PERFORMANCE OF WOOD UTILITY POLES IN SERVICE: THE ROLE OF FUNGI IN WOOD DECAY.

N.J. Whitney and J.A. Johnson
Wood science and Technology Centre, University of New Brunswick, Fredericton,

INTRODUCTION

Deterioration of utility poles by fungi and insects can negatively affect the integrity and serviceability of the poles. The ensuing damage and potential failure of the poles can cause serious disruptions in service and result in high repair and replacement costs. Better information regarding appropriate anti-decay treatments and the effects of particular fungi on utility poles will help interested Utility Companies make informed decisions during their planning exercises.

The Canadian Electrical Association (CEA), in 1983, initiated a research project (118-D-333) designed to produce a database which would catalogue a number of characteristics of in-service poles. The 1983 study sampled 701 poles from across Canada and included six age-classes of nine pole species, and nine chemical treatments. Retention of preservatives below and above the groundline was investigated as well as fungal decay and identification of fungal colonizers. In addition, other parameters were investigated and included; remedial treatments, checking, mechanical damage, surface slope of grain, surface decay, moisture content above and below ground and soil type.

In 1990 the CEA initiated the second phase of the database acquisition project (118-D-333A) to update and supplement the 1983 information. Similar evaluations to those done in 1983 were

performed on the same poles in 1990 as well as a number of additional tests. Electron microscopy of pole cores, detailed identification of isolated fungi, and Pilodyn readings were included to fill out the database.

The resulting manuscript prepared at the Wood Science and Technology Centre in Fredericton, New Brunswick was a multi-disciplinary report involving a number of researchers. The overall results appear in the 'PERFORMANCE OF WOOD POLE SPECIES IN SERVICE: 1990 EVALUATION', CEA publication 118-D-333A. This report will concentrate on the fungal aspects of the 1990 study and address gross and incipient decay and identification of isolated fungi.

Decay-causing fungi are often associated with wood poles and these populations may be having an effect on the serviciblity of the poles in question. Fungi are major players in the decay and decomposition of trees, wood and wood products (Agrios 1978; Boyce 1961, Moore-Landecker 1990). Fungi are capable of colonizing living trees, contributing to rot, and continuing to decay wood-in-service after the tree has been harvested (Boyce 1961; Moore-Landecker 1990). Saprophytic fungi live on dead and dying organic material and are often responsible for decay of wood products. The decay process involves the decomposition of cellulose, hemicellulose, and lignin resulting in structural damage and a weakened state for the wood-product in question (Moore-Landecker 1990).

Fungi which colonize wood do not always cause decay or contribute to structural damage. Sapstain fungi will discolour wood but cause little damage to the wood in question. It is also

known that certain fungi will be antagonistic towards other fungi when a substrate, used as a habitat, is challenged (Wicklow 1981; Carroll 1988). Interference competition is the term used to describe this relationship. By producing secondary metabolites or compounds which inhibit or destroy competitors a fungus can protect the host substrate from colonization by other fungi (Minter and Miller 1980).

The objectives of the 'fungal' component of the 1990 CEA study were to isolate fungi from the poles, identify them and evaluate visual and incipient decay. This report was extracted, with permission, from the 1990 CEA report. Detailed information regarding data collected for this study appears in the report entitled "PERFORMANCE OF WOOD POLE SPECIES IN SERVICE: 1990 EVALUATION" CEA publication 118-D-333A.

MATERIALS AND METHODS

Collection of samples

Pole cores (703) were collected in four regions (EASTERN New Brunswick, Nova Scotia; CENTRAL Quebec, Ontario; PRAIRIE Manitoba, Saskatchewan, Alberta; WESTERN British Columbia). Six pole age-classes were used (1=7-12 yrs; 2=13-17 yrs; 3=18-22 yrs; 4=23-27 yrs; 5=28-32 yrs; 6=33-37 yrs). The same poles which were sampled in the 1983 study were sampled again in this investigation.

Core samples from each pole were collected approximately 150 mm below the groundline using a 4.3 mm increment borer. The area to be tested was brushed to remove any remaining soil and lightly sprayed with alcohol to surface sterilize the area. Before core samples were collected, the increment borer was sterilized by being sprayed with 95% alcohol and passed through a flame. The samples were taken at regions adjacent to the deepest check. The core sample was removed from the borer, placed in sterile glass tubes and plugged with sterile stoppers. All samples were immediately placed in a propane cooler at 5°C before being sent by courier to the Wood Science and Technology Centre. Visual observations regarding decay were made for each pole at the time of sampling.

Fungal isolation and identification

At the laboratory, the samples were stored at 5°C until processed. Each core was removed from the glass tube under aseptic conditions and the core surface was sterilized by being passed through an open flame (1 cm/s). The core was then cut into 10 segments of approximately equal length using a flame sterilized scalpel. Five segments (first [outermost], third, fifth, seventh and ninth) were placed on individual plates of 2% malt extract agar (MEA) containing 0.3 g/L of streptomycin sulfate. The cores were then incubated in the dark at 18°C and 80% relative humidity. All remaining core segments (second, fourth, sixth, eighth and tenth [innermost]) were placed in sterile aluminum foil, and stored at 4°C for future use.

After four weeks the plates were evaluated for the presence or absence of fungi. Fungal colonies were sub-cultured onto fresh media for identification. Plates containing core segments where no fungi grew were discarded. Fungi were identified based on colony description and microscopic morphology.

Gross decay

Visual examination of core segments for decay involved looking at three of the five segments not used for isolating fungi. These segments (second E1, sixth E3, tenth E5) were examined using a stereoscopic dissecting microscope (12x magnification) for decay features such as surface changes, presence of hyphal strands, and fracturing of hyphal cores. An arbitrary scale was created to facilitate the evaluation of the core segments: A- no visible decay, surface of core smooth; B- slight decay, surface pitted; C- obvious surface decay, early wood eroded; D- decay deeply penetrated into core, early wood almost totally decayed leaving late wood; E- core completely decayed leaving woody particles.

Incipient decay

Pole cores were randomly selected from all tree species. Three segments per core were selected (E1, E3, E5) for observation. Disks, approximately 1 mm in length were fractured away from each core segment and the newly exposed surfaces were noted. The disks were freeze-dried for 1 hour before being attached to metal stubs with silver paste. Mounted disks were then coated with gold for three minutes and observed on a JOEL 6400 scanning electron microscope.

RESULTS

The list of fungi isolated from the cores appears in Table 1. Of this list, 34% are known to have the potential to decay wood while no information on decay potential exists for 66% of the fungi isolated. The species of pole the fungi were isolated from is listed in Table 2.

Hyalodendron lignicola and Pachnocybe ferruginea were isolated more frequently than any other fungi and were found in 36% of all poles in which fungi were isolated. Of 272 poles which had core segments colonized by Pachnocybe ferruginea, 248 adjacent segments (92.2%) were found to not be decayed. Similarly for the 226 core segments colonized by Hyalodendron lignicola, 220 adjacent segments (97.3%) were decay free. Hyalodendron lignicola was isolated frequently from all core segment positions and from most of the pole species (Table 3).

Basidiomycetes were isolated from approximately 22% of all poles sampled (Table 1). Seventeen of the 56 fungal taxa were isolated only once.

A total of 877 (25%) out of the 3515 segments observed were determined to have symptoms of decay. Seventeen percent of these were considered severely decayed (Table 4). No visual decay was detected in 210 (30%) poles.

Based on regional location of the poles it was noted that lodgepole pine tended to show more decay in the western and

central regions when compared to the eastern region. In addition, the centre core segments were less decayed than the middle or outermost segments. Red pine poles located in the eastern region were more decayed than poles in the central region. For jack pine poles in age classes 2 and 3 (central and prairie) decay was similar between all regions but for age classes 1 and 4 more decay was observed in pole located in the prairie regions. Overall, there was more decay in the outer edge of the core than in the centre. The type of chemical treatment did not appear to influence the severity of decay.

Segments near the centre of the pole tended to have more fungi associated with them when compared to middle or outer segments. Overall, there was more decay observed in segments near the outer edge. A number of the basidiomycetes were isolated from the central core segments.

There was a slight decrease in isolate frequency of fungi from the western to central regions. In red pine poles, with the exception of age class 4, the number of isolates was similar between eastern and central regions. Jack pine poles had more fungi isolated from cores collected from the central region. Douglas fir had approximately the same number of isolates collected from all regions and for all age classes, the same was true for western red cedar.

Of the 703 poles sampled, 46 (6.5%) were severely decayed and had no fungi associated with them. Two-hundred and fifty-four (36%) poles had no fungi observed on the core segments.

Decay was found, using an electron microscope, where no fungi were isolated.

Western red cedar had high numbers of fungus-free segments with the highest incidence of decay. Western red cedar was noted to have the lowest percentage of decay-free poles when compared to other species. In general, for all species, decay varied inversely with fungi.

Fungi were observed on segments where no decay was noted or fungi isolated (Table 5). Decay and fungus-related damage was observed where there was no fungus isolated and no visual evidence of fungi was found (Table 6).

The amount of decay as related to soil type (organic or non organic) was found to vary little for most pole species. There was slightly more severe decay in non-organic soil as noted for western red cedar.

DISCUSSION

The high number of poles which were found to be decayed (70%) in this study contrasts with the relatively low number of poles reported to be decayed in 1983 CEA Report 118-D-333. The poles are now seven years older resulting in the potential for advancement of existing decay and the initiation of new decay. It had been speculated in the 1983 CEA Report that pre-colonization of poles by Imperfect Fungi may be related to decay or the presence of decay-causing fungi and it is true, that in 1990, more fungi were isolated than in 1983 and more decay was

noted overall. The presence or absence of other microorganisms can affect the ability of some fungi to colonize suitable substrates (Agrios 1978). The effects of changing pH values and moisture content can influence successional patterns and result in a habitat becoming more suitable to a fungus after it has been 'conditioned' by the fungi which have preceded it.

There were differences in the number of fungi isolated for some pole species when related to the regional location of the pole. Western red cedar and Douglas fir tended to have consistent numbers of isolates in all regions sampled while Jack pine poles had more fungi isolated in the Central region. Many of the fungi isolated from the poles are ubiquitous in the environment and their presence on or in utility poles is an indication of their ability to utilize difficult substrates. As outlined in the 1990 CEA Report (118-D-333A), there appeared to be little difference between anti-fungal chemical treatments when related to fungal colonization or presence of decay. In addition, soil type (organic or non-organic) did not have a large influence over the fungal population isolated from the poles.

Detailed identification of fungi isolated from poles can give valuable information on the nature of fungal populations which colonize utility poles in service. In contrast to the 1983 data (CEA Report 118-D-333) the list of Fungi imperfecti isolated in 1990 (CEA REport 118-D-333A) includes the genus, and often, the species. The value in this information is demonstrated by he finding that when H. lignicola and P. ferruginea were isolated there was no decay and no basidiomycete isolates. The likelihood of interference competition between non-decaying and decaying fungi is quite high. Many fungi are known to produce compounds,

in the form of secondary metabolites, which will protect a substrate by inhibiting or destroying competing organisms (Wicklow 1981; Minter and Miller 1980; Duchene et. al 1989; Clark et. al 1989). There was an inverse relationship between the number of fungal isolates and the presence of decay in the poles studied which suggests that some protection may be occurring naturally. The actual scope and nature of this relationship in utility poles is not well known but may deserve more attention as a potential bio-control mechanism for decay suppression which could enhance performance of chemical treatments.

The observation that fungi could be found where none were isolated and that decay was noted in the absence of physical evidence of fungi suggests that methods presently used for detection are deficient. The early detection of fungi or decay symptoms may alleviate some problems in repair and replacement by giving utility companies the luxury of enough time to plan maintenance before failure. Further work on early detection may be indicated.

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Table 1. List of fungi isolated and their potential for decay.

	Taxon	Decay potential[a]
1	Aureobasidium pullulans (de Bary) Arnaud	+(3)[b]
2	Aspergillus terreus Thom	?(5)
3	Basidiomycete with clamp connections	+(19)
4	Fusarium sp.	?(9)
5	Fusarium acuminatum Ell. and Ev.	?(9)
6	Fusarium lateritium Nees [W & R, G, B, J]	?(1)
7	Fusarium merismoides Corda [W & R, G, B, J]	?(1)
8	Fusarium moniliforme Sheldon [W & R, B, J]	?(10)
9	Fusarium oxysporum Schlecht. emend. Synd. & Hans. [S, & H, M & C]	?(7)
10	Fusarium sambucinum Fuckel [W & R, G, B, J]	?(3)
11	Hyalodendron lignicola Diddens	+(112)
12	Leptodontium obscura	?(1)
13	Oidiodendron tenuissimum (Peck) Hughes	+(2)
14	Phoma sp.	?(5)
15	Phialophora botulispora Cole & Kendrick	+(2)
16	Pachnocybe ferruginea (Sow: Fr.) Berk.	?(133)
17	Phialophora fastigiata)Lagerb. &Melin) Conant	+(26)
18	Phialophora mutabilus (Beyma) Schol-Schwarz	?(2)
19	Phialophora melinii (Nannf.) Conant	+(11)
20	Paecilomyces variotii Bainer	+(18)

Table 1 continued.

Taxon	Decay potential[a]
21 Rhizoctonia sp.	?(1)
22 Rhizoctonia solani Kuhn	?(1)[b]
23 Syringospora albicans (Robin) Berkhout	?(1)
24 Sterile White	?(1)
25 Thelephora sp.	+(1)
26 Thanatephorus cucumerus (Frank) Donk	?(1)
27 Trichoderma viride Pers. ex. Fr.	+(5)
28 Umbelopsis versiformis Amos & Barnett	?(1)
29 Scytalidium cirinatum Sigler and Wang	+(19)
30 Scytalidium lignicola Pesante	+(37)
31 Rhinocladiella atrovirens Nannf.	?(34)
32 Trametes sp.	+(7)
33 Phialophora olivacea W. Gams	?(3)
34 Geotrichum candidum Link	?(15)
35 Spegazzinia tessarthra (Berk. & Curt.) Sacc.	?(2)
36 Phialophora malorum (Kidd & Beaum.) McColloch	+(1)
37 Phialophora sp.	?(7)
38 Harpographium fasciculatum Sacc.	?(1)
39 Basidiomycete	+(101)
40 Penicillium sp.	?(4)
41 Hormoconis resinae (Lindau) v. Arx & de Vrie	-(5)
42 Gliocladium sp.	?(3)

Table 1 continued.

Taxon	Decay potential[a]
43 Bispora betulina (Corda) Hughes	+(1)
44 Eurotium sp.	?(2)[b]
45 Verticicladiella sp.	?(2)
46 Phlebia sp.	+(3)
47 Coniothyrium sp.	?(1)
48 Cladosporium sp.	?(3)
49 Cladosporium tenuissimum Cook	?(2)
50 Cladosporium chlorocephalum (Fresen.) Mason & M.B. Ellis	?(2)
51 Cladosporium cladosporioides (Fres.) de Vries	+(1)
52 Cladosporium sphaerospermum Penz.	+(1)
53 Fusarium acuminatum	?(9)
54 Mycelium nadicis atrovirens	?(4)
55 Aspergillus sp.	?(9)
56 Unidentified	?(2)

[a] + Known to cause decay, - Not known to cause decay, ? No information.

[b] Numbers in brackets represent the number of times the fungus was isolated.

Table 2. List of fungal taxa[a] from utility poles and the number of poles, (per species), from which each taxon was isolated.

Fungal[c] taxa	Number of poles per species[b]									
	Tot.	WRC	DF	JP	LPP	SYP	S	WL	RP	SP	AC
3	19	3	6	0	4	1	1	0	3	1	0
8	10	0	0	1	4	1	1	0	2	1	0
11	112	3	19	15	26	23	3	3	20	0	0
16	133	57	17	27	6	9	1	3	11	1	1
17	26	2	0	1	3	2	3	0	7	7	0
19	11	2	0	1	1	0	1	0	3	3	0
20	18	3	6	2	4	1	0	1	1	0	0
29	19	1	4	5	6	0	1	0	2	0	1
30	37	6	4	8	12	0	4	0	3	0	0
31	34	13	6	4	7	1	2	0	1	0	0
34	16	6	2	2	0	1	1	1	1	1	1
39	101	23	13	7	14	9	11	1	18	5	0

[a] Only fungi for which 10 or more isolates were obtained.
[b] WRC western red cedar; DF Douglas fir; JP jack pine; LPP lodge pole pine; SYP southern yellow pine; S spruce; WL western larch; RP red pine; SP scots pine; AC Alaska cedar.
[c] Taxa numbers relate to information found in Table 1.

Table 3. Poles from which Hyalodendron lignicola was isolated.

	Number of isolates					
Pole species	E1	E2	E3	E4	E5	Total
LPP(26)[a]	3	14	9	11	9	46
JP(15)	1	6	4	6	7	24
RP(20)	5	9	11	10	4	39
DF(19)	4	9	11	7	5	36
SYP(23)	10	17	14	12	9	62
WL(3)	0	3	3	3	1	10
Totals	23	58	52	49	35	217

[a] Number of poles.

Table 4. Decay ratings of core segments from all tree species.

	Number of cores		
Decay rating[a]	E1	E3	E5
A,B	307	329	588
C	339	309	82
D,E	60	62	25

[a] A,B = Decay free; C = Decay; D,E = Severe Decay.

Table 5. Number of poles of each species in which there was no detectable decay in the core segments examined.

Pole species	Number of poles decay free	Percent decay free by species
WRC	15	7
JP	45	46
LPP	50	51
RP	44	40
DF	17	26
S	10	17
SYP	28	72
WL	1	20

Table 6. Poles which were decayed but had no fungi isolated from them.

Pole species	Number of poles	Percent species
WRC	39	20
S	1	2
RP	2	2
DF	2	3
JP	1	1
LPP	1	1