COLONISATION OF *PINUS RADIATA* THINNING STUMPS BY *ARMILLARIA* AND OTHER BASIDIOMYCETES FOLLOWING TREATMENT WITH *ARMILLARIA* BASIDIOSPORES

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Abstract

Stumps of thinned trees and partly buried stem segments were treated with basidiospores of two *Armillaria* species, to test the possibility that colonisation of woody material by basidiospores serves to spread *Armillaria* species into *Pinus radiata* plantations in New Zealand. Spore colonisation was confirmed for segments and demonstrated for the first time on freshly cut pine stumps. Effective invasion occurred at high spore concentrations and was apparent from 6 months after felling. Other basidiomycetes were first isolated from stumps at 6 months and were consistently cultured between 1 and 3 years following felling, after which yields became irregular due to stump deterioration and increasing contamination. Certain basidiomycetes were isolated regularly whereas many others were cultured only infrequently. A culture bank was established of basidiomycetes to be tested as candidates for potential biological control of *A. novae-zelandiae* in pine stumps.

Introduction

It is important to know whether *Armillaria novae-zelandiae* (Stevenson) Herink is spreading into stands of *Pinus radiata* D. Don by means of basidiospores dispersed from fruitbodies in nearby indigenous forests in New Zealand. The formation of new, spore-derived colonies is inferred from the high densities of *A. novae-zelandiae* genets in second rotation plantations on sites not originally stocked in native forest. However, direct supporting evidence consists so far only of the demonstrated colonisation of freshly cut partly buried pine billets employed as spore traps (Hood *et al*., 2002). Four field studies were conducted to investigate the capacity for stumps and billets of different ages to become colonised in young, non-commercially-thinned pine stands after treatment with aqueous suspensions of freshly collected *Armillaria* basidiospores during the fruiting season. Stumps and billets were extracted and examined for colonisation by *Armillaria*.

The decomposition of radiata pine thinning stumps has not been systematically researched in New Zealand. The spore treatment studies therefore provided opportunity for a preliminary investigation of the natural basidiomycete populations and associated insects active during stump breakdown. Uplifted stumps were split, isolations attempted, and the cultures obtained described and identified where possible. The divided stumps were also examined for indications of interaction between *Armillaria* and naturally occurring basidiomycetes. Knowledge of stump ecology, and the recognition of species with potential to restrict spore colonisation or mycelial invasion, may assist in the development of a biocontrol method against *Armillaria*.

Materials and methods

The four studies were conducted at six sites, each up to 70 m across, within an area spanning 65 km in the Rotorua district in the North Island. Treatment details are given in Table 1. Studies 1 and 2 involved four young recently thinned second-rotation *Pinus radiata* stands situated up to 19 km apart in Kaingaroa Forest (Sites 1-4). Study 3 was in a first rotation rural stand on a pasture site at Hamurana that had remained free of trees for many decades (Site 5). Study 4, which investigated the effect of spore concentration, was established on a level, tree-free grass lawn at an urban location in Rotorua (Site 6). Bark-encased billets 70 cm long cut from nearby thinnings (ie. from material of the same age as the stumps), were partly buried vertically among selected stumps at Sites 3, 4, and 5. They were protected from *Armillaria* soil rhizomorphs by a cylindrical, earth-filled, plastic shield extending 8-10 cm below the billet (Hood *et al*., 2002). Each billet at Site 5 was cut from the same tree as the stump with which it was paired, after felling on the day of treatment. At Site 6, smaller billets (ca. 6 cm diameter × 35 cm long), were partly buried vertically, 1 m apart, with 5 cm length exposed above soil level, in two lines. Soil was free of woody material, so these billets were not enclosed in protective shields.

Treatments were assigned at random to stumps and billets at all sites. Inoculum was prepared from basidiospores deposited onto plastic sheets in the laboratory from fructifications of *Armillaria novae-zelandiae* or *A. limonea* (Stevenson) Boesewinkel freshly collected in a neighbouring indigenous podocarp-hardwood forest. Spore powders were stored in clean dry stoppered vials at 4°C, until suspended in distilled water in the field at the time of application within 16 days of collection. A measured quantity of inoculum was applied entire or in portions across the stump or billet surface, allowing time for absorption of the fluid between applications. At most sites (Table 1) an end disc was cut from the top of each stump or billet, immediately prior to treatment, and at Sites 1 and 5 some inoculum was also applied to the lower disc surface, before replacing it. Discs were also cut and replaced on untreated control billets at Site 5 (but were not cut on control stumps at Site 1), and on all billets at Site 6, replacing them on half of the latter, only. Dosages were estimated from haemocytometer counts of residual inoculum under a microscope (Table 1). Weather remained dry for several days after treatment at Site 5, moist at Sites 1, 3 and 4, and heavy rain fell during the inoculations at Site 2. A plastic tarpaulin protected billets from light rain during the first 43 hours at Site 6, and for the remainder of this study a shade-cloth cover simulated the lighting within young plantations.

Table 1: Details of four studies treating the cut surface of billets and stumps of *Pinus radiata* with aqueous basidiospore suspensions of *Armillaria* species

Study	Site (*Pinus radiata* plantation or grassed lawn)		Period since felling when treated	Date treated	No. stumps and spore treatment[1]	No. billets and spore treatment[1]	Stump/ billet mean diam. (cut surface) and stand. devn. (cm)	Cap disc cut and replaced on treated surface	Estimated spore No./cm^2 stump/ billet surface
1	1	6 yr. old 2nd rotation	2-3 wks.	3 June 2000	10 Anz 5 Alim 10 control	-	13 ± 2	yes (no, control)	2×10^6 [2]
	2	6 yr. old 2nd rotation	5 mths.	,,	9 Anz 10 control	-	16.5 ± 2.5	no	1×10^6
2	3	5 yr. old 2nd rotation	2 wks.	18 May 2001	3 Anz	3 Anz	range: 16-21 (stump) 13-17 (billet)	yes	2×10^6
	4	6 yr. old 2nd rotation	6 mths.	,,	3 Anz	3 Anz		yes	2.5×10^6
3	5	6 yr. old 1st rotation established on pasture	4 hours	15 May 2002	7 Anz 3 control	7 Anz 3 control	13.9 ± 1.6 (stump) 13.5 ± 1.5 (billet)	yes	13×10^6 [3]
4[4]	6	Open lawn	2-3 wks.	4 June 2003	-	32 Anz	ca. 6 cm	yes/ no (50:50)	23×10^6 2×10^6 5, 000 100

[1]Anz, *Armillaria novae-zelandiae*; Alim, *A. limonea*; control, no treatment
[2]Plus 1.5×10^6/cm^2 to lower disc surface
[3]Plus 5×10^6/cm^2 to lower disc surface
[4]Study 4 design: 2 surfaces (capped or not) × 4 spore concentrations × 4 replicates = 32 billets

Treatment and control stumps and billets were extracted randomly in sets at intervals between 28 and 40 weeks after treatment at Sites 3-6, and between 15 and 174 weeks (17-197 weeks after felling) at Sites 1 and 2. Stumps and billets were washed and examined for signs of *Armillaria* (attached rhizomorphs and mycelial fans beneath bark). In Study 4, comparisons were made among treatments (capped or not, and between basidiospore concentrations). Stumps from Sites 1, 2, and 5 were split longitudinally. Isolations were attempted from usually two or three points well distributed across the exposed cut surface (representing different types of decay, if apparent). Isolations were also attempted from some cap discs. Small chips, ca. 1mm diameter (10 per isolation point), were plated aseptically onto 3% malt agar supplemented with 100 ppm streptomycin sulphate and 10 ppm benomyl. Basidiomycete cultures obtained were subcultured, described, and identified where possible using the approach of Nobles (1965), Stalpers (1978), and Nakasone (1990), as adapted by Hood *et al*. (1989). Several *Armillaria* cultures were identified to species or

intersterility group (genet) using methods outlined in Hood and Sandberg (1987). Wood boring insects were also recorded. Data were examined in order to categorize species commonly emerging from pine stumps, and to identify possible trends with time.

Results

Armillaria *basidiospore treatments*

Armillaria was found on treated billets and both treated and untreated stumps at three of the second-rotation sites in Studies 1 and 2. *Armillaria* colonised 8 of 9 treated stumps and 7 of 10 control stumps at Site 2, but only three of 25 stumps at Site 1 (one of each treatment and a control stump). At Site 1, cultures of *A. novae-zelandiae*, only, were isolated from decayed wood in the control stump and one treated with *A. limonea*, and from the cap of a stump treated with *A. novae-zelandiae*. Similarly, where isolations were attempted at Site 2, only *A. novae-zelandiae* was isolated from decayed wood or rhizomorphs from five stumps treated with *A. novae-zelandiae*, and from two control stumps. Four genets of this species were identified at this site, in each of one, one, two adjacent, and three adjacent stumps, respectively. In Study 2, 2 of 3 stumps and all of 3 billets were colonised by *Armillaria* at Site 3, but no stumps or billets were so colonised at Site 4. In one of the stumps at Site 3, fresh rhizomorphs were prolific between the cap and the stump surface, and subcortical mycelial fans extended downwards from this point. Nevertheless, although colonisation by *A. novae-zelandiae* spores was confirmed in three billets, these studies did not convincingly verify basidiospore colonisation of stumps by *Armillaria*.

However, at the first rotation pasture site (Site 5), 5 of 7 (71%) billets and 2 of 7 (29%) stumps treated with basidiospores of *A. novae-zelandiae* were colonised by *Armillaria* when harvested. Cultural testing confirmed that isolates obtained from all 7 billets and stumps were of *A. novae-zelandiae*. Mycelial fans of *Armillaria* were extensive beneath the bark, and clearly descending from the cut surface in some billets and both stumps. *Armillaria* was not present in any of the untreated stump or billet controls. This was therefore the first confirmed proof that freshly cut stumps of *Pinus radiata* can be colonised by basidiospores of *A. novae-zelandiae*, at high concentrations, and when covered by a disc cap at the inoculated surface.

Results from the spore dilution study (Site 6) are shown in Table 2. Six of 16 billets (38%) were colonised by *Armillaria* after the application of spores at densities equal to or greater than 2 million/cm^2 billet surface, but none were colonised at concentrations of 5,000/cm^2 or less (difference significant, $p<0.05$, Fisher's exact test). There was no indication that the absence of a protective cap led to a reduced level of colonisation, when placed under shade cloth ($p>0.05$).

Table 2: No. billets out of 4 colonised by *Armillaria* after treatment of the freshly cut surface with different concentrations of *Armillaria novae-zelandiae* basidiospores and replacing or not the detached billet cap

Basidiospore concentration[1]	Cap replaced	Cap not replaced
23 million	2	2
2 million	0	2
5,000	0	0
100	0	0

[1]Approximate No. basidiospores per cm^2 billet surface

Stump deterioration and associated insect and fungal activity

Roots appeared sound 17–34 weeks after felling, and stumps were solid and difficult to extract and split longitudinally, but wood was often discolored or yellowed and in places darkly stained internally. Bark was initially firmly attached, but the proportion of easily dislodged bark rose in successive stump samples as bark beetle activity intensified (increasing levels of frass, and of numbers of galleries and exit holes through bark). Roots were noticeably easier to cut 38 and 43 weeks after felling, but stumps were still firm and extracted with effort. Interiors were now softer with visible signs of decay, and insect activity was widespread beneath the readily detached bark. In stumps colonised by *Armillaria novae-zelandiae*, mycelial fans were extensive beneath the bark by 28 weeks after cutting. Zones of a characteristic yellowish decay accompanied by externally attached rhizomorphs were evident from 38 weeks, both of which yielded cultures of this species. Rhizomes of the native orchid, *Gastrodia cunninghamii* Hook. f., were present

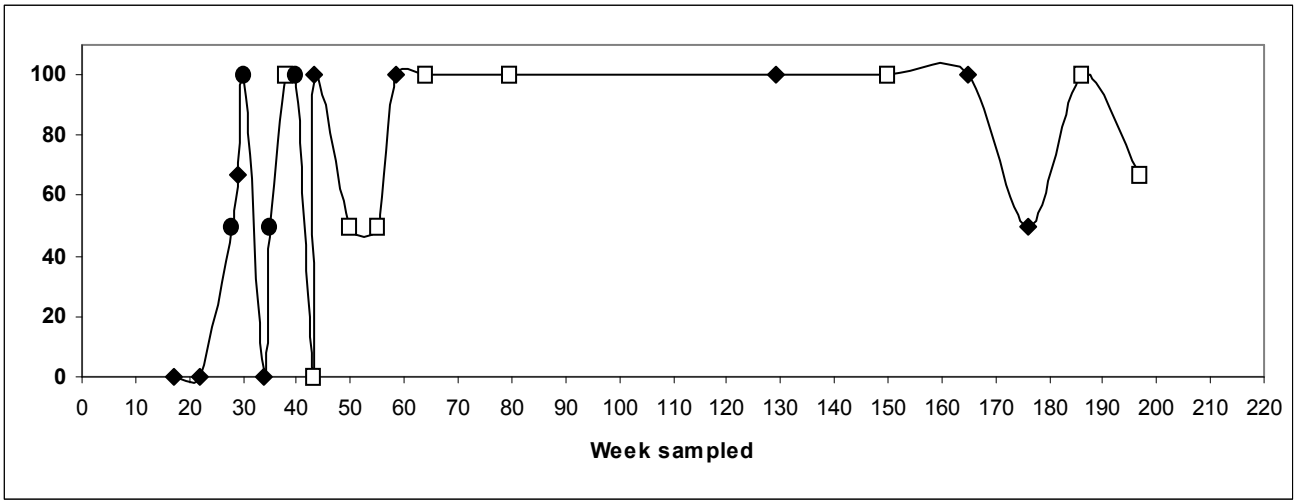
among some stump roots, but were not seen to interact with *Armillaria* rhizomorphs and did not yield cultures of *Armillaria*. Bark beetles sampled over the first summer comprised adults of *Hylurgus ligniperda* (Fabricius) and larvae, pupae, and adults of *Hylastes ater* (Paykull), but numbers were noticeably reduced by January. Frass and old workings remained visible beneath the loose bark in most stumps sampled right to the end of the study period. Small larvae of the native huhu beetle (*Prionoplus reticularis* White) were first recorded within stumps at 38 weeks.

Stumps continued to deteriorate at both sites during the period 50-150 weeks after felling, and towards the end of this phase were easily extracted and readily split. Cerambycids, particularly *Prionoplus reticularis*, were active within stumps throughout this period. Other insects inhabiting the decomposed wood included larvae of click beetles (Elateridae) and stag beetles (Lucanidae). Mycelial fans were not now apparent in stumps colonised by *Armillaria*, except as impressions beneath bark contaminated by frass, possibly as a result of insect feeding, but rhizomorphs were plentiful. White, branching mycelial cords of other basidiomycetes, first seen 17 weeks after felling, were regularly present on external stump surfaces beneath the bark throughout the monitoring period. These belonged to species that included *Phlebiopsis gigantea* (Fries) Jülich, *Resinicium bicolor* (Albertini & von Schweinitz: Fries) Parmasto, and *Hypholoma fasciculare* (Fries) Kummer. After 150 weeks, stumps could be levered out with one thrust of a spade and fragmented manually. Parts were now penetrated by grass roots, and internally there were few zones free from the frass of tunneling cermbycid larvae. An *Arhopalus ferus* (Mulsant) larva was collected from decayed wood in one stump after 186 weeks.

Fungi other than Armillaria

Basidiomycetes were first isolated from stump wood 28 weeks after felling (Fig. 1). Yields increased, and basidiomycetes were regularly cultured from all stumps sampled 59-165 weeks after felling. Subsequent isolations were attempted from disintegrating crumbly wood contaminated by the frass of tunneling larvae, and yields of basidiomycetes became erratic. Basidiomycete species isolated from more than one stump are listed in Appendix 1, giving culture descriptions, codes, sites, frequencies and periods of isolation. There appeared to be successional trends. *Phlebiopsis gigantea*, the most frequently cultured species apart from *Armillaria novae-zelandiae*, was isolated up until 64 weeks after felling, whereas *Hypholoma fasciculare* was obtained mainly after 2½ years from cutting. Other basidiomycetes isolated from more than one stump at often more than one site were *Sistotrema brinkmannii* (Bresadola) Eriksson, *Resinicium bicolor*, and Species O, B, I, DD, Z, HH and BB. Another 18 species recognised as basidiomycetes were each isolated from only one stump. Fruiting was infrequent on decaying pine stumps, but basidiocarps of *Schizophyllum commune* Fries were present on two 5-month old stumps at the time of treatment, and of *H. fasciculare* after 3½ years.

Figure 1: Percentages of 2-4 stumps yielding cultures of basidiomycetes by period after felling at three sites (Site 1, diamonds; Site 2, squares; Site 5, circles)[1]



[1]Since isolation of *Armillaria* from wood was always accompanied by isolation of other basidiomycetes from elsewhere within the same stump, the graph remains unchanged whether or not *Armillaria* is included.

In 14 stumps the same basidiomycete species were cultured from more than one location within each stump (from 2-3 of 3 locations per stump), indicating they had invaded and occupied significant proportions of the stump volume. Species behaving in this way comprised *Armillaria novae-zelandiae*, *Phlebiopsis gigantea*, *Sistotrema brinkmannii*, *Resinicium bicolor*, *Hypholoma fasciculare*, and Species O, Z, HH, BB, and W. In one stump a single genet of *A. novae-zelandiae* was isolated from two locations internally, and from an attached rhizomorph externally. On the other hand, more than one basidiomycete species was isolated from different locations within each of 11 stumps. Pseudosclerotial plates (visible as black zone lines) were seen only in association with wood decayed by *A. novae-zelandiae*, indicating (in part) a barrier of confrontation between this and adjacent species. Basidiomycetes within stump wood also colonised by *A. novae-zelandiae* included *P. gigantea*, *S. brinkmannii*, and Species HH.

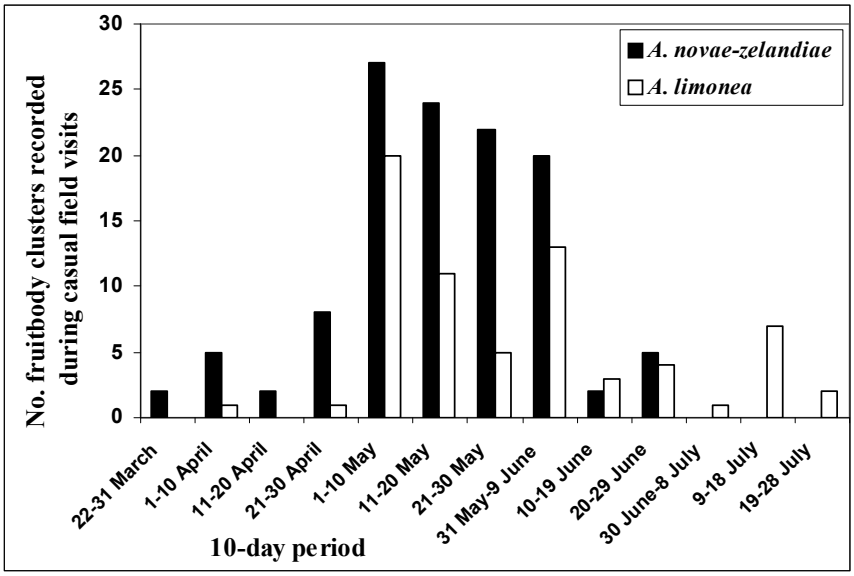
Hyphomycetes, eg. species of *Leptographium*, were isolated during the course of the studies, but were not investigated further, and bacteria and filamentous yeasts were largely ignored. In all billet studies, it was common to find circular colonies ca. 1 cm diameter scattered beneath the bark across an otherwise clean white cambial surface, composed of tiny dichotomously branched mycelial ribbons a few millimetres wide radiating out spoke-like from a central point. Such colonies were present in 90% of billets at Site 5 and 47% at Site 6, but on no stumps. Ribbons were composed of septate, clampless hyphae, and yielded isolates on 3% malt agar only when devoid of benomyl and streptomycin sulphate. Cultures after 6 weeks on plates of 3% malt agar produced low, white, silky, prostrate aerial mycelia in a pattern of radial, dichotomously branching, diffuse arms (culture code: 2/(1), 6, 7, 32, 36, 38/(39,40), 42/43/44(/45), 55). Older cultures appeared as a low, white mat, sometimes forming a blackish central zone of brown hyphae or spherical black nodes 50-120 μm diameter with a dark narrow wall of brown interlocking plectenchyma at the colony margin. Radiating ribbon colonies were reproduced after 18 weeks beneath the bark of freshly cut *Pinus radiata* branch segments inoculated with agar cultures in jars of moist sand sealed with "Gladwrap"™ film, yielding the same cultures on re-isolation. Ascocarps of a species of *Rosellinia* were present in one culture after 22 weeks, and were also found on the bark surface directly above typical radiating ribbon colonies in five billets in Study 4. Polyspore cultures (NZFS 1548-1551) isolated from a black spore mass capping the ostioles of the latter (NZFRI(M)5139) were indistinguishable from those isolated from the mycelial ribbon colonies. This *Rosellinia* species was characterised by a black, even, persistent subiculum, and sub-globose, papillate, carbonaceous stromata (deep red-brown when immature), each about 1 mm diameter, mostly separate in dense clusters, but some fused. The apical ascus ring blued in iodine, and measured 10 μm long × 6.5 μm wide. Ascospores, with a straight germ slit nearly the full spore length, were variable in shape and size within and between collections from four billets. Ascospore apices were blunt or with a tapering, pointed "beak" at each end, both extremities capped by a narrow, pointed, hyaline appendage up to 7 μm long (ascospores, excluding the hyaline appendage, 22-38 μm × 7-10.5 μm, mostly < 30 μm long). Ascospores produced in culture were also beaked at each end (each projection also with a hyaline appendage) and with a straight, nearly-spore-length germ slit, but were slightly shorter (20-26 μm).

Discussion

These studies confirmed the ability of basidiospores of *Armillaria novae-zelandiae* to colonise fresh, partly buried stem segments of *Pinus radiata*, and demonstrated for the first time that newly cut pine stumps can be colonised in the same way. The results of Study 4 suggest that colonisation may occur only when spore concentrations are high. If confirmed, this raises the question as to how genets of *A. novae-zelandiae* occur in high densities in pine plantations. Do basidiospores persist in discrete clouds within atmospheric temperature inversions when dispersed during winter (Fig.2)? Do they gradually accumulate in viable form on woody material over time (Shaw 1981)? Additional aspects also influenced colonisation, since billets and stumps were invaded more frequently at some sites. Possible factors include stump age and variable exposure to sunlight, wind or rain (Rishbeth, 1970). Successful spore colonisation was confirmed only when stumps or billets were comparatively fresh. Direct exposure (ie. unprotected by a cap disc) does not appear inhibitory in a shaded environment under central North Island conditions (Study 4). Studies 3 and 4 were undertaken on ex-pasture or lawn sites, because Studies 1 and 2 were clearly compromised with respect to stumps by pre-existing *Armillaria* inoculum.

Although there have been ecological studies of conifer stumps in Northern Hemisphere forests (eg. Käärik and Rennerfelt, 1957; Capretti and Mugnai, 1985; Ohga, 1998; Varese *et al*., 2003; Woodward, 2003; Murray and Woodward, 2003), none appear to have been undertaken in New Zealand pine plantations. In these studies several basidiomycete species were common, while others were encountered only occasionally. Frequently cultured were *Phlebiopsis gigantea*, *Sistotrema brinkmannii*, and *Resinicium bicolor*, known early invaders of freshly cut *Pinus radiata* (Cunningham, 1959; Butcher, 1967, 1968; Hood *et al*., 2002). *Hypholoma fasciculare* fruited on, and was isolated mostly from well-decayed stumps. Three of these species produced cords beneath the loosened bark. It was found that the tiny colonies of radiating, mycelial ribbons commonly seen under the bark of many pine billets, but not stumps, belonged to a species of *Rosellinia*, tentatively identified as *R. thelena* (Fries: Fries) Rabenhorst. It has yet to be resolved if it is the same *Rosellinia* species that causes a root disease of a number of hosts in New Zealand, including young *P. radiata*, producing identical radiating, ribbon-like colonies beneath the bark of attacked plants. Rhizomes of the native orchid *Gastrodia cunninghamii* were found associated with some stumps, and are common in Kaingaroa Forest, sometimes in large quantities, among roots of pines infected by *A. novae-zelandiae*. *Armillaria* rhizomorphs occasionally ramify across the surface of orchid rhizomes (*personal observation*), but mycorrhizal infection as reported in *Nothofagus* forest in the South Island (Campbell, 1962) has not been confirmed. It therefore remains to be determined if the distribution of the orchid in pine stands is related to the occurrence of *A. novae-zelandiae*.

Figure 2: *Armillaria* fruiting in the central North Island, NZ (1979-2004)



The basidiospore spread of *Armillaria novae-zelandiae* into *Pinus radiata* stands implied by the observed high genet densities has not yet been verified by direct means, but these studies do provide supporting evidence. There is a need to confirm whether or not colonisation of billets and stumps requires high basidiospore concentrations, and to determine the patterns of airborne spore dispersal during the fruiting season. In the meantime, representative basidiomycete cultures obtained from pine stumps have been stocked, and will be used for in vitro testing of activity against *Armillaria* cultures, for potential use as biocontrol agents in stumps.

Summary

Partially buried stem segments of *Pinus radiata* and stumps created during stand thinning were treated with aqueous basidiospore suspensions of *Armillaria novae-zelandiae* and *A. limonea* in order to test the premise that airborne spores may initiate new infection centres in pine plantations. The ecology of stump decomposition was also investigated by periodically excavating and isolating for *Armillaria* spp. and other basidiomycetes. Colonisation by *A. novae-zelandiae* basidiospores was confirmed for segments and demonstrated for the first time for freshly cut pine thinning stumps. Successful invasion occurred at high spore densities. Basidiomycete species frequently cultured from within thinning stumps included *Phlebiopsis gigantea*, *Sistotrema brinkmannii*, *Resinicium bicolor*, and from older, more decayed stumps, *Hypholoma*

fasciculare. A species of *Rosellinia* regularly formed mycelial colonies beneath the bark of fresh stem segments but not stumps. Rhizomes of the native orchid *Gastrodia cunninghamii* were commonly encountered among the roots of stumps and living pine trees, but it is not known if its presence is influenced by mycorrhizal association with *A. novae-zelandiae*. It is now necessary to ascertain patterns of airborne *Armillaria* basidiospore dispersal. A culture bank has been established of stump basidiospore isolates for screening as potential biocontrol agents against *Armillaria*.

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Appendix 1: Basidiomycetes (except *Armillaria*) cultured from within *Pinus radiata* thinning stumps at three sites, ranked by frequency of yield then period isolated[1].

Name (if identified) or species code	Site No.	From (No. stumps)	Weeks after felling	Culture code[2]	Culture appearance	Comment
Phlebiopsis gigantea	1,2,5	9	30-64	2,5,(11),12,13,14,(35), 36,(38)/40,41/42,(48),55	Low, whispy, white, translucent mat (occasional pinkish cushion-like fertile fructifications at plate edge). White plumose cords on wood.	For some stumps, also ex sawn disc cap. Thick-walled lamprocystidia, encrusted hyphal warts, single, double clamps on some septa, oidia.
Sistotrema brinkmannii	1,2,5	6	30-186	1,3,26,32,36,38/(39), 41/42/(44),(53),55	Low, sub-felty, translucent mat; sometimes buff-coloured woolly tufts or bands in concentric rings. Same species from sapwood of fallen podocarps.	For one stump, ex sawn cap. Characteristic chains of clamped hyphal swellings and occasional up to 8-sterigmate basidia.
Resinicium bicolor	1,2	6	43-165	2,3,13,(16),(26),32,36,(38)/40, 42/43/44,55	Low, white, thin, even, whispy or felty mat, slightly floccose in places (eg. in radial lines), or with concentric woolly bands; sometimes with delicate white plumose cords in culture. Mostly bleached beneath.	For one stump, ex feathery cord. With asterocystidia and sometimes capitate cystidia, and rounded hyphal swellings. *R. bicolor* cords observed on stumps, Sites 2, 3, at 39, 43 weeks.
Hypholoma fasciculare	1,2	6	(17-)129-197	2,3,(11),32,36/(37), (38)/39/40, (42)/43/44,55 and 2,6,(11),32,36,40,44/45,55	Low, white or creamish, cottony, woolly or felty mat, sometimes with concentric bands, and radiate-silky or with radiating tufts of prostrate aerial hyphae, often with orange floccose patches, pads or streaks among aerial mycelium to varying degrees; orange zones beneath.	For some stumps ex cords, basidiocarp (17 wk. isolation ex white whispy mycelium under bark). Cultures macroscopically variable, and all with distinctive bundles of needle-like crystals under microscope. Two forms, with and without clamps (both, ex basidiocarp).
I	2	4	43-80	1,6,26,34,36,39,41,55	Limited whispy white aerial hyphae. Agar darkening. Laccase negative.	No clamps, characteristic rounded hyphal swellings. Intercalary, terminal chlamydospores.
O	1	3	29-59	2,3/4,26,32,36/37,38/39,42,55	Low, radiate-silky, felty white or buff (to orange) mat. Yellow-orange flecks, margin.	Chains of *Sistotrema brinkmannii*-like hyphal swellings, but laccase +ve, appearance differs.
B	2,5	3	30-38	1,3,7,32,36,39,41,55	White or pale yellowish cottony mat, with erect tufts or broad, rounded pads. Orange-brown beneath.	Laccase negative, with distinctive culture morphology.
DD *Phanerochaete* sp.?[3]	5	2	40	2,5,(11),32,37,39,42,55	(Purplish-) brown felty mat, with white floccose tufts at plate margin (or occasionally in concentric rings).	Multiple clamps present, agar darkening (culture differs in appearance from EE).
Z *Steccherinum* sp.?, *Trametes* sp.?, *Irpex* sp.?[4]	1	2	129-165	2,3,8,32,36,40,42,55	White, even, whispy or cottony mat, sometimes with faint concentric bands, and yellow flecks at plate edge.	Branched skeletals in culture.
HH	1,2	2	129-197	2,3,(16),(26),32,36,40,43/45,55	Low, white, radiate-silky mat, or with zones of faintly yellowish, woolly aerial hyphae, with vague concentric bands. Producing tiny white cords.	For one stump, ex sawn cap, only. Producing cords in culture
BB	2	2	150-186	1,6,7,32,36,38,42/43,(48),55	Translucent, no aerial hyphae. White or cream, hydnoid, *Hericium*-like basidiocarp in culture.	Clamps absent, basidiospores amyloid, 4.5-5 × 2.5-3µm.
Y *Stereum* sp.?, *Phanerochaete* sp.?[3]	5	1	30	1,5,7,32,36/(37),39,42,55	Low, white, felty mat with white floccose zones.	Multiple clamps. Resembles 'EE', but laccase negative.
EE *Stereum* sp.[3]	5	1	40	2,5,(11),(12),32,36,39/40,42,55	White felty mat, with pale yellow or apricot floccose or crust areas.	Also ex superficial mycelium. Multiple clamps.
W	1	1	59	2,6,7,32,36,38,42/43,55	Radiate, translucent colony, almost totally submerged.	Clamps absent, laccase positive.

[1]From decayed wood within stump unless otherwise stated; includes all species obtained from more than one stump, and those only from one stump referred to in text.
[2]Nobles (1965); except 41-47 indicate period to cover a 9 cm plate from **centrally** placed inoculum (ie. 41, 42, 43, 44-47 approx. equiv. to 42, 44, 46, 47, resp., of Nobles; 1,2 = laccase negative, positive, resp.; Stalpers, 1978).
[3]Recorded fruiting on New Zealand *Pinus radiata*, cultures with multiple clamps: *Phanerochaete crassa* (Lév.) Burdsall; *Stereum sanguinolentum* (Alb. & Schw.: Fr.) Fr. (cultures white or yellowish, laccase response variable, may lack conducting hyphae); *S. hirsutum* (Willd.) Pers. (but cultures often with skeletals); *Dextrinocystidium sacratum* (G.H. Cunn.) S.H. Wu (but cultures white, only, laccase +ve); *Coniophora* spp. (but cultures with oidia).
[4]Recorded fruiting on New Zealand *Pinus radiata*: *Irpex brevis* Berk., *Steccherinum ochraceum* (Pers.) S.F. Gray, *Trametes hirsuta* (Wulfen: Fr.) Pilát; *T. versicolor* (L.: Fr.) Pilát. Herbaria NZFRI (M), PDD.