PATHOLOGICAL AND PHYSIOLOGICAL IMPLICATIONS OF SHOT-HOLE BORER INFESTATION

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Historical Introduction.—The principal work on pathological and physiological aspects of shot-hole borer attack was conducted by Speyer, Gadd and Tubbs. The former pointed out the physiological importance of (*a*) the area of the conducting tissues of tea occluded by borer galleries—*i.e.* the wood between bark and pith which conducts water upwards (Fig. 1); (*b*) the die-back resulting from attack at nodes and destruction of buds, which was also noted by Tubbs, and, (*c*) the ultimate pathological importance of the decay of red stained areas in the vicinity of galleries. He mentioned branch breakage as of importance from its effect on loss of crop only.

Fig. 1. Cross section through shot-hole borer gallery, showing that the gallery is found in the wood (upward conducting tissue) of the shoot.

Gadd conducted numerical surveys of the extent of die-back and wood-rot of *pruned branches* only, comparing infested and non-infested branches following pruning.

He found only minute differences, amounting to a maximum increase of about half an inch of die-back and wood-rot on infested branches, and definitely denied that much die-back or wood-rot could result from shot-hole borer attack. It must be borne in mind that Gadd's results were obtained by Mr. Austin, in Uva, and that at this time little attention had been given to shot-hole borer in the low-country.

Current Investigations.—In 1952 several estates in Sabaragamuwa were advised to extend their pruning cycles to three years, on the basis of advice given in Uva, to mitigate the effects of the severe shot-hole borer attacks which were experienced. Following a conference with Messrs. James Finlay's we were informed that this was not feasible owing to severe defoliation occurring after the second year of the cycle. This defoliation was attributed to attack by the fungus *Rhizoctonia solani* and an experiment was accordingly laid down on possible control measures of this disease. At the termination of the first cycle of this experiment no evidence of Rhizoctonia infection had been found. Nevertheless, a considerable amount of defoliation had been experienced. It was felt that the probable explanation lay in the fact that leaves, defoliated following shot-hole borer infestation, during dry weather fell to the ground, but, on the onset of monsoon conditions, horse-hair blight and thread blight held up these leaves, giving the picture said to be characteristic of Rhizoctonia.

An adjacent field on the same estate showed a considerable amount of die-back ten months after recovery from pruning. No pathogen could be found in this material, and from numerous bundles of young shoots examined it was evident that in many shoots up to 80 per cent of the total conducting tissue was occluded somewhere along its length. This conclusion was arrived at by sectioning through all galleries in a given length of shoot, and super-imposing tracings of the galleries, with the result shown in Fig. 2.

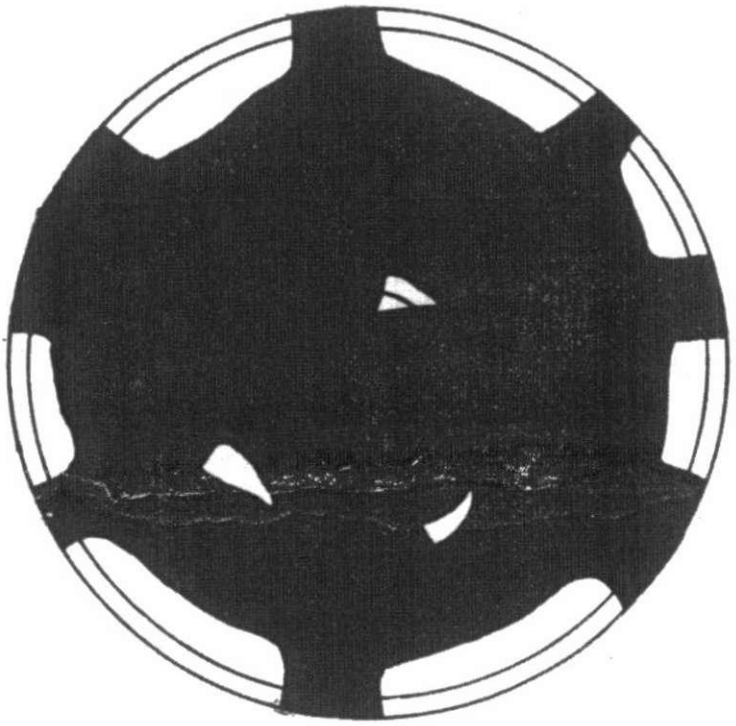

Fig. 2. The result of super-imposing sections (cf. Fig. 1) cut through all the galleries in a shoot 16" long. Note the small amount of uninterrupted conducting tissue.

It had been postulated in the past that in a heavily galleried shoot the ascending sap stream, on being "stopped" by a gallery, would pass sideways into adjacent vessels and thus continue along a zig-zag path. Even if this were the case it must be borne in mind that the lateral rate of water conduction in woody tissues is very much slower than the vertical rate, and consequently that the amount of water reaching the top of a galleried shoot is likely to be very much less than that in an undamaged shoot.

This investigation led to the hypothesis that under extremely dry conditions the amount of water able to reach the top of heavily infested shoots was insufficient to support healthy growth, and the observed symptoms of wilt and subsequent die-back ensued.

The factor of shade must be considered here, and it has been a constant obser vation by several officers, that much of the finest tea in the low-country is to be found under extremely heavy shade.

Laboratory experiments on the uptake of water by artificially galleried shoots have been inconclusive to date, in fact many of the shoots with the largest number of galleries have shown a higher water uptake. The possibility of water loss from open gallery ends is high, and it is proposed to repeat the experiments with blocked and open galleries. However, we *did* demonstrate that very little tissue was required to support shoots, when an *adequate* water supply was available.

The possible physiological implications of the above observations can very well be applied to support the contention that a shorter pruning cycle would be of benefit under low-country conditions. As the cycle length continues, so the number of galleries per branch increases, and presumably the ability to take up water will decrease proportionately. Further the amount of maintenance foliage and consequently water requirement will *increase* as the cycle continues. If then greater water demand is coupled with reduced water availability defoliation must, of necessity, occur, particularly under drought conditions.

It is possible also that galleries in older wood, which has a greater pith area, may restrict water supply to a greater extent than in young wood, which has not developed much pith, and in which the cambium may be more active and better able to replace destroyed tissue. Thus a hypothetical explanation for the increase as the wood ages is available.

The difference between the low-country and Uva, where a three year cycle has been found feasible, must lie in the higher growth rate and increased water demand under low-country conditions. Where a three year cycle has been found possible in the low-country it has proved better than a 2 or 2½ year cycle, thus agreeing with the Uva findings, and bearing out to some extent the fact that attacks do decline in the third year, probably as a result of either a decline of the ambrosia fungus, on which the larvae feed, or the onset of physiological conditions, within the galleries, inimical to the beetle. It should also be borne in mind that hard plucking should also *minimise* transpiration, and so decrease water uptake from the soil.

Turning now to wood-rot, it can be taken for granted that the minute increase in amount of die-back, observed by Gadd to occur at the cut ends of infested branches, may be ignored. Some interesting observations by Tubbs show without doubt, however, that in pruned branches an important factor is whether a healthy bud is available or not. The known propensity of the shot-hole borer to attack at buds and nodes can result in a considerable amount of die-back. Reference to Fig. 3 explains this point diagramatically.

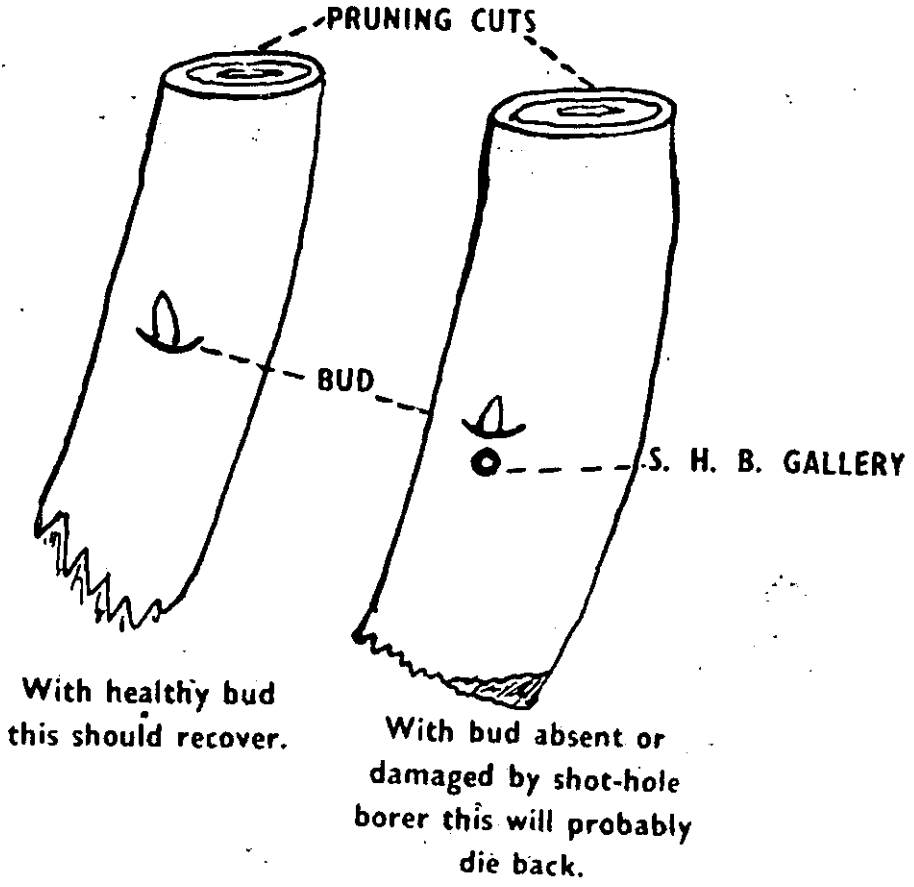

Fig. 3. Two pruned branches, that on the left with a healthy bud, that on the right with a bud damaged by shot-hole borer.

The most important factor, however, would appear to be the amount of wood-rot which results from invasion through the broken off stumps of shot-hole borer branch breakage. A recent survey in an *unpruned* new clearing, which had never been cut, and on which a wood-rot experiment was proposed, gave some very interesting results.

The original experiment was aimed at keeping wood-rot *out* of new clearing tea, and included treatments to obviate entry at the "traditional" points, *i.e.* pruning cuts and sun-scorched branches. (Fig. 4).

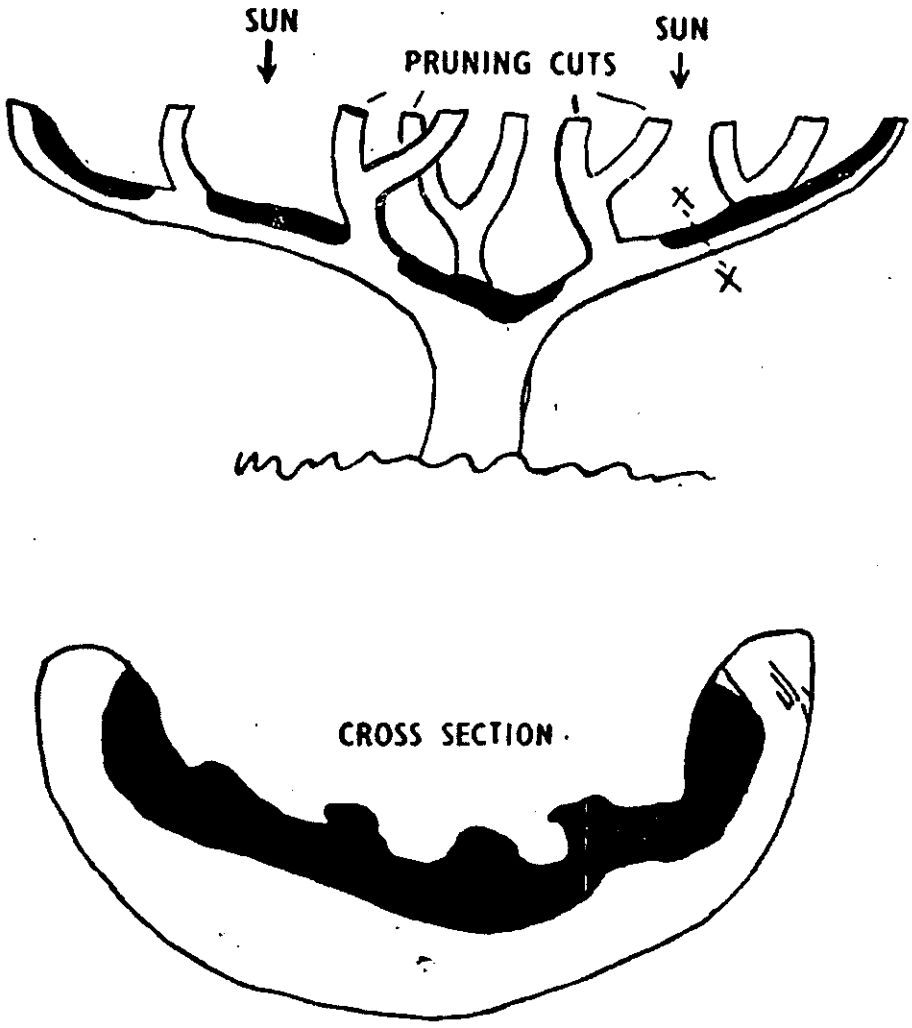

Fig. 4. Frame showing "traditional" causes of wood-rot, *i.e.* sun-scorch and pruning cuts, and cross section of badly rotted branch through X—X.

It was necessary to conduct a preliminary survey of wood-rot already present, with the following results:—

Approximately 60 per cent of the bushes were found to have wood-rot in their frames to a greater or lesser extent, and in almost every case the invasion could be traced to the point where a branch breakage had left a short snag attached to the frame. (Fig. 5). This snag had been invaded by wood-rotting organisms, which had then *continued* their growth in the healthy wood of the parent branch of the frame. An experiment is now being designed to ascertain the actual extent of such damage,

on young and old tea. The reasons for breakage are simple, viz: any cultural operation necessitating passage through the tea and undue movement in the rows. Thus the avoidance of such operations as forking, in the second year of the cycle, is to be strongly encouraged.

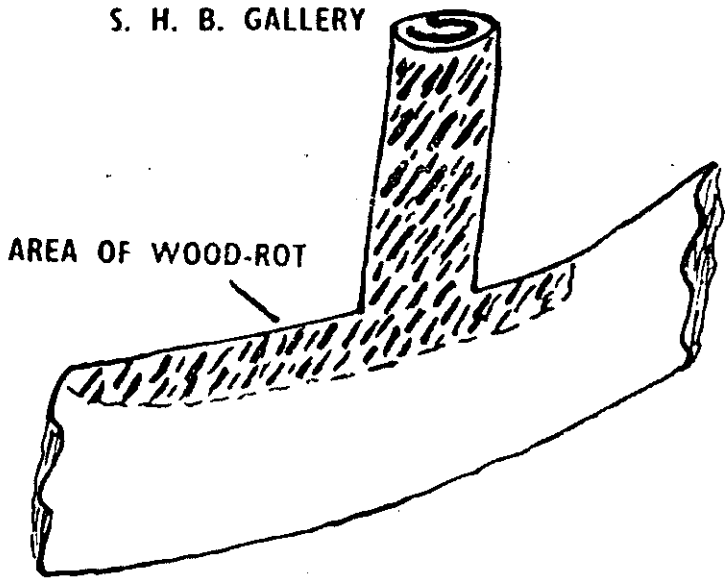

Fig. 5. Wood-rot following S.H.B. branch breakage.

It would appear likely that Speyer's observation regarding the physiological death of the stained tissues surrounding borer galleries can be accepted. That these tissues become "more acceptable" to wood rotting organisms, as suggested by Gadd, cannot be discounted, and the analysis of the staining substance would make a very interesting, and probably useful, study. Further, the possibility of the ambrosia fungus itself being mildly pathogenic is to be considered. It belongs to a natural group of fungi, many of whose members are pathogenic, and the assumption that it is "sown" on living wood, when the gallery is first opened, must bear out the fact that it is at any rate able to grow on living wood.

Further work is envisaged on the following aspects:—

1. The amount of *die-back* resulting from (*a*) total galleries in a given shoot and (*b*) galleries made at, or in the vicinity of nodes.

2. The amount of *wood-rot* resulting from (*a*) broken branch snag infection, (*b*) the death of stained tissues in the vicinity of galleries and (*c*) wood-rot resulting from the continued growth (if this is shown to occur) of the ambrosia fungus.

3. The effect of shade on the degree of die-back under drought conditions.

4. The possibility of controlling the ambrosia fungus with new systemic fungicides, and thus controlling the beetle by depriving it of its food supplies.