumid                                          |
| L.w.2        | <i>Cellulariella warnieri</i> | (Durieu and Mont.) Zmitr. and V. Malysheva | Bosco del Cecco                  | Santa Maria della Versa (PV) | <i>Ulmus minor</i>          | humid supratemperate - subhumid                                          |
| L.w.3        | <i>Cellulariella warnieri</i> | (Durieu and Mont.) Zmitr. and V. Malysheva | Rio Marsinola-Fracion            | Rovescala (PV)               | <i>Populus nigra</i>        | humid supratemperate - subhumid                                          |
| L.w.4        | <i>Cellulariella warnieri</i> | (Durieu and Mont.) Zmitr. and V. Malysheva | RNIS Bosco Siro Negri            | Zerbolò (PV)                 | <i>Quercus robur</i>        | humid supratemperate - subhumid                                          |
| L.w.5        | <i>Cellulariella warnieri</i> | (Durieu and Mont.) Zmitr. and V. Malysheva | RNIS Bosco Siro Negri            | Zerbolò (PV)                 | <i>Robinia pseudoacacia</i> | humid supratemperate - subhumid                                          |
| L.w.6        | <i>Cellulariella warnieri</i> | (Durieu and Mont.) Zmitr. and V. Malysheva | Bosco Sforza nord-Rio Bardonezza | Ziano Piacentino (PC)        | <i>Ulmus minor</i>          | humid supratemperate - subhumid                                          |
| P.f.1        | <i>Perenniporia fraxinea</i>  | (Bull.) Ryv.                               | R.N. Bosco Giuseppe Negri        | Pavia (PV)                   | <i>Populus nigra</i>        | humid supratemperate - subhumid                                          |
| P.f.2        | <i>Perenniporia fraxinea</i>  | (Bull.) Ryv.                               | Via Scala                        | Pavia (PV)                   | <i>Celtis australis</i>     | humid supratemperate - subhumid                                          |
| P.f.3        | <i>Perenniporia fraxinea</i>  | (Bull.) Ryv.                               | Rio Bardonezza                   | Rovescala (PV)               | <i>Salix alba</i>           | humid supratemperate - subhumid                                          |

Table 2. Cont.

| Mic UNIPV ID | Species                          | Authors             | Locality                        | Municipality                 | Host                          | Phytoclimate Class                                   |
|--------------|----------------------------------|---------------------|---------------------------------|------------------------------|-------------------------------|------------------------------------------------------|
| P.f.4        | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | Via Ubaldo degli Ubaldi         | Pavia (PV)                   | <i>Unidentified broadleaf</i> | humid supratemperate - subhumid                      |
| P.f.5        | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | Via Borgo Calvenzano            | Pavia (PV)                   | <i>Platanus x hispanica</i>   | humid supratemperate - subhumid                      |
| P.f.6        | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | Via Borgo Calvenzano            | Pavia (PV)                   | <i>Platanus x hispanica</i>   | humid supratemperate - subhumid                      |
| P.f.7        | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | Bosco Giuseppe Negri            | Pavia (PV)                   | <i>Populus nigra</i>          | humid supratemperate - subhumid                      |
| P.f.8        | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | Bosco Giuseppe Negri            | Pavia (PV)                   | <i>Populus nigra</i>          | humid supratemperate - subhumid                      |
| P.f.9        | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | Cascina Venara                  | Zerbolò (PV)                 | <i>Populus alba</i>           | humid supratemperate - subhumid                      |
| P.f.10       | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | Pizzofreddo                     | Santa Maria della Versa (PV) | <i>Unidentified broadleaf</i> | mesomediterranean - humid thermotemperate - subhumid |
| P.f.11       | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | Parco della Vernavola           | Pavia (PV)                   | <i>Robinia pseudoacacia</i>   | humid supratemperate - subhumid                      |
| P.f.12       | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | Parco della Vernavola           | Pavia (PV)                   | <i>Robinia pseudoacacia</i>   | humid supratemperate - subhumid                      |
| P.f.13       | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | Parco della Vernavola           | Pavia (PV)                   | <i>Robinia pseudoacacia</i>   | humid supratemperate - subhumid                      |
| P.f.14       | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | Parco della Vernavola           | Pavia (PV)                   | <i>Robinia pseudoacacia</i>   | humid supratemperate - subhumid                      |
| P.f.15       | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | Parco della Vernavola           | Pavia (PV)                   | <i>Robinia pseudoacacia</i>   | humid supratemperate - subhumid                      |
| P.f.16       | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | Parco della Vernavola           | Pavia (PV)                   | <i>Robinia pseudoacacia</i>   | humid supratemperate - subhumid                      |
| P.f.17       | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | Parco della Vernavola           | Pavia (PV)                   | <i>Robinia pseudoacacia</i>   | humid supratemperate - subhumid                      |
| P.f.18       | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | Parco della Vernavola           | Pavia (PV)                   | <i>Robinia pseudoacacia</i>   | humid supratemperate - subhumid                      |
| P.f.19       | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | Via D. Alighieri 25             | Illasi (VR)                  | <i>Olea europaea</i>          | humid supratemperate - subhumid                      |
| P.f.20       | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | via Mascherpa                   | Castelvetro Piacentino (PC)  | <i>Populus alba</i>           | humid supratemperate - subhumid                      |
| P.f.21       | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | Lungolago                       | Mergozzo (VCO)               | <i>Robinia pseudoacacia</i>   | humid supratemperate/hyperhumid                      |
| P.f.22       | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | Cascina Scova                   | Pavia (PV)                   | <i>Robinia pseudoacacia</i>   | humid supratemperate - subhumid                      |
| P.f.23       | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | RNIS Bosco Siro Negri           | Zerbolò (PV)                 | <i>Quercus robur</i>          | humid supratemperate - subhumid                      |
| P.f.24       | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | RNIS Bosco Siro Negri           | Zerbolò (PV)                 | <i>Populus nigra</i>          | humid supratemperate - subhumid                      |
| P.f.25       | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | Santa Sofia                     | Torre d'Isola (PV)           | <i>Quercus robur</i>          | humid supratemperate - subhumid                      |
| P.f.26       | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | Cono di Volo Malpensa           | Gallarate (VA)               | <i>Unidentified broadleaf</i> | mesotemperate - humid supratemperate                 |
| P.f.27       | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | Viale Gorizia - Mura Spagnole   | Pavia (PV)                   | <i>Celtis australis</i>       | humid supratemperate - subhumid                      |
| P.f.28       | <i>Perenniporia fraxinea</i>     | (Bull.) Ryv.        | Fossone - Bosco della Fame      | Roveskala (PV)               | <i>Populus nigra</i>          | humid supratemperate - subhumid                      |
| P.m.1        | <i>Perenniporia meridionalis</i> | Decock and Stalpers | R.N. Regionale Piramidi di Zone | Zone (BS)                    | <i>Quercus robur</i>          | hyperhumid supratemperate/humid                      |
| P.m.2        | <i>Perenniporia meridionalis</i> | Decock and Stalpers | Sormano                         | Castellina in Chianti (SI)   | <i>Olea europaea</i>          | supratemperate/humid mesotemperate/hyperhumid        |

Table 2. Cont.

| Mic UNIPV ID | Species                           | Authors                    | Locality              | Municipality           | Host                        | Phytoclimate Class                                 |
|--------------|-----------------------------------|----------------------------|-----------------------|------------------------|-----------------------------|----------------------------------------------------|
| P.och.1      | <i>Perenniporia ochroleuca</i>    | (Berk.) Ryvarden           | Belcaro               | Siena (SI)             | <i>Quercus ilex</i>         | subhumid mesotemperate/humid                       |
| P.och.2      | <i>Perenniporia ochroleuca</i>    | (Berk.) Ryvarden           | Le Manie              | Savona (SV)            | <i>Quercus ilex</i>         | mesomediterranean/dry-subhumid thermomediterranean |
| Ph.c.1       | <i>Phellinus contiguus</i>        | (Pers.) Pat.               | Rio Bardonezza        | Ziano Piacentino (PC)  | <i>Robinia pseudoacacia</i> | humid supratemperate - subhumid                    |
| Ph.tor.1     | <i>Phellinus torulosus</i>        | (Pers.) Bourdot and Galzin | Ticino                | Torre d'Isola (PV)     | <i>Prunus avium</i>         | humid supratemperate - subhumid                    |
| Pl.e.1       | <i>Pleurotus eryngii</i>          | (DC.) Quél.                | Aidomaggiore          | Aidomaggiore (OR)      | unidentified                | subhumid mesomediterranean                         |
| Pl.e.2       | <i>Pleurotus eryngii</i>          | (DC.) Quél.                | Spadafora             | Spadafora (ME)         | unidentified                | thermomediterranean/subhumid mesomediterranean     |
| Punc.s.1     | <i>Punctularia strigosozonata</i> | (Schwein.) P.H.B. Talbot   | Bosco di Bauli'       | Palazzolo Acreide (SR) | <i>Quercus sp.</i>          | mesomediterranean/dry thermomediterranean-subhumid |
| Sp.p.1       | <i>Spongipellis pachyodon</i>     | (Pers.) Kotl. and Pouzar   | Rio Marsinola-Fracion | Rovescala (PV)         | <i>Prunus avium</i>         | humid supratemperate - subhumid                    |
| Sp.p.2       | <i>Spongipellis pachyodon</i>     | (Pers.) Kotl. and Pouzar   | Civezza               | Imperia (IM)           | <i>Quercus pubescens</i>    | mesomediterranean/dry thermomediterranean-subhumid |

The species reported in Table 2 represent about one in five of the comprehensive collection of wood decay species in MicUNIPV. The temperate region and Mediterranean region in Italy are reciprocally intersected and several phytoclimates are represented based on both thermal–pluviometrical parameters and floristic–vegetational ones. According to our field observations, this has the consequence that several species can be found in different phytoclimates and on different hosts, whereas a minor fraction is strictly related to one or few hosts.

*Daedaleopsis confragosa* and *D. tricolor* are easily distinguished by morphology; nevertheless, ITS sequences are important to discriminate the species strain. *D. tricolor* seems more common in Central and Southern Europe; in Italy, it has been reported in seven out of 20 regions [45]. Our strain (MicUNIPV D.tric.1) comes from the lower Apennines in Pavia Province; other field observations suggest that *Prunus avium* is the favourite host of *D. tricolor* in North and Central Italy. The strain has not been characterized yet, although pharmacological effects have been reported [46].

*Daedalea quercina* has been reported in 11/20 Italian regions [45]; as expected, all MicUNIPV strains were isolated from *Quercus* spp. Nevertheless, strain MicUNIPV D.q.1 efficiently colonized poplar wood chips and confirmed that this species is a typical brown rot agent [47].

Despite being apparently cosmopolitan, *Desarmillaria tabescens* is strictly related to *Quercus* in warm climates, where it behaves as a secondary pathogen [48]. *D. tabescens* has been reported in 16/20 Italian Regions [45]. Accordingly, our strain was isolated from roots of *Q. robur* in RNIS Bosco Siro Negri (Pavia, Italy), which is a significant, unmanaged residue of typical forest of the western Po Plain.

*Fomitopsis iberica* is a rare species, reported in three Italian regions [45]. All the strains in MicUNIPV were isolated close to Varese lakes, either on broadleaves or conifers.

*Ganoderma* is represented in MicUNIPV by seven species: *G. adspersum*, *G. applanatum*, *G. carnosum*, *G. pfeifferi*, *G. lucidum*, *G. resinaceum* and *G. valesiacum*. This genus has been intensely studied due to its wide range of secondary metabolites, including several bioactive compounds [49]. According to Ryvarden and Melo [6], *Ganoderma* is one of the most difficult genera to identify at species level. As reported in Table 2, we obtained strains of *G. adspersum*, confirming that is a southern species in Europe [50]. *G. carnosum* is usually located in the *G. lucidum* complex due to its morphological similarity, despite it showing clear differences in host relationship. Our strain was isolated from its type-locality in Italy, i.e., a forest of *Abies alba*, that is likely to be its preferred host in South Europe [33]. Molecular identification by ITS region met difficulties in discriminating *G. carnosum* from *G. tsugae* and *G. oregonensis*; this topic presents questions about the real interspecific diversity within this conifer-related species in *Ganoderma*. Strains in pure culture will thus help us to investigate both the molecular and morphological nested diversity in this complex. An analogous problem concerns *G. pfeifferi*, as it partially shares its trophic niche with *G. lucidum* and *G. resinaceum*.

*L. sulphureus* is particularly related to *Quercus* according to our observations in North Italy, although *Castanea sativa* is also represented. Interestingly, *C. sativa* is also one of the favourite hosts of *Phellinus torulosus*, according to field observations, despite strain MicUNIPV Ph.tor.1 being isolated from *P. avium*.

Genus *Perenniporia* is represented in MicUNIPV by *P. fraxinea*, *P. meridionalis* and *P. ochroleuca*. According to our field observation, *P. fraxinea* is more common and widespread than expected, particularly in urban areas. We have focused our attention in indentifying strains, which, to date, number 27. Some of the isolated strains have been used for population studies and tests on heavy metal bioaccumulation [16,51].

*Pleurotus eryngii* is a typically Mediterranean species as well as its herbaceous hosts in *Apiaceae*. Consistently, the MicUNIPV Pl.e.1 and Pl.e.2 strains were isolated in properly Mediterranean areas (Sardinia and Sicily).

*Punctularia strigosozonata* is a rare, poorly studied species, typically related to the Mediterranean area; its resupinate morphology increases the difficulty in achieving pure isolates.

*Spongipellis pachyodon* has a mainly central–southern distribution in Europe; according to Onofri et al. [45], in Italy it is known in five out of 20 Regions, not including either Lombardy or Liguria.

This species is reported as uncommon but locally abundant; regarding this, our field observations suggest that the population in the Pavia-Piacenza Apennines is particularly related to *P. avium*.

Further species listed in Table 2 are reported below in more detail owing to their taxonomic controversy or potential applications.

### 3.1. *Cellulariella Warnieri* (Durieu and Mont.) Zmitr. and V. Malysheva

#### 3.1.1. Background

As detailed in Table 2, the basidiomata of some species were collected in the Mediterranean area and others that are known to prefer warm environment, even if they were collected in continental or temperate zones. An example is *Cellulariella warnieri*, a poorly investigated species related to warm climates, according to Bernicchia and Gorjón [44]; despite not strictly being related to the Mediterranean region, Ryvarden and Melo [6] reported it as a southern and rare species.

The notable scarcity of data about this species has probably contributed to its uncertain systematic and taxonomic status. Currently it is reported as: *Lenzites warnieri* Durieu and Mont. by Mycobank [40], *C. warnieri* by Index Fungorum [52] and *Trametes warnieri* (Durieu and Mont.) Zmitr., Wasser and Ezhov by Ryvarden and Melo [6]. The latter indication is suggested also by Justo and Hibbett [53] based on a five marker-based phylogenetic classification of *Trametes*. Significantly, only 108 records for this species have been reported by the GBIF (Global Biodiversity Information Facility) [54] and only 10 sequences are available in GenBank, almost half of them being critical as they are reported from South East Asia [55]. Further analyses on a more representative number of strains are thus needed to clarify the position of *C. warnieri*.

Strain MicUNIPV L.w.1 was tested for the evaluation of lignocellulolytic activity and resulted in a very low production of Mn peroxydase and lack of lignin peroxydase, whereas cellulase and hemicellulase had the highest presentation among the species under examination [47]. This was also confirmed when testing the effect of its colonization on *Medicago sativa* for pre-treatment, as cellulose and hemicellulose were preferentially removed [56].

#### 3.1.2. MicUNIPV WDF Strains Results

According to our field observations, localities are distributed as small local clusters which are very scattered in turn. Thus, the strains MicUNIPV L.w.1, L.w.4 and L.w.5 were collected from Po plain areas (Pavia and RNIS Bosco Siro Negri), whereas strains the MicUNIPV L.w.2, L.w.3 and L.w.6 were collected from hill area (Oltrepo Pavese).

The six strains of MicUNIPV were collected from *Quercus*, *Ulmus*, *Populus* and *Robinia*; interestingly, our field observations pointed out some preference for *Ulmus*, which was not previously reported as a host in Italy. As expected, all the strains were isolated from individuals behaving as saprotrophs. It should be noted that, since *C. warnieri* develops basidiomata in late autumn but it releases spores in spring, the basidioma itself remains vital even at low temperatures and under the snow.

### 3.2. *Dichomitus squalens* (P. Karst.) D.A. Reid

#### 3.2.1. Background

*Dichomitus squalens* is a model species for studies about the selectivity of white rot and its enzymatic basis [57–60]. Despite being reported all throughout the boreal emisphere, it appears scattered and is commonly found in the northern parts of Europe, North America and Asia [61]; the GBIF [54] places the wide majority of records in the Fennoscandian region. The host relationship is apparently controversial and surprising: Ryvarden and Melo [6] assumed *Pinus* as the only European host species, whereas Bernicchia and Gorjón [44] recorded *Picea abies* for the Italian sample and Niemelä [62] assigned most samples to *Pinus* and a smaller fraction to *Picea abies* in Białowieża Forest (Poland / Belarus). Nevertheless, it should be noted that American samples have been reported on six

different genera in *Pinaceae*. Furthermore, young basidiomata of *D. squalens* are easily misidentified due to the close morphological resemblance with *Neoantrodia serialis* (Fr.) Audet and related species. Consistently, a remarkable intraspecific variability in growth and enzyme profiles was revealed by testing different monokarya strains [61]. This is also consistent with the numerous mating types deriving from tetrapolarity [61].

### 3.2.2. MicUNIPV WDF Strains Results

Strains MicUNIPV D.sq.1 and MicUNIPV D.sq.2 were recovered from *Pinus pinea* and *Cedrus* sp. respectively near the Adriatic Sea and Varese Lake. The Italian strains have not yet been investigated for their enzymatic properties, so they may provide an additional tool to explore the diversity in degradation potential of this selective decayer.

### 3.3. *Hericium Erinaceus* (Bull.) Pers.

#### 3.3.1. Background

*Hericium erinaceus* (Bull.) Pers. is one of the most famous cultivated medicinal species in the world; a wide range of peculiar compounds, both related to primary (e.g.,  $\beta$ -glucans) and secondary metabolism (e.g., erinacines and hericenones) have been up to now characterized and screened for bioactivity [7,63–66]. GBIF [54] places the wide majority of *H. erinaceus* sites in Europe, North America and North Eastern Asia. According to the phylogenetic study by Cesaroni et al. [67], a subclade containing European and American ITS sequences is well distinguished from the Asian clade. Despite relying on ITS region only, these data suggest the possibility to differentiate *H. erinaceus* strains also by the phylogeographic structure. Notwithstanding the scarcity of available data for Asian samples, *H. erinaceus* apparently has a quite broad trophic niche including several host species in *Fagaceae*, and *Aceraceae* to lesser extent, and particularly showing a preference for *Quercus* all throughout its distribution area [37]. Consistently, European samples have mainly been recovered from *Quercus* and *Fagus*, the former likely being the exclusive host in Italy and the only known host in North Africa [34,68]. Strain MicUNIPV H.e.2 was analyzed for the production of erinacine A and hericenones (presumably A, B, C, D). Thus, a complete quali-quantitative comparison of these selected metabolites was provided throughout different growth stages but within the same strain, which is a powerful tool for the standardization of bioactive products [69].

Strain MicUNIPV H.e.1 was selected to test the effect of oral supplementation on mice memory. The results indicate an improvement in recognition memory and induction of hippocampal and cerebellar neurogenesis during aging. This strain has therefore contributed to pointing out which areas are directly involved in the neuroactivity of *H. erinaceus* compounds, highlighting which type of memory is increased [70].

#### 3.3.2. MicUNIPV WDF Strains Results

Accordingly, all four strains in the MicUNIPV collection were recovered in the municipality of Siena from *Q. ilex*, that is, a featuring species in the flora of Mediterranean area often forming homogeneous woodlands. It is noteworthy that the Mediterranean basin hosts a great variety of *Quercus* species, whose phylogenetic and systematic relationships are still controversial, with particular concern to the *Q. ilex* group [71–73].

### 3.4. *Inocutis Tamaricis* (Pat.) Fiasson and Niemelä

#### 3.4.1. Background

The relationship of *Inocutis tamaricis* with *Tamarix* is apparently so strict to be regarded as a discriminant character in identification [6,33,44]. Although the genus *Tamarix* consists of 72 accepted species in Europe, Asia and Africa [74], *I. tamaricis* is restricted to the Mediterranean basin and

Macaronesia. Here, it grows on different *Tamarix* species according to their availability but shows a preference for *T. gallica* [75,76]. Consistently, strains MicUNIPV I.t.1 and I.t.2 were both isolated from *T. gallica*. As a whole, the intra-familial phylogeny of *Hymenochaetaceae* is still to be clarified; multiple revisions have tried to point out nested diversity within polyphyletic taxa, such as *Inonotus* [77,78]. Thus, the genus *Inocutis* is nowadays accepted to be distinct from *Inonotus* itself, as formerly suggested by Fiasson and Niemelä [79]. Interestingly, the type-species for *Inocutis* is *I. rheades* (Pers.) Fiasson and Niemelä, which is morphologically very similar to *I. tamaricis* and is mostly distinguished by host and distribution [6]. Thus, *I. tamaricis* may be regarded as the Mediterranean counterpart of *I. rheades*. As a whole, only 12 sequences have been up to now deposited in GenBank [55] as belonging to this species, some of which are lacking data to assess their effective reliability. Further sequences from the Mediterranean area, equipped with information about host and geographic origin, are needed to support studies about intrageneric diversity in *Inocutis* in the light of biogeographic patterns.

#### 3.4.2. MicUNIPV WDF Strains Results

Strains MicUNIPV I.t.1 and I.t.2 were both isolated from *T. gallica*, forming in both cases ornamental rows along the sea coast.

### 3.5. *Fomitiporia Mediterranea* M. Fisch.

#### 3.5.1. Background

As mentioned for *Inonotus*, the genus *Phellinus* is increasingly revealing its hidden diversity; recognized as being polyphyletic, several species have been distributed into other genera, such as *Fomitiporia* Murrill. *Fomitiporia mediterranea* is a peculiar example due to its morphology, being actually indistinguishable from *P. punctatus*. According to Fischer [80], these two species also show differences in growth rate at selected temperatures and mating behaviour. The same study provides strong evidence for dichotomy in host selection by *F. mediterranea* depending on biogeography, i.e., this species grows on several tree species in Italy [81,82], whereas north of the Alps it apparently grows on *Vitis vinifera* exclusively [83,84].

It should be considered that misidentification with *P. punctatus* has probably led to the underestimation of *F. mediterranea* in the Mediterranean area [85]. Analogously, Polemis et al. [86] suggested that the relationship with *P. pseudopunctatus* A. David, Dequatre and Fiasson should be reconsidered as well, enclosing the latter in *F. mediterranea* clade. It may be observed that the *P. pseudopunctatus* is apparently more related to the South Mediterranean region and climates [87,88]. Further analyses on strains from different geographic origins and hosts are thus needed to clarify both phylogenetic relationships and biogeographic patterns. As a whole, this species complex is characterized by intense necrotrophic white rot; *F. mediterranea* in particular is regarded as one of the main agents responsible for wood rot in *V. vinifera*, *Corylus avellana* and *Olea europaea* [82,83,85].

#### 3.5.2. MicUNIPV WDF Strains Results

All of the 17 Italian strains up to now attained by the Laboratory of Mycology DSTA–University of Pavia were assigned to *F. mediterranea* instead of *P. punctatus* and recovered from different substrates in North Italy. Even within one province (Pavia), *F. mediterranea* was located on five hosts, namely *Q. robur*, *Hedera helix* (State Natural Strict Reserve Bosco Siro Negri), *Salix alba* (University of Pavia courtyard), *R. pseudocacacia* and *V. vinifera* (Oltrepo Pavese hills).

The identified strains thus provide a tool to deepen pathology dynamics and different susceptibility depending on host species and cultivar.

### 3.6. *Perenniporia meridionalis* Decock and Stalpers

#### 3.6.1. Background

Genus *Perenniporia* Murrill sensu lato is large, cosmopolitan and supposed to be polyphyletic, and thus is in need of further phylogenetic analysis based on sequences from different species [6]. In turn, an example of intrageneric complexity is provided by *P. meridionalis*, within *P. medulla-panis* (Jacq.) Donk group. Actually, the complete revision by Decock and Stalpers [89] arose the doubt that several records, as well as specimens in herbaria, are to be referred to *P. meridionalis* instead of *P. medulla-panis* (or closely related species), particularly when coming from the Mediterranean area. Up to now, only a partial and fragmentary investigation into the intra-generic diversity in *Perenniporia* has been carried out from a molecular and phylogenetic point of view [90]. It is noteworthy that no sequences at all are available in GenBank by the name of *P. meridionalis*, whereas 40 sequences are referred to *P. medulla-panis* [55]. Strains from culture collections are thus needed as basic material for this purpose. According to the indications by both Bernicchia and Gorjón [44], as well as Ryvarden and Melo [6], *P. meridionalis* is particularly related to *Quercus* (more than *P. medulla-panis*), the holotype having been isolated from *Q. ilex* in Sardinia [62,89].

#### 3.6.2. MicUNIPV WDF Strains Results

Strains MicUNIPV P.m.1 and P.m.2 strains were respectively isolated from *Q. robur* (North Italy, near a lake) and *Q. ilex* (Central Italy). Besides considerations on biodiversity, *P. meridionalis* has a great applicative potential. MicUNIPV P.m.1 showed remarkable selectivity as a white rot agent and versatility when inoculated onto unusual substrates such as grass. The selective removal of lignin by this species contemporarily relies on high activity for Mn peroxidases and very low for one cellulase; the final delignification in the substrate is clear both in thermogravimetric analysis and FTIR spectroscopy [12,47].

### 3.7. *Perenniporia ochroleuca* (Berk.) Ryvarden

#### 3.7.1. Background

*Perenniporia ochroleuca* is another example of the unsolved intra-generic diversity within *Perenniporia*. This species is suspected to hide a complex, and transfer to *Truncospora* Pilát ex Pilát has thus been suggested [91]. According to the same authors, the Iberian/Macaronesian clade gives *T. atlantica* Spirin and Vlasák, whereas the status of Australian samples is more uncertain, which would mainly belong to *T. ochroleuca*. Nevertheless, the new taxonomy has not yet been fully accepted, neither by Mycobank [40] nor by Index Fungorum [52]. These hypotheses therefore need to be supported by entering further sequences into the phylogenetic analyses from an exhaustive geographic range. *P. ochroleuca* was reported by Bernicchia and Gorjón [44] and Ryvarden and Melo [6] as tropical and growing on several hosts, whereas in Europe it is particularly related to the Mediterranean area. Nevertheless, Bernicchia and Gorjón [44] report a range of typically Mediterranean hosts, whereas Ryvarden and Melo [6] also include host plants whose distribution exceeds the Mediterranean area to include samples from the coasts of South England and Wales. Further phylogenetic analyses focused on the Mediterranean region versus the adjacent Atlantic ones are needed to test the monophyly of the proposed *T. atlantica*.

#### 3.7.2. MicUNIPV WDF Strains Results

Both strains MicUNIPV P.och.1 and P.och.2 were isolated from *Q. ilex* in Central Italy and the Ligurian west coast, respectively.

#### 4. Conclusions

At the moment, MicUNIPV, the fungal research culture collection of University of Pavia (Italy), maintains 500 strains from wood decay species. Examples particularly correlated to the Mediterranean area were discussed and their roles in accomplished research were mentioned in this study.

Culture collections of wood decay fungi are an important tool both for systematic and applied studies. Strains in pure culture are more easily and reliably identified and analyzed for metabolic activities and competitiveness. The environmental features of the strain origin place have often been underestimated; nevertheless, the diversity of wood decay fungi strongly depends on biogeography and is related to host distribution. This also highlights the need for an investigation including a wider concept of the Mediterranean region than one strictly limited by climate or phytoclimate classification, i.e., even continental regions surrounding the Mediterranean area contribute to the explanation of Mediterranean diversity.

The Laboratory of Mycology DSTA–University of Pavia (Italy) has up to now successfully collaborated with both researchers from other universities and amateurs in order to increase the diversity richness and geographic origin range of strains, as well as to enter these strains in original pure and applied research such as MATER and CE4WE (grants from Cariplo Foundation and Regione Lombardia).

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