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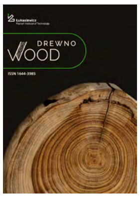

Ability of Selected Basidiomycetous Fungi to Decay Black Locust Wood

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Black locust (*Robinia pseudoacacia* L.) is a non-native tree species widespread all over Europe that has already gained some commercial importance. This study assessed the ability of selected basidiomycetous fungi (*Coniophora puteana*, *Heterobasidion annosum*, *Trametes versicolor*, *Fomitiporia robusta*) to decay black locust wood, based on the dry mass loss during a 16-week decay test. Wood samples were collected in the Głogów Forest District (SW Poland) and represented three age classes (38, 60 and 71 years). The density of the investigated wood ranged from 612 to 907 kg/m3 and significantly decreased with tree age ($p < 0.001$). The recorded mass loss ranged from 0.00% to 5.81%, amounting to 1.03% on average. We found that the resistance of black locust wood significantly increased with tree age ($p = 0.011$). Also, the observed mass loss differed significantly between fungal species ($p < 0.001$). The highest values were recorded for *T. versicolor* (mean = 2.14%). Comparing two *F. robusta* strains, we found significantly smaller mass loss for black locust wood than for oak wood ($p < 0.001$). The investigated strains caused greater mass loss in the wood of the species from which they had been isolated ($p = 0.021$ and $p = 0.049$ for locust and oak, respectively). Our findings confirm the hypothesis that black locust wood is highly resistant to fungal decay.

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Introduction

Black locust (*Robinia pseudoacacia* L.) was brought to Europe from North America in the early 17th century, initially as an ornamental plant for parks and gardens. For various utilitarian reasons, the species spread widely all over the continent and became highly expansive and invasive in many regions [Weber 2003; Vitkova et al. 2017].

It was introduced into forest cultivation due to its fast growth, low site requirements and high viability, as well as its valuable and durable wood, which, with properties similar to oak timber, is resistant to biotic factors [Bellon et al. 1977]. It was first cultivated in France and Germany in the middle of the 18th century [Nowinski 1977; Cierjacks et al. 2013]. As early as the 19th century, black locust was planted in Hungary [Redei et al. 2008]. In Poland, the introduction of this species into forests was initiated by Władysław Jedliński (later professor of the Faculty of Forestry at the Warsaw University of Life Sciences) in the Olkusz Forest District in 1914 [Białkiewicz 1952].

In Poland, black locust is mainly a scrub, not a forest species [Szwagrzyk 2000]. Currently, in the forests

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managed by the State Forests NFH, it occupies about 273,000 hectares [Wojda et al. 2015; Smyk 2019]. It is also the most widespread non-native species in national and landscape parks in Poland [GDOŚ 2016; Bomanowska et al. 2019].

Long-term studies have proved that black locust has an adverse impact on the biodiversity and functioning of forest ecosystems outside its natural range [Benesperi et al. 2012; Obidziński et al. 2016; Gentili et al. 2019; Sibikova et al. 2019]. In Poland, this species is considered highly invasive [Tokarska-Guzik et al. 2018].

R. pseudoacacia wood has found uses in various fields. It has been used in construction, cooperage and veneer, floor staves, furniture, and even energy production. It is a raw material for turned and milled haberdashery products. Due to its hardness, it has been applied for making vineyard poles or fences as well as railroad sleepers and mine stamps. A variety of sports equipment, namely bows, skis, field or ice hockey sticks, and tennis rackets, used to be or still are made of black locust wood. In the past, it was used to make machine parts (guides, sliders or bolts – when saturated in hot oil), tools (handles, grips, bindings), carts (ladders, drawbars, hubs, spokes), and pegs (shoemaking, furniture and construction). Finally, it is also a material suitable for carving [Białkiewicz 1952; Galewski and Korzeniowski 1958; Kozakiewicz and Wiktorski 2007; Obidziński and Woziwoda 2014; Wojda et al. 2015].

In its native range, black locust belongs to the group of hardwood tree species that are most susceptible to insects or diseases [Hepting 1971; Huntley 1990]. At least 114 fungus species have been found to attack *R. pseudoacacia* wood. The list includes such species as *Phellinus rimosus* (Berk.) Pilát and *Vanderbylia robiniophila* (Murrill) B.K. Cui & Y.C. Dai, which are considered a serious threat as they cause the decomposition of the trunk, which leads to problems in timber production [Huntley 1990; Farr et al. 1995]. For long since its naturalization in Europe, black locust has not had any significant consumers or threatening pathogens. In recent decades, many fungal parasites and saprotrophs existing on this species have also been reported from the area of its introduction [Farr et al. 1995; Michalopoulos-Skarmoutsos and Skarmoutsos 1999; Rehnert and Böcker 2007; Bartha et al. 2008; Cierjacks et al. 2013].

There are at least 106 species of fungi that colonize *R. pseudoacacia* in Poland, among which 29 taxa belong to the Ascomycota, and 77 to the Basidiomycota [Lisiewska et al. 1986; Wojewoda 2003; Żółciak 2003, 2005; Szczepkowski 2007; Kujawa 2008; Mułenko et al. 2008; Ślusarczyk 2012; Szczepkowski et al. 2013; Chachuła et al. 2015; Karasiński et al. 2015; Wilga 2016; Brzeg and Lisiewska 2018; Kozłowska et al. 2019; Friedrich 2020; Gierczyk and Ślusarczyk 2020; Gierczyk and Kujawa 2023]. The group of lignicolous fungi includes more than 90 taxa, including several dangerous pathogens degrading the wood of the roots and trunks of living trees (e.g. *Armillaria* spp., *Cerioporus squamosus* (Huds.) Quél., *Fomitiporia robusta* (P. Karst.) Fiasson & Niemelä, *Laetiporus sulphureus* (Bull.) Murrill). In turn, as many as 69 species of lignicolous fungi were found on black locust growing in southern Germany [Rehnert and Böcker 2007], including 43 species not recorded in Poland.

European studies on the resistance of black locust wood to fungal decomposition date back to the middle of the 20th century [Vintila 1944; Jagielski 1953]. Later, this issue was investigated by Pollet et al. [2008], Dünisch et al. [2010], Reinprecht and Zubková [2010], and others. The research showed that the timber's natural resistance to fungi is fairly high, and this was reflected in the EN 350 standard [2016]. In general, the lifespan of black locust wood in the open air is about 80 years, in water it is about 500 years, and in the dry state it may reach ca. 1500 years [Pacyniak 1981].

The objectives of this study were (i) to determine the resistance of *Robinia pseudoacacia* wood to the decay caused by three species of basidiomycetous fungi (*Coniophora puteana*, *Heterobasidion annosum*, *Trametes versicolor*) depending on the age of the trees, and (ii) to compare it with the resistance of oak wood to the decay caused by two strains of *Fomitiporia robusta* originating from *Robinia pseudoacacia* and *Quercus robur* as host species.

Materials and methods

1. Experiment design

The ability of the selected basidiomycetous fungi to decompose black locust wood was assessed based on the dry mass loss determined in a 16-week-long decay test. We performed this test following the procedures described in the EN 350 [2016] and EN 113-2 [2020] standards, and as described by Szczepkowski et al. [2021] and Marciszewska et al. [2024].

Primarily, we analysed the decay potential of three fungi (*C. puteana*, *H. annosum* and *T. versicolor*). In total, we used 108 samples, which included 12 samples per experimental variant (3 isolates and 3 age classes). Additionally, we investigated the ability of *F. robusta* strains isolated from *R. pseudoacacia* and *Q. robur* as host species to decay black locust and English oak wood. In this case we used 48 samples, again consisting of 12samples per variant (2 host species, 2 species of wood undergoing decay). Only trees of age class IV were used to analyse the decay caused by *F. robusta* strains.

To compare and verify the properties of the isolates, an additional decomposition test was performed on

20 beech wood samples (4 samples per fungus/strain) following the procedures adopted in the experiments described above.

2. Characteristics of investigated wood

Black locust wood samples were collected in the Głogów Forest District (SW Poland). This is the region with the greatest abundance of black locust in Poland [Wojda et al. 2015; Jamińska et al. 2018]. Three stands under standard management with black locust as a dominant species were chosen. The ages of these stands were 38 (hereafter referred to as age class II), 60 (age class III) and 71 (age class IV) years. In each stand, six trees were selected according to Hartig's method, and felled. From each such tree, we took two 50 cm long sections, which were debarked and split open to improve the uniformity of drying. From the internal part of the split logs we cut out enough wood to form 2.0×2.0×5.0 cm samples, which were prepared from the outer part of the trunk (mature wood). English oak wood samples were collected in the Wołów Forest District (SW Poland), while European beech material originated from the Kartuzy Forest District (N Poland). The age of the sampled oaks was 117 years, and the beeches were 90 years old. The dimensions of both oak and beech samples were 1.5×2.5×5.0 cm.

The density of wood samples was estimated using the drying-and-weighing method [Krzysik 1978; Kokociński 2004]. The moisture content of the samples was approximately 10%. The density of black locust wood ranged from 612 to 907 kg/m^3 and decreased with tree age (Figure 1). Significantly higher values were recorded for younger trees ($H_{K\text{-}W} = 79.76$, $p < 0.001$). This strong effect of age was also observed at the level of individual fungus species (Table 1).

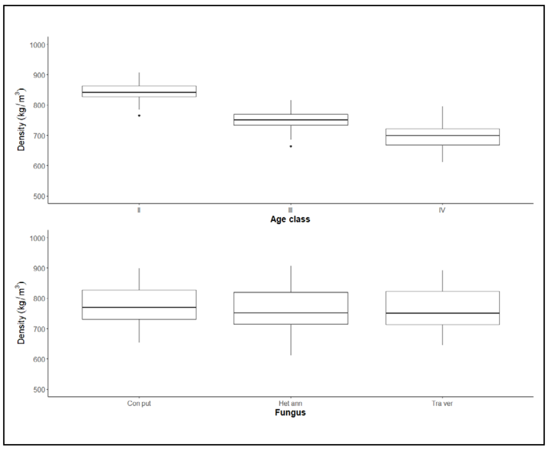

Fig. 1. Density of black locust wood with respect to age class (upper panel) and wood-decaying fungus species (lower panel; Con put – *Coniophora puteana*, Het ann – *Heterobasidion annosum*; Tra ver – *Trametes versicolor*)

Table 1. Density [kg/m^3] of *Robinia pseudoacacia* wood samples used in the decay test by three species of fungi with regard to the age class

Fungus	**Age class**	**Minimum**	**Maximum**	**Mean**	**Median**	**Standard deviation**	**Kruskal-Wallis test**	
							p	**homogenous groups**
Coniophora puteana	II	786	900	847	837	33.76	<0.001	a
	III	738	790	763	769	15.28		b
	IV	654	767	695	679	38.72		c
Heterobasidion annosum	II	764	907	844	850	36.56	<0.001	a
	III	663	804	740	745	34.40		b
	IV	612	768	695	695	43.38		c
Trametes versicolor	II	803	892	844	845	25.49	<0.001	a
	III	685	815	739	738	34.17		b
	IV	645	796	710	708	38.56		c

Table 2. Density [kg/m^3] of *Robinia pseudoacacia* and *Quercus robur* wood samples used in the decay test by two strains of *Fomitiporia robusta* originating from *Quercus robur* (33 Q. ro) and *Robinia pseudoacacia* (90 R. ps)

Tree species	Fomitiporia robusta strain host	Minimum	Maximum	Mean	Median	Standard deviation	Mann-Whitney test p	Mann-Whitney test homogenous groups
Robinia pseudoacacia	33 Q. ro	645	746	706	715	28.31	0.248	a
	90 R. ps	653	719	698	707	20.90		a
Quercus robur	33 Q. ro	591	640	621	623	14.90	0.419	a
	90 R. ps	571	635	615	622	19.57		a

By contrast, we found no significant difference in wood density with respect to the decay-causing fungus species ($H_{K-W} = 0.37$, $p < 0.829$) or *F. robusta* strains (Table 2).

3. Fungal decay experiment

We used four species of Basidiomycota fungi, each representing a different type of wood decay. *Coniophora puteana* (Schumach.) P. Karst. (strain BAM Ebw. 15) (WAMLCK – 2) represented the brown rot type, while *Fomitiporia robusta* (P. Karst.) Fiasson & Niemelä and *Trametes versicolor* (L.) Lloyd (WAMLCK – 13) represented the white uniform rot type. *Heterobasidion annosum* (Fr.) Bref. (WAMLCK – 86) represented white pocket rot. Additionally, we used *F. robusta* strains isolated from two different hosts: *Quercus robur* (WAMLCK – 33) and *Robinia pseudoacacia* (WAMLCK – 90). These strains originated from the collection of pure cultures held at the Department of Forest Protection at Warsaw University of Life Sciences (WAMLCK).

Following conditioning in standard climatic conditions, the samples were measured with a precision of 0.01 mm and weighed with a precision of 0.01 g. Additionally, for each variant, three extra wood samples were dried at 103±2 °C until a constant weight was attained. These samples were then weighed to determine the average moisture content in samples conditioned in a standard climate (22±2 °C, 65±5%). Moisture was calculated as the ratio of water content in the wood to the mass of absolute dry wood. Mean moisture was calculated as an average from three measurements [Kokociński 2004].

It is important to note that the wood samples used in the decay test were not artificially dried. Before the decay test, the samples were sterilized twice in an autoclave with steam for 20 minutes, and again 24 hours later for another 10 min. The sterilized samples were then hydrated in sterile distilled water for about one hour. Following hydration, two samples of wood were placed in Kolle flasks with approximately three-week-old cultures of the tested species of fungi grown in 50 ml of 2% MEA medium (Carl Roth, Germany).

After 16 weeks of incubation at 22±2 °C and 70±5% relative humidity, the samples were removed, cleaned of surface mycelium, and weighed. They were then dried at 105 °C to constant weight, they were reweighed, and the mass loss was calculated.

4. Statistical analyses

The distribution of mass loss differed significantly from a normal distribution, as shown by a Shapiro–Wilk test ($W = 0.71$, $p < 0.001$). Therefore, we used non-parametric tests to investigate the significance of the differences observed among age classes or fungus species (the Kruskal–Wallis test) and between *F. robusta* strains (the Mann–Whitney test). Pearson linear correlation was used to assess the relationship between wood density and mass loss. For the calculations, we used PAST 4.14 software [Hammer et al. 2001]. The significance level for the observed differences was set at 0.05.

Results

Dry mass loss in the case of the analysed black locust wood ranged from 0.0% to 5.81%, and was 1.03% on average. We found significant effects of tree age ($H_{K-W} = 8.97$, $p = 0.011$) and fungus species ($H_{K-W} = 49.04$, $p < 0.001$) on this parameter (Figure 2). A decreasing effect of age was also observed in the case of samples decayed by *C. puteana*, but no age effect was recorded for *H. annosum* or *T. versicolor* when individual fungi were investigated (Table 3).

In the comparison of *F. robusta* strains, the mass loss ranged from 0.42% to 5.99%, with the values recorded for black locust wood being significantly lower than those for English oak wood ($U_{M-W} = 35.5$, $p < 0.001$). A significant difference in this parameter was also recorded between the analysed strains with respect to the host

Table 3. Mass loss [%] of *Robinia pseudoacacia* wood samples used in the decay test by three species of fungi with regard to the age class

Fungus	Age class	Minimum	Maximum	Mean	Median	Standard deviation	Kruskal-Wallis test	
							p	homogenous groups
Coniophora puteana	II	0.13	0.67	0.46	0.48	0,22	<0.001	a
	III	0.00	0.67	0.43	0.45	0,15		b
	IV	0.00	0.85	0.27	0.24	0,31		c
Heterobasidion annosum	II	0.13	1.10	0.62	0.64	0.12	0.086	a
	III	0.00	1.24	0.59	0.60	0.55		a
	IV	0.00	0.82	0.44	0.48	0.22		a
Trametes versicolor	II	1.83	5.81	3.43	2.96	0.69	0.333	a
	III	0.40	4.55	2.09	1.56	0.81		a
	IV	0.33	2.44	0.91	0.74	0.51		a

Table 4. Mass loss [%] of *Robinia pseudoacacia* and *Quercus robur* wood decayed by two strains of *Fomitiporia robusta* originating from *Quercus robur* (33 Q. ro) and *Robinia presudoaccacia* (90 R. ps)

Tree species	Fomitiporia robusta strain host	Minimum	Maximum	Mean	Median	Standard deviation	Mann-Whitney test	
							p	homogenous groups
Robinia pseudoacacia	33 Q. ro	0.42	0.94	0.69	0.71	0.02	0.021	a
	90 R. ps	0.49	2.08	1.08	1.01	0.50		b
Quercus robur	33 Q. ro	1.32	5.99	2.58	1.93	2.08	0.049	a
	90 R. ps	1.14	5.36	1.99	1.47	1.81		b

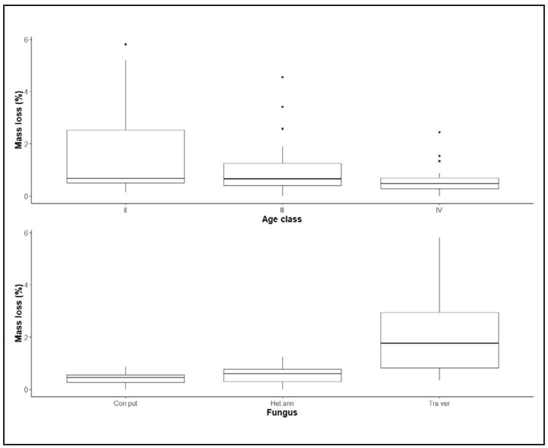

Fig. 2. Mass loss of black locust wood with respect to age class (upper panel) and wood-decaying fungus species (lower panel; Con put – *Coniophora puteana*, Het ann – *Heterobasidion annosum*; Tra ver – *Trametes versicolor*)

Table 5. Density [kg/m^3], moisture at the end of the test [%] and mass loss [%] of *Fagus sylvatica* (L.) wood samples used in the decay test by particular fungi (N = 4 per fungus)

Fungus	**Density**	**Moisture**	**Mass loss [%]**		
			range	**mean**	**median**
Coniophora puteana	667	91.08	16.59-20.59	18.22	17.86
Fomitiporia robusta (33 Q. ro)	660	87.14	27.41-29.38	28.19	27.99
Fomitiporia robusta (90 R. ps)	691	87.50	25.80-28.24	27.23	27.43
Heterobasidion annosum	659	66.49	10.62-15.34	12.76	12.55
Trametes versicolor	659	177.67	60.14-75.89	69.91	71.81

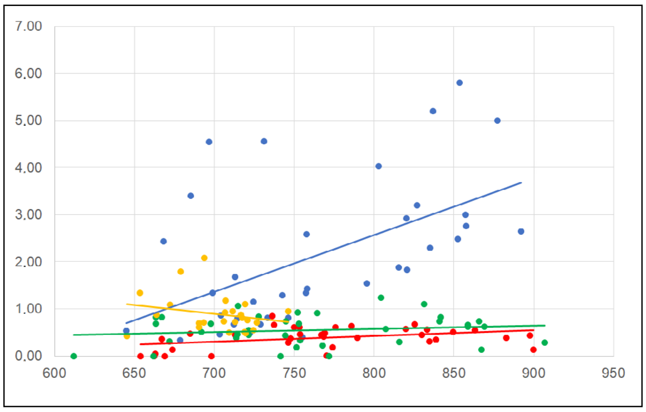

Fig. 3. Relationship between mass loss [%] and wood density [kg/m3] for investigated fungus species causing decay of black locust wood (red – *Coniophora puteana*; green – *Heterobasidion annosum*; blue – *Trametes versicolor*; yellow – *Fomitiporia robusta*)

wood (Table 4). In the case of the decay of both black locust and English oak, significantly higher mass loss values were obtained for the strains isolated from the same wood species ($U_{M\text{-}W} = 31.5$, $p = 0.021$ and $U_{M\text{-}W} = 37.5$, $p = 0.049$, respectively).

In general, the observed mass loss positively and significantly depended on the wood density ($r = 0.238$, $p = 0.006$; all samples included) (Figure 3). Such a relationship was recorded for *T. versicolor* and *C. puteana* ($r = 0.530$, $p < 0.001$ and $r = 0.378$, $p = 0.023$, respectively). For *H. annosum* we found that wood density had no significant influence on the rate of decay of black locust wood ($r = 0.151$, $p = 0.378$). In the case of *F. robusta* we recorded a negative but insignificant correlation between wood density and mass loss ($r = -0.223$, $p = 0.295$), pooling the values for both investigated strains.

The parallel experiment carried out on samples of beech wood provided values of mass loss higher than those observed for black locust wood. In the case of both locust and beech, the highest decomposition rate, although not significantly different, was found for *T. versicolor*, while the lowest rate was recorded for *H. annosum* in the case of beech and for *C. puteana* in the case of locust (Table 5).

Discussion

1. Wood density

The values obtained for *R. pseudoacacia* wood density are in line with previous findings that cause its wood to be classified as a dense type [Krzysik 1978; Molnar 1995; Wagenführ 2000; Pollet et al. 2012; Bijak and Lachowicz 2021]. The recorded range of black locust wood density (612–907 kg/m^3) is much wider than the range of 720–800 kg/m^3 indicated in the EN 350 standard [2016]. Our values are also higher than those recorded by Wąsik et al. [2023], which ranged from 482 to 747 kg/m^3.

Similarly to Kraszkiewicz [2008] and Bijak and Lachowicz [2021], we found that the wood density significantly decreases with the age of the trees. Contrasting results were obtained by Wąsik et al. [2023], who found no significant differences in wood density between age classes II and III. They also found no significant variation between analysed site types.

The density of the *Q. robur* wood used in the decay test (571–640 kg/m^3) was within the range reported by Wagenführ [2000] (430–960 kg/m^3) and was slightly lower than the values reported in the EN 350 standard [2016] (650–760 kg/m^3). Similarly, the density of the beech wood used in the experiment (659–691 kg/m^3) did not differ from the range reported by Wagenführ [2000] (540–910 kg/m^3), although it was slightly lower than the values indicated in the EN 350 standard [2016] (690–750 kg/m^3).

2. Mass loss in the decay test

Many features and properties of wood are drivers of its natural resistance to fungal decay [Cartwright and Findlay 1958; Rayner and Boddy 1988; Schwarze et al. 2000; Schmidt 2006]. Natural resistance varies depending on the attacking fungus, and even different strains of the same fungus can result in different levels of decay. Therefore, even under laboratory-controlled conditions, the degradation of samples of the same wood species can vary significantly [Sierota 1997; Puentes Rodriguez et al. 2009; Szczepkowski et al. 2021].

The very low mass losses of black locust wood recorded in the present study (< 6%) irrespective of tree age or wood density confirm the high resistance of the wood of this species to basidiomycetous fungi. This is in line with the EN 350 standard [2016], which classifies *R. pseudoacacia* wood as durable or very durable. In our study, all three tested species, including two (*C. puteana*, *T. versicolor*) used in standard decay tests, caused a slightly lower mass loss as the tree age increased. A significant effect of age×density on mass loss was recorded only for *C. puteana*. This partially corresponds with the results of Pollet et al. [2008] and Dünisch et al. [2010], who showed that young heartwood (close to the pith) had lower resistance to decay by *C. puteana* and *T. versicolor* than mature wood from the outer part of the heartwood.

The natural durability of *R. pseudoacacia* wood depends on the content of extractives and phenolic substances with antifungal properties, which are more abundant in mature than in young heartwood [Pollet et al. 2008; Dünisch et al. 2010; Sergent et al. 2014]. The extractive compounds obtained from black locust heartwood are able to increase the durability of the wood of some other tree species (e.g. beech, aspen) against *T. versicolor* [Hosseinihashemi et al. 2016; Sablík et al. 2016; Vek et al. 2020], *Gloeophyllum trabeum* (Pers.) Murrill [Smith et al. 1989] or *Schizophyllum commune* Fr. [Vek et al. 2020].

Of the four fungal species used in the experiment, the greatest, although not significantly different, mass loss of black locust wood (mean 2.14%) was caused by the white rot fungus *T. versicolor*. Similar results, but with a range of values from 0.9% to 10.1%, were reported in a Romanian study [Vintila 1944], with only one of the 12 samples used in the experiment having a mass loss exceeding 4.4%. After 16 weeks of exposure to *T. versicolor* the mass loss of juvenile heartwood was reported to be 8.5% [Pollet et al. 2008] or 17.0% [Dünisch et al. 2010]. For the mature heartwood the values were much lower, at 0.6% and 1.7%, respectively. These latter values correspond to our results as well as to findings by other authors [Jagielski 1953; Reinprecht and Zubková 2010] (0.64–1.8%).

The white rot fungus *F. robusta* proved to be the second most effective species in terms of induced mass loss (however, the samples were only from the oldest trees and the observed differences were not significant). Strain no. 90 (isolated from *R. pseudoacacia*) decomposed black locust wood to a greater extent than strain no. 33 (isolated from *Q. robur*). In contrast, oak wood was decomposed to a greater extent by strain no. 33 than by strain no. 90. These results indicate that the strains are slightly better adapted or exhibit higher activity of enzymes in decomposing the wood of the species from which they were isolated. However, the results obtained for wood mass loss depending on the strain used may be affected by various factors unrelated to the inherent decomposition abilities of the strains, and the studies should be extended to include more isolates and appropriate enzymatic analyses. In the case of *Inonotus obliquus* (Fr.) Pilát such a relationship was only partially confirmed [Szczepkowski et al. 2021].

The least effective decomposing species were the white pocket rot fungus *H. annosum* (0.0–1.24%) and the brown rot fungus *C. puteana* (0.0–0.85%). The first of these causes one of the most dangerous diseases in forestry – Heterobasidion root rot – which was the reason for the use of this species in the experiment. The pathogen usually affects conifers; deciduous trees, including *Robinia* spp., are attacked less often [Woodward et al. 1998; Ryvarden and Melo 2014; Sierota et al. 2019; Szczepkowski et al. 2022]. The strain of *H. annosum* was isolated from *Q. robur*, and together with *C. puteana* caused the lowest mass loss among the tested fungi (a mean of 0.55%). As reported by Piętka et al. [2021], *H. annosum* causes similar mass reduction in paulownia wood (0.56%). In the case of beech wood the rate is much higher (5–6%) [Schmidt et al. 1986]. For Scots pine wood incubated for two months, the mass loss was 3.4% [Mitchelson and Korhonen 1998]. Peunto and Rodrigez [2009] reported significant differences in Norway spruce wood decay, with mass loss ranging from 1.7% to 16.9%, after 6 months of incubation with various strains of *Heterobasidion parviporum* (Fr.) Niemela & Korhonen.

The mass loss caused by *C. puteana* obtained in our study contrasts with the relatively high level reported by Vintila [1944] (range: 2.0–20.8%, average: 10.26%). It is probable that the wood samples used in that study came from heartwood of different maturity. Results similar to the above were obtained by Jagielski [1953] and by Reinprecht and Zubková [2010], who reported mass losses in black locust wood caused by *C. puteana* at levels of 7.0% and 11.51% respectively. Notably, they did not determine the proportions of 'mature' and 'juvenile' heartwood. Pollet et al. [2008] and Dünisch et al. [2010] found mass losses in juvenile heartwood amounting to 2.7% and 10.1% respectively, while the values for mature heartwood were only 0.2% and 0.7%. These latter values are similar to our findings.

Only a few fungal species are able to decompose the most durable wood. For example, after 3 months of incubation, the brown rot fungus *Laetiporus sulphureus* caused mass losses of 12.0% and 8.0% in oak and locust wood, respectively [Schwarze et al. 2000]. Szczepkowski [2010] found that the mass loss in English oak wood after a 16-week decay test (as applied in the present study) amounted to – depending on the geographical origin, age, and condition of the trees – 1.0–16.3% (*L. sulphureus*), 0.3–6.5% (*T. versicolor*) and 0.2–10.7% (*C. puteana*). The fungal isolates used in the present experiment exhibit very good decomposition ability, as evidenced by the high values obtained for beech wood in the parallel decay test. Particularly high average values of beech wood mass loss were observed for *T. versicolor* (close to 70%), both isolates of *F. robusta* (approximately 28%), and *C. puteana* (approximately 18%).

Conclusions

The mass loss observed in the decay tests amounted to 1.03% on average, ranging from 0.0% to 5.8%. This result confirms the high resistance of black locust wood to the decay caused by selected basidiomycetous fungi (*Coniophora puteana, Heterobasidion annosum* and *Trametes versicolor*).

The general decrease in mass loss with the age of the analysed trees (38–71 years) may suggest that the resistance of black locust wood increases as it gets older.

The *Fomitiporia robusta* strain isolated from black locust decomposed its wood to a greater extent than the strain isolated from oak. Similarly, the strain isolated from oak caused a greater mass loss of oak wood than the strain isolated from black locust wood.

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References

Bartha D., Csiszár A., Zsigmond V. [2008]: Black locust (*Robinia pseudoacacia* L.). In: Botta-Dukát Z. and Balogh L. (eds.) The most important invasive plants in Hungary. Institute of Ecology and Botany, Hungarian Academy of Sciences. 63-76.

Bellon S., Tumiłowicz J., Król S. [1977]: Obce gatunki drzew w gospodarstwie leśnym (Non-native tree species in forestry). PWRiL, Warszawa.

Benesperi R., Giuliani C., Zanetti S., Gennai M., Mariotti Lippi M., Guidi T., Nascimbene J., Foggi B. [2012]: Forest plant diversity is threatened by *Robinia pseudoacacia* (black-locust) invasion. Biodiversity Conservation 21: 3555–3568. https://doi.org/10.1007/s10531-012-0380-5.

Białkiewicz F. [1952]: Grochodrzew (Black locust). PWRiL, Warszawa.

Bijak S., Lachowicz H. [2021]: Impact of tree age and size on selected properties of black locust (*Robinia pseudoacacia* L.) wood. Forests 12: 634. https://doi.org/10.3390/f12050634.

Bomanowska A., Adamowski W., Kirpluk I., Otręba A., Rewicz A. [2019]: Invasive alien plants in Polish national parks – threats to species diversity. PeerJ 7: e8034. https://doi.org/10.7717/peerj.8034.

Brzeg A., Lisiewska M. [2018]: Grzyby makroskopijne kampusu Uniwersytetu im. Adama Mickiewicza Morasko w Poznaniu (Macromycetes in the area of the Adam Mickiewicz University Morasko campus in Poznań). Badania Fizjograficzne 8, Seria B – Botanika (B66): 7–28, https://doi.org/10.14746/bfb.2018.8.1.

Cartwright K. S. G., Findlay W. P. K. [1958]: Decay of timber and its prevention. 2nd ed. H.M. Stationery Office, London

Chachuła P., Dorda A., Fiedor M., Rutkowski R. [2015]: Grzyby Cieszyna (Fungi of Cieszyn). Urząd Miejski w Cieszynie, Cieszyn.

Cierjacks A., Kowarik I., Joshi J., Hempel S., Ristow M., Lippe M., Weber E. [2013]: Biological Flora of the British Isles: *Robinia pseudoacacia*, Journal of Ecology 101: 1623–1640. https://doi.org/10.1111/1365-2745.12162.

Dünisch O., Richter H. G., Koch G. [2010]: Wood properties of juvenile and mature heartwood in *Robinia pseudoacacia* L.. Wood Science and Technology 44, 301–313 (2010). https://doi.org/10.1007/s00226-009-0275-0.

Farr D. F., Bills G. F., Chamuris G. P., Rossman A. Y. [1995]: Fungi on Plants and Plant Products in the United States, 2nd ed. APS Press, St. Paul, Minnesota, USA.

Friedrich S. [2020]: Grzyby wielkoowocnikowe Ogrodu Dendrologicznego w Przelewicach (Macromycetes in the Przelewice Dendrological Park). Ogród Dendrologiczny w Przelewicach, Przelewice.

Galewski W., Korzeniowski A. [1958]: Atlas najważniejszych gatunków drewna (The most important wood species). PWRiL, Warszawa.

GDOŚ [2016]: Kodeks dobrych praktyk – Ogrodnictwo wobec roślin inwazyjnych obcego pochodzenia (Good practices – horticulture in respect of invasive plants), Warszawa.

Gentili R., Ferrè C., Cardarelli E., Montagnani C., Bogliani G., Citterio S., Comolli R. [2019]: Comparing negative impacts of *Prunus serotina*, *Quercus rubra* and *Robinia pseudoacacia* on native forest ecosystems. Forests 10: 842. https://doi.org/10.3390/f10100842.

Gierczyk B. Ślusarczyk, T. [2020]: Materiały do poznania mykobioty Wielkopolski (Contribution to the knowledge of the mycobiota of the Greater Poland). Przegląd Przyrodniczy 31 (1): 3–83.

Gierczyk B., Kujawa A. [2023]: Rejestr grzybów chronionych i zagrożonych w Polsce. Część XI. Wykaz gatunków przyjętych do rejestru w 2015 (Register of protected and endangered fungi in Poland Part XI. A list of species added in 2015). Przegląd Przyrodniczy 34 (1): 3-72.

Hammer Ø., Harper D. A. T., Ryan P. D. [2001]: PAST: Paleontological statistics software package for education and data analysis. Palaeontologia Electronica 4 (1). http://palaeo-electronica.org/2001_1/past/issue1_01.htm

Hepting G. H. [1971]:. Diseases of forest and shade trees of the United States. Agriculture Handbook, US Department of Agriculture, Washington.

Hosseinihashemi S. K., Hossein Ashrafi S. K., Goldeh A. J., Salem M. Z. M. [2016]: Antifungal and antioxidant activities of heartwood, bark, and leaf extracts of *Robinia pseudoacacia*. BioResources 11: 1634–1646.

Huntley J. C. [1990]: *Robinia pseudoacacia* L. Black Locust In: R. M. Burns, B.H. Honkala (eds.) Silvics of North America, vol. 2. Hardwood. Agriculture Handbook 654: 755–761.

Jagielski A. [1953]: Porównanie naturalnej odporności drewna grochodrzewu, dębu i sosny na rozwój grzybni (Comparative natural resistance of locust, oak and pine wood to fungi attacks). Prace Instytutu Badawczego Leśnictwa 95: 40-56.

Jamińska J., Bronisz K., Bijak S. [2018]: Wielkość i wartość zasobów surowca drzewnego robinii akacjowej i daglezji zielonej w Lasach Państwowych (Amount and value of black locust and Douglas fir timber resources in the State Forests in Poland). Sylwan 162 (9): 737–744. https://doi.org/10.26202/sylwan.2018068.

Karasiński D., Kujawa A., Gierczyk B., Ślusarczyk T., Szczepkowski A. [2015]: Grzyby wielkoowocnikowe Kampinoskiego Parku Narodowego (Macrofungi of the Kampinos National Park). Kampinoski Park Narodowy, Izabelin.

Kokociński W. [2004]: Drewno. Pomiary właściwości fizycznych i mechanicznych (Wood. Measurements of physical and mechanical properties). Wydawnictwo-Drukarnia PRODRUK, Poznań

Kozakiewicz P., Wiktorski T. [2007]: Robinia akacjowa (*Robinia pseudoacacia* L.) – drewno egzotyczne z Ameryki Północnej (Black locust (*Robinia pseudoacacia*) – exotic wood from North America). Przemysł Drzewny 1: 25-28.

Kozłowska M., Mułenko W., Anusiewicz A., Mamczarz M. [2019]: An annotated catalogue of the fungal biota of the Roztocze Upland. Richness, diversity and distribution. Maria Curie-Skłodowska University Press, Polish Botanical Society, Lublin.

Kraszkiewicz A. [2008]: Analiza gęstości wybranych sortymentów surowca drzewnego robinii akacjowej (Analysis of density of selected assortments of black locust timber). Problemy Inżynierii Rolniczej 16: 69–76.

Krzysik F. [1978]: Nauka o drewnie (Wood science). PWN, Warszawa

Kujawa A. [2008]: Grzyby wielkoowocnikowe zadrzewień śródpolnych, parków wiejskich i lasów gospodarczych Parku Krajobrazowego im. gen. Dezyderego Chłapowskiego (Macrofungi of afforestations, rural parks and managed forests in D. Chłapowski Landscape Park). Wydział Biologii Uniwersytet im. Adama Mickiewicza w Poznaniu.

Lisiewska M., Linkowska R., Kaźmierczak B. [1986]: Obserwacje mikologiczne na rekultywowanych zwałowiskach Konińskiego Zagłębia Węgla Brunatnego (Mycological studies on reclaimed dumpings of Konin Lignite Area). Badania Fizjograficzne Polski Zachodniej B 37: 131-165.

Marciszewska K, Szczepkowski A, Lachowicz H, Antczak A, Szadkowska D, Suchodolski J. [2024]: The physical, mechanical, and chemical properties of black cherry tree wood (*Prunus serotina* Ehrh.) and its susceptibility to fungal decomposition in areas where it is secondary and invasive: a case study in the Kampinos National Park (Poland). European Journal of Wood and Wood Products 82: 683–701. https://doi.org/10.1007/s00107-023-02026-2.

Michalopoulos-Skarmoutsos H., Skarmoutsos G. [1999]: Pathogenicity of fungi affecting black locust (*Robinia pseudoacacia)* in Greece. Phytoparasitica 27: 239–240.

Mitchelson K, Korhonen K. [1998]: Diagnosis and Differentiation of Intersterility Groups. In: Woodward S., Stenlid J., Karjalainen R., Hüttermann A. (eds). *Heterobasidion annosum*: Biology, Ecology, Impact and Control. CAB International, Cambridge, UK.

Molnar S. [1995]: Wood properties and utilization of black locust in Hungary. Drevarsky Vyskum Wood Resources 1: 27–33.

Mułenko W., Majewski T., Ruszkiewicz-Michalska M. [2008]: A preliminary checklist of micromycetes in Poland. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Nowiński M. [1977]: Dzieje roślin i upraw ogrodniczych (History of horticultural plants and cultivations). PWRiL, Warszawa.

Obidziński A., Woziwoda B. [2014]: Robinia akacjowa *Robinia pseudoacacia* L. In: A. Otręba, D. Michalska-Hejduk (eds.). Inwazyjne gatunki roślin w Kampinoskim Parku Narodowym i jego sąsiedztwie, 82-87.

Obidziński A., Woziwoda B. [2016]: Robinia akacjowa *Robinia pseudoacacia* L. In: A. Obidziński, E. Kołaczkowska, A. Otręb (red.), Metody zwalczania obcych gatunków roślin występujących na terenie Puszczy Kampinoskiej. Kampinoski Park Narodowy, 106–120.

Pacyniak C. [1981]: Robinia akacjowa (*Robinia pseudoacacia* L.) w warunkach środowiska leśnego Polski (Black locust in forests of Poland). Roczniki AR w Poznaniu 111: 1-83.

Piętka J., Łakomy P., Lachowicz H. [2021]: Wpływ grzybni *Heterobasidion annosum* (Fr.) Bref. na drewno Paulownia COTE–2 w warunkach laboratoryjnych (Influence of the *Heterobasidion annosum* (Fr.) Bref. Mycelium on Paulownia COTE–2 wood in in vitro conditions). Sylwan 165 (5): 402–411. DOI: https://doi.org/10.26202/sylwan.2021040.

Pollet C., Jourez B., Hébert J. [2008]: Natural durability of black locust (*Robinia pseudoacacia* L.) wood grown in Wallonia, Belgium. Canadian Journal of Forest Research 38 (6): 1366–1372. https://doi.org/10.1139/X07-244.

Pollet C., Verheyen C., Hébert J., Jourez B. [2012]: Physical and mechanical properties of black locust (*Robinia pseudoacacia*) wood grown in Belgium. Canadian Journal of Forest Research 42: 831–840. https://doi.org/10.1139/x2012-037.

Puentes Rodriguez Y., Zubizarreta Gerendiain A., Pappinen A., Peltola H., Pulkkinen P. [2009]: Differences in wood decay by *Heterobasidion parviporum* in cloned Norway spruce (*Picea abies*). Canadian Journal of Forest Research 39: 26–35. https://doi.org/10.1139/X08-159.

Rayner A. D. M., Boddy L. [1988]: Fungal Decomposition of Wood. Its Biology and Ecology. Wiley, Chichester.

Rédei K., Osváth-Bujtás Z., Veperdi I. [2008]: Black Locust (*Robinia pseudoacacia* L.) Improvement in Hungary: a Review. Acta Silvatica & Lignaria Hungarica 4 (1): 127–132. https://doi.org/10.37045/aslh-2008-0011

Rehnert M., Böcker R. [2007]: Untersuchungsgebiet südlicher Schönbuch: Lignicole Pilze an *Robinia pseudoacacia* im Vergleich zu Stadt- und Alleebäumen. Ber. Inst. Landschafts- Pflanzenökologie Univ. Hohenheim 17: 189-198.

Reinprecht L., Zubková G. [2010]: Decay resistance of laminated veneer lumbers from black locust wood. Wood Research 55 (2): 39-52.

Ryvarden L, Melo I. [2014]: Poroid fungi of Europe. Synopsis Fungorum 31. Fungiflora, Oslo.

Sablík P., Giagli K., Pařil P., Baar J., Rademacher P. [2016]: Impact of extractive chemical compounds from durable wood species on fungal decay after impregnation of nondurable wood species. European Journal of Wood and Wood Products 74: 231–236. https://doi.org/10.1007/s00107-015-0984-z.

Schmidt O. [2006]: Wood and tree fungi. Biology, damage, protection, and use. Springer, Germany

Schmidt O., Bauch J., Rademacher P., Göttsche-Kühn H. [1986]: Mikrobiologische Untersuchungen an frischem und gelagertem Holz von Bäumenaus Waldschadensgebieten und Prüfung der Pilzresistenz des frischen Holzes (Microbiological investigations on fresh and stored wood of trees from diseased forest sites and investigation of fungal decay resistance of fresh wood). HolzRoh- undWerkstoff 44 (8): 319-327.

Schwarze F. W. M. R., Engels J., Mattheck C. [2000]: Fungal Strategies of Wood Decay in Trees. Springer-Verlag Berlin Heilderberg, Germany.

Sergent T., Kohnen S., Jourez B., Beauve C., Schneider Y-J. Vincke C. [2014]: Characterization of black locust (*Robinia pseudoacacia* L.) heartwood extractives: identification of resveratrol and piceatannol. Wood Science and Technology 48: 1005–1017. https://doi.org/10.1007/s00226-014-0656-x.

Sibikova M., Jarolimek I., Hegedusova K., Majekova J., Mikulova K., Slabejova D., Skodova I., Zaliberova M., Medvecka J. [2019]: Effect of planting alien *Robinia pseudoacacia* trees on homogenization of Central European forest vegetation. Science of the Total Environment 687: 1164-1175. https://doi.org/10.1016/j.scitotenv.2019.06.043.

Sierota Z. [1997]: Dry weight loss of wood after the inoculation of Scots pine stumps with *Phlebiopsis gigantea*. Forest Pathology 27 (3): 179–185. https://doi.org/10.1111/j.1439–0329.1997.tb00859.x.

Sierota Z., Grodzki W., Szczepkowski A. [2019]: Abiotic and Biotic Disturbances Affecting Forest Health in Poland over the Past 30 Years: Impacts of Climate and Forest Management. Forests 10 (1): 75. https://doi.org/10.3390/f10010075.

Ślusarczyk T. [2012]: Lasy robiniowe ostoja rzadkich i zagrożonych grzybów wielkoowocnikowych (Robinia forests as a refuge for rare and threatened macrofungi). Przegląd Przyrodniczy 23(2): 11-41.

Smith A., Campbell C., Walker D., Hanover J. [1989]: Extracts from Black Locust as Wood Preservatives: Extraction of Decay Resistance from Black Locust Heartwood. Holzforschung 43(5): 293-296. https://doi.org/10.1515/hfsg.1989.43.5.293.

Smyk J. [2019]: Robinia akacjowa – zagrożenie dla lasów czy niewykorzystany potencjał? Las Polski 15-16

Szczepkowski A. [2007]: Macromycetes in the Dendrological Park of the Warsaw Agricultural University. Acta Mycologica 42 (2): 179-186.

Szczepkowski A. [2010]. Odporność drewna dębu szypułkowego (*Quercus robur* L.) z drzew o różnym stanie zdrowotnym, na rozkład powodowany przez grzyby

(Resistance to decay caused by fungi of common oak (*Quercus robur* L.) wood from trees of different health status). Leśne Prace Badawcze 71 (2): 125-133.

Szczepkowski A., Kowalczuk W, Sikora K, Damszel M, Sierota Z. [2022]: Fungi occurring in Norway spruce wood decayed by *Heterobasidion parviporum* in Puszcza Borecka stands (northeastern Poland). Forests 13 (2): 229. https://doi.org/10.3390/f13020229.

Szczepkowski A., Kujawa A., Halama M. [2013]: *Volvariella bombycina* (Schaeff.) Singer in Poland: Notes on Its Ecology, Distribution and Conservation Status. Polish Journal of Environmental Studies 22 (1): 41-51.

Szczepkowski A., Sołowiński P., Piętka J., Zaniewski P.T. [2021]: Zdolność rozkładu drewna przez wybrane izolaty błyskoporka podkorowego *Inonotus obliquus* (Wood decay ability of some isolates of *Inonotus obliquus*). Sylwan 165 (6): 470-478. https://doi.org/10.26202/sylwan.2021053.

Szwagrzyk J. [2000]: Potencjalne korzyści i zagrożenia związane z wprowadzaniem do lasów obcych gatunków drzew (Advantages and risks associated with introducing alien tree species to forests). Sylwan 144 (2): 99-106.

Tokarska-Guzik B., Dajdok Z., Zając M., Zając A., Urbisz A., Danielewicz W., Hołdyński C. [2012]: Rośliny obcego pochodzenia w Polsce ze szczególnym uwzględnieniem gatunków inwazyjnych (Alien plants in Poland with specific regard to the invasive species). Generalna Dyrekcja Ochrony Środowiska, Warszawa.

Vek V., Balzano A., Poljanšek I., Humar M., Oven P. [2020]: Improving Fungal Decay Resistance of Less Durable Sapwood by Impregnation with Scots Pine Knotwood and Black Locust Heartwood Hydrophilic Extractives with Antifungal or Antioxidant Properties. Forests 11 (9): 1024. https://doi.org/10.3390/f11091024.

Vintila E. [1944]: Cercetari pe cale mycologica asupra durabilitatii naturale a lemnului de salcam in comparatie cu lemnul de stejar [Mycological studies on the durability of wood of *Robinia* compared with that of *Oak*]. Analele Institutuliu de Cercetari Forestiere al Romanei 10(1): 103-127.

Vitkova M., Mullerova J., Sadlo J., Pergl J., Pysek P. [2017]: Black locust (*Robinia pseudoacacia*) beloved and despised: A story of an invasive tree in Central Europe. Forest Ecology and Management 384: 287–302. https://doi.org/10.1016/j.foreco.2016.10.057.

Wagenführ R. [2000]: Holzatlas. 5. ergänzte und erweiterte Auflage. mit zahlreichen Abbildungen (Wood atlas. 5th, supplemented and expanded edition with numerous illustrations). Fachbuchverlag Leipzig im Carl Hanser Verlag, München, Wien.

Wąsik R., Michalec K., Gach M. B. [2023]: Differentiation of selected macrostructural features and the basic wood density on the radius of the stem−cross section of black locust *Robinia pseudoacacia* L. from southern Poland. Sylwan 167 (8): 477−489. https://doi.org/10.26202/sylwan.2023045.

Weber E. [2003]: Invasive plants species of the world: a reference guide to environmental weeds. CABI Publishing, Oxon-Cambridge, USA.

Wilga M. S. [2016]: Cuda oliwskiej przyrody. Grzyby (Wonders of the nature in Oliwa. Fungi). Wydawnictwo Koziorożec, Gdańsk.

Wojda T., Klisz M., Jastrzębowski S., Mionskowski M., Szyp-Borowska I., Szczygieł K. [2015]: The geographical distribution of the black locust (*Robinia pseudoacacia* L.) in Poland and its role on non-forest land. Papers on Global Change 22: 101-113. https://doi.org/10.1515/igbp-2015-0018.

Wojewoda W. [2003]: Checklist of Polish larger basidiomycetes. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Woodward S., Stenlid J, Karjalainen R, Hüttermann A. [1998]: *Heterobasidion annosum*: Biology, Ecology, Impact and Control. Cambridge, UK, CAB International

Żółciak A. [2003]: Rozmieszczenie grzybów z rodzaju *Armillaria* w Polsce oraz ich rośliny żywicielskie (Distribution of *Armillaria* fungi in Poland and their host plants). Prace Instytutu Badawczego Leśnictwa. Seria A 956: 7-22.

Żółciak A. [2005]: Opieńki (Honey fungi). CILP, Warszawa.

List of standards

EN 113-2, 2020 Durability of wood and wood-based products – Test method against wood destroying basidiomycetes – Part 2: Assessment of inherent or enhanced durability. European Committee for Standardization, Brussels.

EN 350, 2016. Durability of wood and wood-based products – Testing and classification of the durability to biological agents of wood and wood-based materials. European Committee for Standardization, Brussels.