# BLUESTAIN IN HOOP PINE LOGS.

By H. E. YOUNG, D.Sc.Agr., Pathologist, Science Branch, Division of Plant Industry.

## SUMMARY.

*An account is given of a series of experiments in connexion with the development of bluestain in hoop pine logs. A number of anti-stain treatments are described and the results summarized. It was shown that a commercial ethyl mercury chloride preparation is superior to the other mixtures used in the experiment.*

*It was further demonstrated that logs left in the rain-forest with the bark on and the ends protected remained in perfect condition.*

## INTRODUCTION.

Summer losses of hoop pine (*Araucaria cunninghamii*) timber in Queensland due to degrade on account of bluestain were sufficiently great to warrant experiments aimed at finding some means of preventing or at least minimizing these losses and also at acquiring a closer knowledge of the conditions necessary for the development of bluestain.

With these ends in view a series of experiments was designed in co-operation with forestry officers and carried out under normal logging conditions. The work was located at Imbil in the Mary Valley in southern Queensland because of the heavy incidence of bluestain in that locality and because a sawmiller at Imbil was prepared to provide milling facilities for the logs involved in the experiments.

The initial experiments were designed to provide information on the following points:—

(1). The period required for the development of bluestain under field conditions; the site at which infection is most likely to occur (for example, at the tree stump in the rain-forest, at the scrub loading ramps on the rain-forest edge, or in the open); and the effect of position of the logs at the ramps (that is, whether they were on the ground or on skids) on bluestain incidence.

(2). Whether direct contact at the scrub ramps of a clean log with a log affected with bluestain increases the possibility and degree of infection of the clean log.

(3). The value of certain chemical and physical treatments which, while cheap in initial cost and application, were considered likely to prevent or check the development of bluestain.

When the initial experiments revealed that a commercial mercurial fungicide was a promising control agent, a further series of trials was conducted with this material.

The maximum time for which logs are left in the rain-forest or at the scrub ramps because of delays in haulage occasioned by wet weather is about five weeks. The experiments were designed to cover a period of eight weeks from the initiation of each experiment. This gave a wide margin and made it more likely that the logs would experience weather conditions suitable for the development of bluestain. Because weather conditions cannot be foretold accurately it was decided to commence the experiments regardless of the weather obtaining at the time, and if the appropriate conditions conducive to bluestaining, as evidenced by the control logs, did not appear within 14 days, then the experiment was to be repeated.

## INITIAL SERIES OF EXPERIMENTS.

### Experimental Procedure.

For the purpose of the experiment freshly felled hoop pine logs were essential. "Special" quality logs were not used on account of their high value, nor were "tops" because of the complications involved in making observations, due to the previous entry of bluestaining organisms through old branch stubs and knots. Because of the difficulty of obtaining sufficient "B" class logs concentrated in the one area it was decided that both "A" and "B" class logs should be included in the experiment. The use of short log lengths—for example, three feet—would allow for more replications, but stains penetrating from each end might meet and make any observations of side penetration useless. Also, the high value of full length timber would be lost. Accordingly full-sized logs were employed. The logs varied in length from 16 feet to 29 feet with an average length of 23 feet and an average centre girth of 58 inches. These logs were utilized for normal milling purposes on the completion of the experiment.

With the object of gaining a measure of the penetration of the bluestain, the logs when milled were sawn longitudinally down the centre, the cut being made in the vertical plane in relation to the position of each log during the experiment. The edges of the cut surfaces were then smoothed with a hand plane (see Plate 1) in order that the staining might be more easily seen. The depth of stain penetration was measured at intervals of one foot along the length of the log on both top and bottom sides; all measurements were commenced from the butt end. Owing to inaccuracies introduced by end penetration separate figures were taken out for two feet at each extremity of the log; this left the remaining data for the bulk of the log to give an accurate representation of the side penetration of the log by the stain.

Means were taken out for each individual log for the maximum penetration along the top and bottom surfaces of the length of the log and for the two ends, thus enabling a comparison to be made. The means for all the logs with the same treatments were then assessed. Measurements were made to one-tenth of an inch; the first one-tenth from the outside was disregarded as being liable to confusion with discolouration due to weathering. For the purpose of easy reference all measurements for each log were then averaged and a figure obtained indicative of the relative staining of each log. In practice this figure was found to be well correlated with the detailed figures for each log.

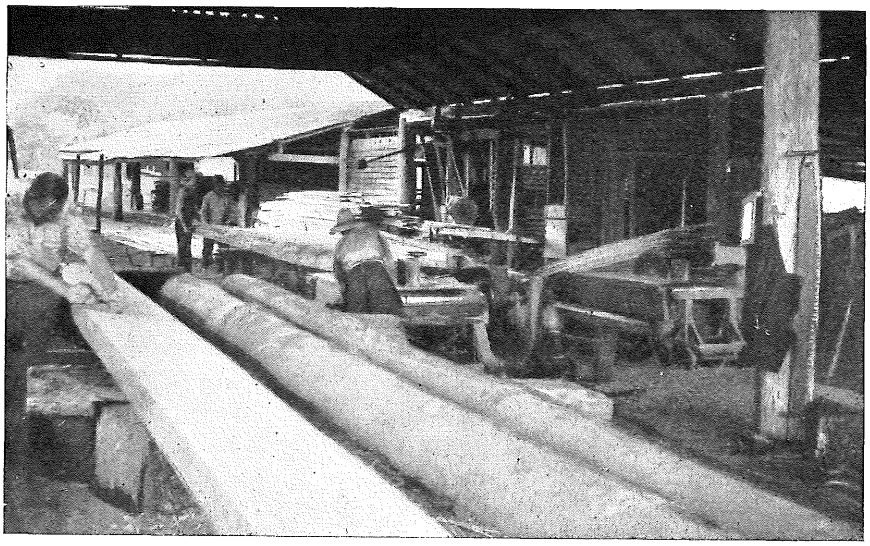

Plate 1.

PLANING SURFACE OF FLITCH OF AN EXPERIMENTAL HOOP PINE LOG AT THE SAWMILL IN ORDER TO MEASURE BLUESTAIN PENETRATION.

The weather conditions obtaining during the experiment are detailed in an appendix.

### Period and Amount of Bluestain Development in the Rain-forest.

For this experiment 22 logs were available. These were barked and left lying in the rain-forest at the stump where they fell. They were milled after various predetermined periods as shown in Table 1. The logs were cut as described and the amount of stain penetration measured.

**Table 1.**

STAIN PENETRATION IN LOGS AT THE STUMP AT WEEKLY INTERVALS AFTER FELLING.

| No. of Logs. | Weeks from Felling to Milling. | Mean Depth of Stain Penetration (Inches). | | | | | | Overall Mean. |
|---|---|---|---|---|---|---|---|---|
| | | Under Surface. | Upper Surface. | Butt Under. | Butt Upper. | Top Under. | Top Upper. | |
| 1 | 2 | 0 | 0 | 0 | 1·0 | 1·2 | 0 | 0·36 |
| 2 | 3 | 0 | 0 | 0·4 | 0·9 | 0·4 | 0·6 | 0·38 |
| 3 | 4 | 0·2 | 0·5 | 0·7 | 1·0 | 0·9 | 0·9 | 0·7 |
| 4 | 5 | 0·2 | 0·3 | 2·0 | 1·2 | 0·4 | 1·7 | 0·96 |
| 4 | 6 | 0·3 | 0·6 | 0·6 | 0·8 | 0·4 | 0·7 | 0·6 |
| 4 | 7 | 0·5 | 0·6 | 1·8 | 1·5 | 1·8 | 1·8 | 1·3 |
| 4 | 8 | 0·7 | 0·9 | 3·1 | 3·2 | 1·3 | 0·8 | 1·6 |

From Table 1 it is seen that under the conditions obtaining during the experiment staining does not reach serious proportions in logs left lying in the rain-forest until the fourth week, when penetration from the sides along the length of the log becomes evident. This is probably due to the slow drying of the logs under the humid shaded rain-forest conditions, where wood remains at a high moisture content for a long time and does not permit the growth of aerobic organisms until a considerable period has elapsed.

End penetration commenced more rapidly owing to the faster drying out of the ends in relation to the sides; and the penetration was deeper because the fungi concerned, not being cellulose destroyers, find it easier to follow the course of the vessels than to cross them. The upper sides of the logs tended to stain more than the lower, though the difference was small. There was no staining difference between butt and top ends of the log. At the time of milling the ends of all the logs except those exposed for two weeks showed an external discolouration of the sapwood. In no cases was the heartwood discoloured either internally or externally. The surface discoloration was also evident on the longitudinal surface of the log.

### Period and Amount of Bluestain Development at the Scrub Ramps.

For this experiment, 12 logs were available. Six were placed on the ground at the loading ramps on the edge of the rain-forest, whence they had been hauled from the stumps in the usual routine fashion, and six were raised off the ground on skids allowing ventilation beneath the logs. The results shown in Table 2 indicate that the logs on the ground were somewhat more

**Table 2.**

MEAN DEPTH IN INCHES OF STAIN PENETRATION IN LOGS STORED AT THE SCRUB RAMPS ON THE GROUND AND ON SKIDS.

| Position. | Weeks from Felling to Milling. | Mean Depth of Stain Penetration (Inches). | | | | | | Mean. |
|---|---|---|---|---|---|---|---|---|
| | | Under Surface. | Upper Surface. | Butt Under. | Butt Upper. | Top Under. | Top Upper. | |
| On Ground | 3 | 0 | 0 | 0 | 0 | 0·2 | 0 | 0·03 |
| | 5 | 3·3 | 2·4 | 3·7 | 3·1 | 2·9 | 2·8 | 3·0 |
| | 6 | 0·2 | 1·4 | 0·7 | 2·8 | 2·2 | 1·6 | 1·5 |
| | 7 | 0·9 | 1·1 | 2·8 | 3·0 | 2·6 | 3·1 | 2·2 |
| | 8 | 0·6 | 0·3 | 1·4 | 1·4 | 1·9 | 1·5 | 1·2 |
| Mean .. | .. | 1·0 | 1·0 | 1·7 | 2·1 | 1·9 | 1·8 | 1·6 |
| On Skids | 3 | 0 | 0 | 0·4 | 0 | 2·5 | 1·0 | 0·6 |
| | 5 | 0·3 | 0·3 | 2·2 | 2·0 | 1·2 | 0·5 | 1·1 |
| | 6 | 0·4 | 0·2 | 0·2 | 0·1 | 2·2 | 1·8 | 0·8 |
| | 7 | 0·6 | 0·5 | 3·1 | 2·4 | 0·6 | 1·7 | 1·5 |
| | 8 | 0·3 | 1·2 | 0 | 2·2 | 1·3 | 2·0 | 1·2 |
| Mean .. | .. | 0·3 | 0·4 | 1·2 | 1·3 | 1·6 | 1·4 | 1·0 |

stained than those on the skids. The anomalies appearing in the table (e.g. log 2 on ground) are probably due to varying degrees of susceptibility of the respective logs, which could be the result of differences in the relative moisture or nutrient contents. Because only a limited number of logs was available, only one log could be cut each week and consequently no mean could be arrived at for any individual period.

### Period and Amount of Bluestain Development in the Open.

For this experiment 18 logs were available. Of these 12 were placed on the ground and six on skids in cleared country. Observations (see Table 3) showed that stain penetration effects were similar for the two positions except that penetration tended to be greater on the upper than the lower surface in both cases. This no doubt is due to the quicker drying conditions of the upper surface producing a more favourable moisture content for fungal growth.

**Table 3.**

STAIN PENETRATION IN LOGS LEFT IN THE OPEN ON THE GROUND AND ON SKIDS.

| Position. | Weeks from Felling to Milling. | No. of Logs. | Mean Depth of Stain Penetration (Inches). | | | | | | Mean. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Under Surface. | Upper Surface. | Butt Under. | Butt Upper. | Top Under. | Top Upper. | |
| On Ground | 5 | 6 | 0·6 | 0·9 | 2·2 | 2·7 | 2·4 | 3·2 | 2·0 |
| | 8 | 6 | 0·6 | 1·6 | 4·4 | 3·8 | 3·1 | 3·3 | 2·8 |
| On Skids | 8 | 6 | 1·1 | 1·5 | 3·7 | 4·2 | 2·8 | 3·2 | 2·8 |

The infection over the same period and at the same time was much more severe than in either those placed at the scrub ramps or those left in the rainforest (Tables 1 and 2). The warming of the logs by the sun in the open may have produced a more suitable incubation temperature for the development of the fungus than existed at the relatively well-protected scrub ramps, and the conditions of drying may also have more quickly reduced the moisture content of the wood to a suitable figure for fungal growth.

### Effect of Direct Contact with an Infected Log on Possibility and Degree of Infection of Clean Logs.

For this purpose three logs only were used; one of these was badly bluestained, the others clean and newly felled.

These logs were stored on the ground at the scrub ramps. It is evident from the table that contact with the infected log had no effect on side penetration. The end penetration, however, appeared to be greater, though this need not necessarily have been due to the presence of the infected log.

**Table 4.**

STAIN PENETRATION IN CLEAN LOGS IN CONTACT WITH AN INFECTED LOG.

| No. of Logs. | Weeks from Felling to Milling. | Mean Depth of Stain Penetration (Inches). | | | | | | Mean. |
|---|---|---|---|---|---|---|---|---|
| | | Under Surface. | Upper Surface. | Butt Under. | Butt Upper. | Top Under. | Top Upper. | |
| 2 | 8 | 0·9 | 0·7 | 4·9 | 4·6 | 2·7 | 4·4 | ·0 |

## Value of Various Chemical and Physical Methods of Control.

Six treatments were used in this series and for each treatment four logs were obtained and left at the stump in the rain-forest (Plate 2) and two logs were hauled to the scrub ramps and treated in an identical fashion (Plates 3 and 4). The six treatments were:—

1. "Lignasan."
2. Bordeaux mixture.
3. Creosote–soap emulsion.
4. "Quartzite"–arsenic mixture.
5. Bark on with creosote-vaseline paint on cut ends.
6. Bark on with clean ends.

Plate 2.

HOOP PINE LOGS TREATED AT THE STUMP IN THE RAIN-FOREST.

Plate 3.

HAULING A HOOP PINE LOG FROM THE RAIN-FOREST TO THE RAMPS FOR TREATMENT.

Plate 4.
TREATED HOOP PINE LOGS ON THE GROUND AT THE SCRUB RAMPS.

It was essential that the treatments chosen should be easy of application, enabling the logs to be sprayed in the field. The soda solutions which have in places been employed with some success were not used because of the high temperatures at which the solutions must be maintained. A spray for use on logs under rain-forest conditions should be capable of being applied cold, and should be easy to prepare and to apply. The four sprays chosen were selected because they represented divergent groups of fungicides.

In all cases where two logs were obtained from the same tree a different treatment was applied to each log in order to compensate in some degree for any individual differences which might be present in the trees. The distribution of the logs in the rain-forest was also made as varied as possible for each treatment. This was relatively easy as the trees from which the logs were cut were distributed over several acres of natural forest in broken country.

In the case of the spray treatments the logs were treated immediately after felling and barking, and were spun with a cant-hook in order that all surfaces, including the ends, might be thoroughly sprayed by means of a knapsack sprayer. In preparing the spray mixtures, water from the nearest of the numerous creeks in the area was used. The logs which were treated at the scrub ramps were hauled into position by bullocks as soon as possible after cutting. In the case of the two treatments in which the bark was left on the logs all of the logs were left in the rain-forest at the stump because of the difficulty of hauling hoop pine logs in their bark over the ground. Untreated control logs were used in all cases for purposes of comparison.

The logs were left in position for from five to eight weeks, with an average of seven weeks, after treatment to the time of milling.

### "Lignasan" Solution.

"Lignasan," as used, is an ethyl mercury chloride compound which is soluble in cold water. The mixture was prepared according to the directions supplied with the product—that is, "Lignasan" was dissolved at the rate of one pound of "Lignasan" in 40 Imperial gallons of water. In practice it was found that one gallon of the solution was sufficient to thoroughly treat 130 square feet of log surface.

On inspection the logs treated with "Lignasan" presented a clean, glazed, whitish surface. In the rain-forest (see Table 5), "Lignasan" exercised much more effective control over sapstaining fungi than any of the other treatments. The untreated controls showed bad "blueing." Similarly at the scrub ramps "Lignasan" was more effective than the other treatments represented there.

**Table 5.**

STAIN PENETRATION IN LOGS AFTER VARIOUS CHEMICAL AND PHYSICAL TREATMENTS.

| Treatment. | In the Rain-forest. | | At Scrub Ramps on Ground. | |
|---|---|---|---|---|
| | No. of Logs. | Penetration (Mean Depth—inches). | No. of Logs. | Penetration (Mean Depth—inches). |
| "Lignasan" solution .. .. | 4 | 0·1 | 2 | 0·8 |
| Bordeaux mixture .. .. | 4 | 0·3 | 2 | 1·9 |
| Creosote–soap emulsion .. | 4 | 0·65 | 2 | 1·9 |
| "Quartzite"–arsenic mixture | 4 | 1·7 | 2 | 2·4 |
| Bark on (sealed ends) .. .. | 4 | nil | .. | .. |
| Bark on (ends bare) .. .. | 14 | 10·9 (ends only) | .. | .. |
| Control .. .. .. .. | 8 | 1·6 | 2 | 2·7 |

### Bordeaux Mixture.

Bordeaux mixture was used as a representative of the copper group of fungicides. It was prepared according to the 6-4-40 formula and a resin-soda sticker was mixed with the spray at the rate of one gallon of sticker to 25 gallons of spray. It was found that one gallon of Bordeaux spray as prepared above was sufficient to cover 110 square feet of log surface. The spray gave the logs a bluish appearance which persisted on the surface of the sapwood on the cut ends of the logs up to the completion of the experiment but faded on the longitudinal surface, where spray penetration was less.

The Bordeaux mixture treatment of logs in the rain-forest exercised considerable control over side penetration by sapstaining fungi, but the protection against end penetration was weak. Compared with the untreated control (Table 5) the treatment showed good results and also appeared in a favourable light when compared with the treatments with creosote-soap emulsion and with

"Quartzite"—arsenic mxture. The Bordeaux mixture treatment compared with "Lignasan" treatment, however, was inferior in regard to both efficiency as a stain control and ease of preparation of the spray mixture.

The logs treated at the scrub ramps were badly "blued," evidencing adverse weathering qualities for the Bordeaux mixture as compared with "Lignasan."

**Creosote-Soap Emulsion.**

Creosote being a well known wood preservative, it was included as a treatment. Its staining effect would be no drawback in the case of unmilled logs, the surfaces of which are removed at processing. Because of the sappy wet state of the logs the creosote was applied as a water emulsion and soft soap was used as an emulsifying agent. After a number of trial mixes the following formula for preparing the emulsion was arrived at and proved sufficiently stable for its purpose:—

Creosote, 1 gallon;

Soft soap, 1 pound;

Water, 4 gallons.

The creosote used was that prepared according to the K55 specification of the Australian Council for Scientific and Industrial Research. The soap was first dissolved in water by kneading it by hand. The creosote was then added and the mixture pumped several times through the sprayer until a good yellow-brown emulsion was obtained. This emulsion proved to be stable during the time of application but had to be agitated again after the operator had walked to another site. One gallon of the spray was sufficient to thoroughly treat 110 square feet of log surface. The sprayed logs turned to a red-brown colour after treatment but became brown in a few days.

The logs treated with creosote-soap emulsion proved to be slightly better with regard to freedom from stain than the untreated controls and the "Quartzite"-arsenic treatment but not as good as the "Lignasan" and Bordeaux mixture treatments. The logs at the scrub ramps were more severely stained than those left in the scrub, as was the case with the other treatments described. It appeared that the active constituents of the creosote were too volatile to have any lasting effect on the surface of a wet log. In addition, there was little or no penetration of the wood by the creosote and the dressing was partly washed off by rain within a short time.

**" Quartzite "-Arsenic Treatment.**

"Quartzite" is a meta-silicate of sodium and is said to be of some value as a controlling agent for sapstaining fungi in sawn timber. Previous work in connexion with borers in hoop pine logs indicated that "Quartzite" mixed with

arsenious oxide might be of value as a preventive of sapstain and borers, and accordingly the mixture was included as a treatment in this experiment. The mixture was prepared as follows:—

"Quartzite" 17 per cent. solution, 1 gallon;
Arsenious oxide, 3·2 oz.

In order to dissolve the arsenious oxide it was boiled with caustic soda in the proportion of one ounce of caustic soda to four ounces of arsenious oxide. The "Quartzite" was then diluted with water to make a 17 per cent. solution and the arsenic well stirred in. One gallon of the mixture was sufficient to cover 130 square feet of log surface. The spray set to a jelly-like substance on exposure and soon hardened to form a varnished surface. However, the surface proved to be an excellent substrate for various superficial fungi such as *Penicillium* spp. and within a few weeks the logs were completely covered with mould on the surface and borers attacked the logs during and after the first week from treatment.

On reference to Table 5 it will be seen that, if anything, the "Quartzite"-arsenic spray gave worse results than the untreated controls both in the scrub and at the scrub ramps and in addition to this the mixture is more difficult to prepare than any of the others in the experiment and has a corrosive action on the skin.

**Bark on; Creosote-Vaseline Mixture on the Ends.**

At times selected trees of good form are cut for the sake of obtaining the seed for plantation purposes before the logging area on which they stand is normally logged and the logs are wanted or can be got out of the forest for milling purposes. Consequently the logs may have to remain in the rain-forest for a considerable period until logging operations catch up to them. In order to preserve the timber in the trees it was decided to try leaving the logs in their bark at the stump and painting the cut ends with a mixture of equal parts of creosote (K55 specification) and petroleum jelly. Four logs were treated thus.

Reference to Table 5 shows that all the logs reached the mill in perfect condition after lying for eight weeks at their stumps in the rain-forest. There was no penetration of bluestain from the cut ends of the logs and the creosote had penetrated from the cut ends of the logs approximately one-eighth of an inch into the log at each end. All the logs were full of sap at milling and the treatment would appear to be an excellent one for the preservation of the timber of seed trees.

When the bark has been left on a hoop pine tree for some weeks after felling it tightens on the tree and becomes increasingly difficult to remove; moreover, the timber cutters must make another trip later to take the bark off. Both of these factors increase costs and as a general practice the procedure tested would be unsound, except for special cases such as seed tree felling as cited above.

**Bark on; Ends Untreated.**

For this purpose 14 logs were left with the bark on and the ends were left untreated. The logs were barked and milled after having been left lying at their stumps in the forest for periods of five and seven weeks.

The greatest penetration in any one log was 27 inches from one end. There was no staining in the bark-covered area. The results (Table 5) show how necessary it is to cover the ends of the log. The bark itself was an efficient covering over the length of the log.

**Untreated Control Logs in the Scrub.**

Eight logs were left untreated in the scrub and two were hauled to the scrub ramps and left on the ground.

Reference to Table 5 shows that all treatments with the exception of the "Quartzite"-arsenic spray gave better results than the untreated control. It is also again shown that logs hauled to the scrub ramps became more severely stained than those left in the rain-forest over the period of the experiment.

**Conclusions.**

The experiment was strictly of an observational nature. Bluestain is most severe in logs left outside the rain-forest in the open and logs left at the scrub ramps on the rain-forest edge are worse stained than those left to lie where they fall in the rain-forest.

Logs placed on skids contain a greater volume of stained timber than those in the same location on the ground.

In the case of logs left on the ground the upper side of the log contains more stained timber than the under side.

Bluestain, under the conditions of the experiment, did not seriously affect untreated logs in the rain-forest, for immediate milling purposes, until the fourth week, though end penetration was evident in the second week.

Some trees appear to possess an individual resistance to bluestaining due to an unknown factor or factors probably related to moisture and nutrient content.

Of all the spray treatments used, "Lignasan" gave the best results, with Bordeaux mixture, creosote-soap emulsion and "Quartzite"-arsenic mixture following in that order. The untreated controls were less stained than those logs treated with "Quartzite"-arsenic mixture, though more so than those sprayed with other mixtures.

Logs left with the bark on and the ends painted with a creosote-vaseline mixture remained clean throughout the experiment. Those left with the bark on and the ends untreated showed considerable end penetration of the bluestaining organisms.

In all cases the penetration of the stain was greater from the ends of the logs than from the sides.

## SECOND SERIES OF EXPERIMENTS.

Because of the promising results given by "Lignasan" treatment, the initial experiment was followed up by a series of treatments with this product in order to obtain further information concerning the effectiveness of the fungicide as a control for bluestain. With this object in view three distinct treatments were designed, viz.:—

(1) The logs were sprayed immediately after felling and barking, and were milled at different periods after treatment. This was to determine how long "Lignasan" remained effective over the time of the experiment.

(2) The logs were treated immediately after felling and barking and resprayed at later intervals in order to find if a second treatment at some particular period after the first would check any bluestaining coming in due to the weakening of the first treatment.

(3) The logs were felled and barked and then sprayed at varying intervals after barking in order that some estimate of the period in which active infection first takes place after barking might be determined.

### Treatment 1.

For the purposes of this treatment 12 logs were available. Six of these were left untreated as controls and the remaining six were treated with "Lignasan" immediately after barking. Three weeks after barking the first log was milled and thereafter one was milled each week to the seventh week, when two were milled. The corresponding control logs were milled at similar intervals.

**Table 6.**

STAIN PENETRATION IN LOGS TREATED ONCE WITH "LIGNASAN."

| Treatment. | No. of Logs. | Mean Depth of Penetration in Inches at Various Intervals. | | | | |
|---|---|---|---|---|---|---|
| | | 3 Weeks. | 4 Weeks. | 5 Weeks. | 6 Weeks. | 7 Weeks. |
| "Lignasan" .. .. | 6 | nil | nil | nil | nil | nil |
| Control .. .. .. | 6 | nil | 0·6 | 0·4 | 0·7 | 1·3 |

From Table 6 it will be seen that "Lignasan" proved to be a perfect control for bluestain over the period of the experiment while the control logs became progressively worse in regard to discolouration. This showed that "Lignasan" remained active on the logs for at least seven weeks under the conditions obtaining, while in the control logs staining was evident from the fourth week onwards when the second control log was cut.

**Treatment 2.**

Fourteen logs were used in this experiment (Table 7) and of these four were left untreated as controls while 10 were used for treatment purposes. The logs were treated immediately after felling and barking and six were left with but one treatment while the remaining four were retreated once at intervals of one week between logs.

**Table 7.**

STAIN PENETRATION IN LOGS TREATED TWICE WITH "LIGNASAN."

| Treatment. | Mean Depth of Penetration in Inches after 5 Weeks. Logs Resprayed as Shown. | | | | | |
|---|---|---|---|---|---|---|
| | Unsprayed. | One Spray. | Resprayed. | | | |
| | | | 1 Week. | 2 Weeks. | 3 Weeks. | 4 Weeks. |
| "Lignasan" .. .. | .. | nil | nil | nil | nil | nil |
| Control .. .. .. | 0·8 | .. | .. | .. | .. | .. |

On referring to Table 7 it will be seen that one spraying gave as effective control of bluestaining over the period of the experiment as two sprayings. The controls showed considerable staining over the same period.

**Treatment 3.**

Fourteen logs were available for this experiment and of these four were left as controls and 10 were used for treatments. The treatments were carried out immediately after barking, four hours after barking, 24 hours after barking, two days after barking and seven days after barking.

**Table 8.**

STAIN PENETRATION IN LOGS SPRAYED WITH "LIGNASAN" AT VARIOUS INTERVALS AFTER FELLING AND BARKING.

| Treatment. | Immediately. | 4 Hours. | 24 Hours. | 2 Days. | 7 Days. | No Treatment. |
|---|---|---|---|---|---|---|
| Mean Depth of Penetration (inches) .. | nil | 0·1 | 0·1 | 0·7 | 0·5 | 0·8 |

Reference to Table 8 will show that staining was present in logs treated four hours after barking but did not become serious until after 24 hours had elapsed between barking and treatment. Treatment after an interval of two days appeared to be useless, as the fungus had penetrated beyond reach of the spray when applied at that time.

**Conclusions.**

No advantage accrues from treating the logs a second time at an interval after the first treatment, since a single treatment gives effective control for seven weeks.

Logs treated later than 24 hours after barking become seriously stained.

## THE BLUESTAINING ORGANISM.

A series of pure culture isolations from stained timber obtained from the experimental logs established the identity of the causal organism of the bluestaining as *Diplodia pinea* (Desm.) Kickx. This fungus was also isolated from bluestained timber of slash pine (*Pinus caribaea*) obtained from thinnings from plantations at Beerwah (Queensland). This fungus has also been identified as the causal organism of sapstaining of *Pinus radiata* timber in New Zealand (Birch, 1936).

## BORER INCIDENCE IN TREATED LOGS.

Though the experiments were designed to provide information regarding bluestain alone, a number of observations concerning borers were made and it appears from literature on the subject that borers and bluestain can be directly correlated inasmuch as both presumably depend for their existence on the food reserves of the living wood cells at the time of felling. For this reason the majority of the borers were found only in the sapwood.

In the case of many logs borer attack was apparent within 14 days after felling and became progressively worse up to milling. In a few cases borer attack was noted seven days after felling; this was chiefly in the logs treated with "Quartzite"-arsenic mixture and in the control logs. It also occurred in logs subjected to other treatments with the exception of creosote-soap emulsion, in which case the borers entered the logs in the fourth week. In one or two instances the borers had entered from the ends of the logs but in the vast majority of cases entry was gained through the sides. It was very evident that "Lignasan" did not in any way act as a borer deterrent and though "Lignasan" might save the logs from degrade due to bluestaining an equal amount of degrade was brought about by borer infestation.

The logs left with the bark on were uniformly free of borers. The species of borers observed during the experiment were:—

*Platypus australis* Chap.
*Crossotarsus omnivorous* Lea.
*Platypus froggatti* Samp.
} fam. Platypodidae.

*Xyleborus testaceus* Walk., fam. Scolytidae.

The most prevalent species were the last three, with the second and third being the most plentiful.

*Xyleborus pseudosolidus* Schedl. (fam. Scolytidae) was also found in a few cases but had evidently attacked the living tree. It had also penetrated the true wood whereas the other species listed only attacked the sapwood.

# APPENDIX.

WEATHER DATA FOR PERIOD OF BLUESTAIN EXPERIMENT.

| Date. | Rainfall. | Dew. | Temperature °F. | | Relative Humidity Per Cent. | |
|---|---|---|---|---|---|---|
| | | | Maximum. | Minimum. | 9 a.m. | 3 p.m. |
| 1935. | | | | | | |
| January 17 | .. | Light | 89 | 71 | 82 | .. |
| January 18 | 60 | .. | 91 | 71 | 81 | .. |
| January 19 | .. | .. | 83 | 67 | 72 | .. |
| January 20 | .. | .. | .. | .. | .. | .. |
| January 21 | .. | Light | 87 | 60 | 72 | .. |
| January 22 | 2 | .. | 85 | 66 | 85 | .. |
| January 23 | .. | .. | 85 | 61 | 73 | .. |
| January 24 | .. | .. | 88 | 66 | 95 | .. |
| January 25 | .. | Medium | .. | .. | .. | 51 |
| January 26 | .. | Medium | 89 | 63 | 63 | .. |
| January 27 | .. | .. | .. | .. | .. | .. |
| January 28 | .. | .. | 89 | 65 | 78 | .. |
| January 29 | .. | .. | 95 | 67 | 82 | .. |
| January 30 | 18 | Light | 85 | 68 | 86 | 60 |
| January 31 | 49 | .. | 93 | 65 | 95 | .. |
| February 1 | .. | Light | 93 | 72 | 82 | 57 |
| February 2 | 15 | .. | 93 | 72 | 90 | .. |
| February 3 | .. | .. | .. | .. | .. | .. |
| February 4 | .. | Light | 95 | 59 | 86 | 76 |
| February 5 | .. | Light | 92 | 72 | 86 | 70 |
| February 6 | 14 | .. | 95 | 67 | 81 | 54 |
| February 7 | .. | .. | 89 | 63 | 76 | 68 |
| February 8 | .. | .. | .. | .. | .. | .. |
| February 9 | .. | Medium | 91 | 67 | 90 | .. |
| February 10 | .. | Medium | .. | .. | .. | .. |
| February 11 | 145 | Light | 93 | 67 | 91 | 100 |
| February 12 | 152 | Heavy | 92 | 69 | 95 | 75 |
| February 13 | 4 | Heavy | 91 | 64 | 80 | 70 |
| February 14 | 18 | .. | 91 | 65 | 90 | 52 |
| February 15 | 6 | Heavy | 85 | 65 | 90 | 53 |
| February 16 | .. | Heavy | 91 | 65 | 76 | .. |
| February 17 | .. | .. | .. | .. | .. | .. |
| February 18 | 10 | Heavy | 91 | 66 | 73 | .. |
| February 19 | .. | .. | 92 | 68 | 95 | .. |
| February 20 | 161 | .. | 97 | 70 | 95 | .. |
| February 21 | 248 | .. | 92 | 69 | 100 | 55 |
| February 22 | .. | Medium | 92 | 69 | 82 | 78 |
| February 23 | 36 | .. | 88 | 70 | 73 | .. |
| February 24 | .. | .. | .. | .. | .. | .. |
| February 25 | 293 | .. | 80 | 66 | 95 | 69 |
| February 26 | 55 | .. | 78 | 66 | 90 | 66 |
| February 27 | 3 | .. | 81 | 67 | 80 | 62 |
| February 28 | .. | .. | 82 | 65 | 90 | 77 |