

STUDIES OF SHOT-HOLE BORER OF TEA

III—DAMAGE TO THE TEA BUSH

C. H. GADD

The primary damage to the tea bush caused by shot-hole borers is done during the construction of their galleries in the stems. This of itself would be of little importance were it not for other consequences which result more or less accidentally from the presence of the galleries. The secondary damage may be classed under three headings: (1) Wood-rot, (2) Dieback, and (3) Branch breakage. Of these the last named is the most important as it leads to the greatest loss of crop.

WOOD-ROT

The term wood-rot is used to describe the decayed condition of woody parts of stems brought about mainly by fungi. These fungi as a rule cannot gain access to the wood except through wounds which lay bare a surface of wood, and for this reason wood-rot normally follows pruning. The wounds made by borer beetles, as seen on the surface of stems, are very small. Nevertheless, they provide a means by which fungus spores may come into contact with the wood of infested branches. There is also a suspicion that beetles may carry fungus spores on their bodies when they start the construction of galleries, and should the spores of wood-rotting fungi be amongst them, the risk of wood-rot infection would be materially increased.

The charge against borer beetles, however, is more frequently based on other grounds than these suspicions. The wood of infested branches in the vicinity of galleries is stained reddish or dark purple and the stain is very obvious when the

branches are pruned. In Speyer's opinion (1922) 'this staining is "not serious so far as the upper branches of a bush are concerned, but in the thicker branches and collar which remain after pruning, the stained area decays entirely where the attack has been of long standing." The suggestion here is that the staining is a forerunner of wood-rot.

Decay in thick branches and at the collar is prevalent in bushes which have never been attacked by shot-hole borer, so there must be some doubt that similar decayed areas in infested bushes are the direct consequence of borer invasion. Yet it has been the experience of many planters that, in heavily infested fields, pruned branches showing the characteristic stain at the cut are found to be badly decayed at the next pruning. It should be noted however that the stained branches were pruned, an operation which predisposes bushes to invasion by wood-rotting fungi. Also, when bushes are infested, practically every branch shows the stain at the cut, and unless unstained branches are marked in some way, it is impossible to judge accurately two years later whether the decay is the more severe in those branches which were originally stained.

In order to determine whether there is any direct connection between the stain around borer galleries and the later rotted condition of stained branches after pruning, it is necessary first to consider what causes the stain. Growing on the gallery walls is an ambrosia fungus on which the beetles

feed. That fungus penetrates the wood in the vicinity of the galleries and can normally be recovered from the stained areas (Gadd 1936).¹ When the fungus is isolated and grown in pure culture on agar media, a wine red colouring matter is formed which stains the agar deeply. This stain closely resembles that of the wood around the galleries, and there can be no doubt that the stain in the wood results from the growth of the ambrosia fungus.

The next step is to determine whether the ambrosia fungus causes decay of tea wood. Experiment with the fungus have failed to cause any detectable decay of the wood. Moreover, other fungi isolated from stained wood around borer galleries in un-wounded stems have also failed to cause rot of tea wood in controlled experiments (Gadd 1936).¹ These results indicate that neither the ambrosia fungus itself nor other fungi normally carried into the galleries by the beetles are organisms capable of decaying wood.

It should be noted that the wood-rot of borer-stained branches invariably begins after the bushes are pruned, and that no recognisable decay occurs before pruning. This leaves little doubt that the wood-rotting organisms gain entry through the exposed wood surface after pruning or after the branches break. One problem remains. It seems improbable that the invasion and growth of the ambrosia fungus will leave the wood entirely unchanged. Does that change, whether chemical or physical, render the wood liable to more speedy decay when invaded by true wood-rotting organisms?

An attempt to answer this question (Gadd 1943)² was made by measuring the length of wood-rot in infested bushes three years after the branches were pruned. The

branches were divided into those having borer galleries in the rotted zone and those without. The galleries in the rotted zone were undoubtedly made before the branches were pruned and it may be assumed that wood around them was stained. One cannot be equally sure however that when no gallery was visible the wood was free from stain, but in general the probability is that the areas containing galleries were more consistently stained than those without galleries. If then invasion by the ambrosia fungus renders the wood liable to more speedy decay, more wood-rot would occur in the areas with galleries than without.

The results from three fields were similar, and in each the rot had progressed furthest in those branches which had borer galleries in the rotting area. It appears therefore that although the ambrosia fungus does not of itself cause wood-rot, invasion by that fungus allows the wood to be reduced more rapidly to a friable condition when invaded by a true wood-rotting organism. This fact is not of serious importance as the difference in rates of decay is not very appreciable. In the writer's opinion, the part played by the borer in causing or accelerating wood-rot is generally over-rated. So long as tea bushes have to be pruned, wood-rot will occur, no matter whether the bushes are infested by borer or not.

DIEBACK

In an earlier article (Gadd 1947)³ it was shown that the borer beetles exhibit a preference for the node as a place of entry into the stem. The entrance to the gallery is frequently situated just below the base of a bud, and, although the boring usually does not injure the bud itself, it severs the channels along which water must pass to the bud. This injury cannot be repaired.

and it deprives the bud permanently of sufficient water to cause it to burst. The bud thereby becomes functionless and incapable of further growth. The damage however does not become evident until the bush is pruned.

The pruning of a branch causes the bud nearest the cut to break and the piece of stem above the bud to die. For this reason one of the first rules of pruning to be learned by a young gardener is "Prune to an eye (bud)." By selection of the bud the position of the branch to be grown can be determined, and by making the cut close to the bud the length of the dieback is diminished. Although tea bushes are not pruned with that care the same principles hold good.

If however the uppermost bud, nearest the pruning cut, is incapable of growth owing to the presence of a borer gallery immediately below its base, the next lower bud takes up its function. Obviously the length of the dieback is increased by the length of the internode, the distance between the damaged and undamaged buds. If several successive buds below the cut are similarly damaged the length of the dieback is correspondingly increased. The length of the dieback depends not only upon the number of ineffective buds but also upon the *jat* of the bush, because high *jat* bushes have longer internodes. For this reason dieback resulting directly from borer injuries is usually greatest and most noticeable in high *jat* bushes.

Shot-hole borer however is not the sole cause, nor the commonest cause of dieback in tea bushes. Buds may fail to break for reasons other than the presence of borer galleries, the chief of which is undoubtedly a deficiency of food reserves at the time of pruning. Such a deficiency, particularly when the bushes are clean pruned, may

result in the bursting of relatively few buds, and the death of whole branches. In bad cases no buds may break and the bush dies in consequence. Unfortunately shot-hole borer is prevalent in many areas where bushes are liable to be deficient of food reserves, and the cause of dieback there is apt to be wrongly diagnosed. Where dieback is due to the borer, a gallery is to be found at the buds which fail to break. The absence of such evidence is indicative that the dieback is due to another cause.

BRANCH BREAKAGE

Borer damage resulting in dieback and wood-rot becomes evident after pruning, but the breaking of branches occurs shortly after the galleries are made. Galleries of certain designs (Gadd 1947)^a weaken the stems to such an extent that invaded branches are easily broken, at the site of the galleries, by wind and during cultural operations. The loss of branches must result in a reduction in the cropping capacity of the bush, but no satisfactory means has been devised to measure the amount of crop lost. The extent of the loss will be dependent on the number of branches broken, but it will not be directly proportional to that number because of the different times at which breakages occur.

The collection of broken branches from an experimental area, 3.2 acres in extent in the Passara District, weekly after each plucking, was started in 1942 when the bushes were in the second year of the cycle, having been pruned in September 1940. In February the collections averaged 377 per acre per week, and in June they reached a peak of 765 per acre per week. Afterwards the numbers decreased until in February, 1943 they were only 83 per acre per week, and they remained about that level till September when the bushes were

pruned again at the end of a 3-year cycle (Gadd 1944).³

The importance of these observations lies in their indication that borer damage falls to an almost insignificant level during the third year from pruning. Like many other borer infested areas this one had previously been pruned on a 2-year cycle, the pruning being done at a time when borer damage was near its maximum. The length of a pruning cycle is dependent upon reasons other than borer infestation, but one can well imagine a planter, after inspecting infested bushes towards the end of the second year, deciding that unless he prunes soon he will have little frame left to prune on to. To what extent decisions of that sort have influenced the length of pruning cycles in infested areas is impossible to say.

The prolongation of the pruning cycle in the experimental area proved successful in every way. The yield in the third year (660 lb. per acre) exceeded the average of the first two years by 60 lb. per acre, and the frames were in better condition for pruning. When the bushes were pruned in September 1943 at the end of a 3-year cycle, the borer damage, and presumably the beetle population, were at their minima; whereas at the 1940 prune, coming at the end of a 2-year cycle, the damage was near its maximum and the beetle population large. This fact will be referred to later as a possible explanation of a marked reduction in damage during the second 3-year cycle.

Broken branches again began to appear in the plots in May 1944, eight months after pruning, and the weekly average then was only 6 broken branches per acre per week. By the end of the pruning year (September 1944) the

number was 108 and by June 1945 it had reached 264 and by July 267 per acre per week. Thereafter the numbers fell as in the previous cycle until the low level of 36 was reached in May, 1946 (Gadd 1945, 1946).^{4, 5} These results confirm those previously obtained, and demonstrate clearly that borer damage decreased markedly during the third year from pruning. The data do not indicate any likelihood of a further decrease during a fourth year though damage could be expected to remain small.

During this cycle the damage was very much less than in the previous cycle. The peak months, June and July 1945, gave 264 and 267 broken branches per acre per week whereas in the corresponding months in the previous cycle (1942) the numbers were 766 and 703, respectively. As there is no evidence to support the view that the years 1943-6 were less favourable for the borer than the years 1940-3 the suggestion is put forward that the smaller damage in the 1943-6 cycle was due to the smaller population at the beginning of the cycle as already explained; but further observations will be necessary to establish that point.

Relatively little damage is done during the first year because for the greater part of it the young branches are unsuitable for attack. Speyer (1919) made use of that fact in his scheme for controlling shot-hole borer by pruning at short intervals. His scheme proved neither practicable nor effective, and need not be discussed here.

The records of borer damage during the first part of the 1943-6 cycle in the experimental area are of particular interest as they show that the greatest variation occurs during that period. The experimental area consists of four blocks, one of which (No. 1)

is separated from the others by a distance of about 200 yards. The areas were carefully selected for uniformity for manurial trials, but the records show that although the damage was similar in blocks 2, 3 and 4, which lie side by side, that in block 1 was more extensive and followed a somewhat different course. The records of blocks 2, 3 and 4 are so similar that those of block 2 only are given in Table 1 for comparison with those of block 1.

In blocks 2, 3 and 4 the breakages steadily increased in number from May 1944 till July 1945, but in block 1 the increase was more rapid and a peak (398 per acre per week) was reached as early as October 1944. In that month the blocks were cultivated and manured and because of that extra work the breakages for the month were exceptionally numerous, particularly in block 1, indicating the larger number of infected breakable branches present. The breakages in block 1, as may be seen from the table, fluctuated somewhat between October 1944 till July 1945, near the end of

the second year from pruning, when in all blocks they reached similar peaks. At the end of July 1945 11,701 broken branches had been collected from block 1 whereas the totals removed from blocks 2, 3 and 4 were 5,394, 5,129 and 5,926 respectively. (The area of each block is 0.8 acre). The damage was therefore twice as great in block 1 as in the other blocks during that part of the cycle. But after July 1945 and during the third year the damage decreased in all blocks and that in block 1 was no greater than that in the others.

No reason can be offered at present why the damage should have been greater in block 1 nor why it should have reached a maximum there early in the cycle and remained at a high level until the general decrease set in towards the end of the second year. It is evident, however, that although a decrease in damage can be confidently forecast for the third year of a cycle its course during the earlier years is not so certain.

TABLE 1

Mean weekly counts of broken branches from two experimental blocks given as breakages per acre.

	1943-4		1944-5		1945-6	
	Block 1	Block 2	Block 1	Block 2	Block 1	Block 2
September	—	—	251	44	205	206
October	—	—	398	62	161	166
November	—	—	224	60	125	122
December	—	—	191	77	122	136
January	—	—	250	115	102	107
February	—	—	250	111	107	97
March	—	—	171	127	82	82
April	—	—	227	154	53	55
May	17	4	284	242	40	36
June	73	15	279	241	47	45
July	185	19	280	261	41	32
August	254	36	215	227	38	35

REFERENCES

1. Gadd, C. H. (1936).—Report of the Mycologist for 1935.—T. R. I. Bull. 13, 24-34.
 2. Gadd, C. H. (1943).—Shot-hole Borer and Wood-Rot.—*Tea Quart.* XVI, 6-9.
 3. Gadd, C. H. (1944).—Shot-hole Borer Damage and Tea Yields.—*Tea Quart.* XVII, 2-11.
 4. Gadd, C. H. (1945).—Report of the Entomologist for 1944.—T. R. I. Bull. 26, 31-37.
 5. Gadd, C. H. (1946).—Report of the Entomologist for 1945.—T. R. I. Bull. 27, 30-36.
 6. Gadd, C. H. (1947). Studies of Shot-hole Borer of Tea, 2—Galleries.—*Tea Quart* XVIII, 114-124.
 7. Speyer, E. R. (1922).—Shot-hole Borer of Tea.—Damage caused to the Tea Bush.—*Dept. of Agric. Ceylon, Bull.* 80
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