TRIALS WITH A METHOD OF ASSESSMENT OF INFESTATION CAUSED BY SHOT-HOLE BORER *(XYLEBORUS FORNICATUS* EICH.) ON OLD TEA

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The method of assessment as presented in this article furnishes greater detail than that described in a previous paper (JUDENKO, 1956), the primary object of which was to find a standard unit which would both be easily available and contain the maximum number of galleries.

Work on the establishment of a suitable standard unit was divided into three parts: (1) Initial selection of length of unit and diameter at base, (2) Final selection of diameter of base, and (3) Final selection of length of unit and diameter at top.

1. Initial selection of length of unit and diameter at base

The following method was applied during examinations carried out on 8 tea fields. All live parts of branches, termed here units, of a minimum length of at least 4 inches, were measured. Parts of branches of length shorter than 4 inches were not considered as the number of galleries in them would be small. Therefore the unit was confined to a 4 inch minimum length of the stem between two axils, provided it was approximately circular and carried no green shoots.

Diameter measurements were taken with a gauge of 1/16 inch accuracy. The diameters investigated varied from 5/16 inch to 12/16 inch. Parts of branches with diameter smaller than 5/16 inch were not examined because the numbers of galleries were too small and branches with diameters larger than 12/16 inch were rare.

400 units from each of the 8 fields were examined and these were taken from mature bushes selected at random. All available parts of living branches were examined until 400 units were found.

Examinations were carried out from May-July, 1956, in the fields listed in table 1.

Table 1. *Details of fields chosen for trials*

Estate	Field No.	Age after planting (years)	Age after pruning	Length of pruning cycle (years)	Type of pruning	No. of bushes from which 400 units were obtained
Palmgarden	Clearing 1952	4	—	—	—	24
Mahawela	Clearing 1950	6	10-15 days	2	Cut across	35
Mahawela	Clearing 1948	8	23 months	2	Cut across	24
Millawitiya	1	Approx. 31	2-10 days	2	Cut across	28
Millawitiya	6	Approx. 31	22 months	2	Cut across	17
Nayabedde	11/19	37-54	10 days	4	Cut across	26
Nayabedde	17/31	42-44	10-14 days	4	Clean	11
Nayabedde	4/24	44-67	17 months	4	Cut across	20

The results of these examinations showed that, of 3,200 units measured, the most frequently found were those of 6/16 inch diameter at base and 4-5 inches in length, as well as those of 7/16 inch in diameter at base and 4 inches in length The corresponding details are furnished in table 2.

Table 2. *Details of units found.*

Diameter at the base	Length	Number of units per bush			% of bushes with at least one unit available		
		Min.	Max.	Avg.	Min.	Max.	Avg.
6/16"	4"	3.1	7.8	4.5	86	100	94
6/16"	5"	2.7	6.9	4.0	77	100	91
7/16"	4"	1.8	6.0	3.4	80	100	92

Tables 1 and 2 show that the units were found in tea fields of different ages and at different times after pruning, from which it can be assumed that they will be available on all tea plantations in Ceylon by at least 4 years from planting. Data given in table 2 show that units 6/16 inch in diameter at base and 4 inch in length were most common.

2. Final selection of diameter of base

In the following examinations units 6/16 inch in diameter at base and top were compared with those of 7/16 inch in diameter. All units examined were 4 inches long and were collected from 5 tea fields on 4 estates.

The bushes examined were from 8 to 56 years old and from 3 to 23 months from pruning. 100 units of each of the sizes mentioned above were taken from each field. Only one unit of these sizes was taken from each bush and samples were taken from different parts of the fields.

In the laboratory the bark of each unit was first examined. If stripes appeared only on a small part of the surface, or did not appear at all, it was considered to be old bark. Each unit was next split lengthwise into four parts. The galleries then found were classified as follows: those whose entrances were found open on the unit were termed "obviously open galleries"; those whose entrances were closed were called "healed galleries". Yet another type of gallery appeared on the units examined. These galleries had their entrances on the branches from which the units had been cut and it was unknown whether these entrances were open or healed. They were considered as "unknown galleries". Both the healed and the unknown galleries were classified together as "other galleries". The results of these examinations are given in Table 3.

Table 3. *Comparison of units of different base diameters.*

Diameter at the base and top of units	Length of units	Number of units examined	No. of units with young bark	Number of galleries		
				obviously open	other	Total
6/16"	4"	500	101 (100%)	116 (100%)	422	538 (100%)
7/16"	4"	500	41 (41%)	99 (85%)	543	642 (119%)

Although there are indications that the total number of galleries was larger in the case of units of base diameter 7/16 inch, units of the diameter 6/16 inch were selected for the following reasons. Young bark was more frequently found among units of diameter 6/16 inch; in other words heterogeneity of young and old bark was better represented. There was also an indication that in the case of units of 6/16 inch the obviously open galleries were more numerous. This is an important factor in the case of the assessment of the infestation because of the presence of live insects inside them. Finally, as can be seen from table 2, units of 6/16 inch diameter were found more frequently than units of 7/16 inch diameter.

3. Final selection of length of unit and diameter at top

In addition to the units described in the previous paragraph, further samples for these selections were also collected. Details of all units examined are given in table 4.

Table 4.—*Comparison of units of 6/16 inch base diameter and of different lengths and top diameters*

Length of unit	Number of units examined	Diameter at top						
		6/16"			5/16"		Other sizes	
		No. of units	%	Number of obviously open galleries per unit	No. of units	%	No. of units	%
4"	612	417	68	0.27	169	28	26	4
5"	494	314	64	0.32	154	31	26	5

Units 6/16 inch in diameter at top were selected as they are more predominant. Although there was an indication that the 5 inch units contained a greater number of "obviously open" galleries, the 4 inch units were selected for the following reasons: as can be seen from table 2, units of this size were found more often than those of 5 inch length. It appears, also from table 2, that the number of units 4 inches long and 6/16 inch diameter at base is on an average 4.5 per examined bush. Table 4 shows that among such units only 68 per cent have a diameter of 6/16 inch at the top, so that the corresponding number of units of diameter 6/16 inch at base and top would be 32 per cent less than was shown in table 2. This would mean that on an average 3.1 of such units could be obtained per bush.

It should be finally emphasised that the data given in tables 2 and 4 are confined to only a limited number of fields and it is, therefore, very probable that there are fields where the units appear less frequently than has been indicated in these tables. The easy collection of units is a very important factor, hence the selection of the 4 inch long units.

On the basis of the investigations described, a standard unit for the assessment of shot-hole borer infestation of bushes 4 years of age and older was selected and defined as *a piece of live branch 4 inches long, 6/16 inch in diameter at base and top, and free of any secondary branch or green shoot.*

4. Trial assessment of shot-hole borer infestation in individual tea fields

Results of observations on 30 tea fields situated in different parts of tea growing areas, are tabulated in column (8) of table 5.

Table 5.—*Details of assessments*

1	2	3	4	5	6	7	8	9
Examination No.	Date of Examination	Estates and Divisions	Field No.	Age after planting (years)	Age after pruning (months)	Approx. Elevation (ft.)	Total number of galleries in 50 standard units	Opinion of Superintendents*
1	15-11-1956	St. Coombs	5	Approx. 60	39	4,700	0	—
2	15-11-1956	St. Coombs	9	Approx. 30	10	4,500	0	—
3	13-11-1956	Nayabedde, St. Catherine Div.	22	52-56	4	6,000	0	—
4	13-11-1956	Nayabedde, Nayabedde Div.	9	31-32	34	4,300	4	—
5	20- 2-1957	Baddegama, Makrugoda Div.	2	47	18	50	11	?
6	3-10-1956	Neuchatel Group, Home Div.	1	Approx. 50	5-6	30-100	13	—
7	18- 9-1956	Ekkerale	4	Approx. 34	13	Approx. 600	14	+
8	14 & 16- 6-1956	Millawitiya	9	Approx. 31	14	350	18	—
9	20- 2-1957	Baddegama, Makrugoda Div.	3	46	9	50	19	?
10	6 & 7- 6-1957	Millawitiya	5	Approx. 31	10	350	23	—
11	21- 2-1957	Semidale Group, Low Div.	Kurundu-watte	13	20	350	30	?
12	21- 2-1957	Semidale Group, Low Div.	Panwila	18	32	300	32	?
13	20- 2-1957	Citrus Group, Keembiya Div.	1	8	20	100	32	—
14	12-10-1956	Wellandura Group, Div. Nabuluwa No. 2	Clearing 1953	3	4	1,350	34	?
15	20- 2-1957	Citrus Group Citrus Div.	2	8	6	100	36	—
16	3-10-1956	Neuchatel Group, Home Div.	7	Approx. 50	4-5	30-100	37	—
17	8 & 10-10-1956	Wellandura Group Div. Nabuluwa Div. No. 2	4	Approx. 40	7	1,350	40	+
18	25- 9-1956	Hantane	10	43	17-18	2,500	59	+
19	18- 9-1956	Ekkerale	10	Approx. 30	1	Approx. 600	61	+
20	11 & 15- 6-1956	Mahawale	Clearing 1948	8	23	500	62	+
21	22- 2-1957	Deniyaya, Downside Div.	28	9	22	1,500	68	?
22	9- 7-1956	Allupolla Group	38½/22½	More than 56	16	1,800	74	+
23	14-11-1956	Hingurugama Low. Div.	3	60	34	2,700	80	?
24	14-11-1956	Hingurugama Middle Div.	10	49	33	3,100	84	?
25	18- 7-1956	Galbode, Galkondura Div.	1	24-28	0	700-1,150	89	+
26	21- 6-1956 2- 7-1956	Madampe Group, Div. No. 2	4	Approx. 40	3	1,000-1,500	93	+
27	25- 9-1956	Hantane	12	29, 40, 41	0-2	2,200	95	+
28	26- 9-1956	Hantane	2	70	21-22	2,100	105	+
29	21- 2-1957	Deniyaya, Longford Div.	2	60	2	2,500	108	?
30	22- 1-1957	Dundanell	2	Approx. 25	32	2,300	129	+
						Average	48	

* **Note.** — Means that according to the Superintendent shot-hole borer does not cause loss of yield.
+ Means it causes loss of yield.
? Means influence of shot-hole borer on the yield is unknown.

The standard units were collected from bushes at approximately equal distance apart from one another and confined to those growing along roads or paths. 55 standard units were collected from each field, but only 50 examined in the laboratory. Depending on the size of the fields and the number of suitable units, it took two assistants from 1 to 2 hours to collect them; an exception was in the case of No. 14 field (3 years after planting) where the collection took a longer time. Standard units were easily available and confirm investigations carried out during the initial establishment of the method. Occasionally more than 55 standard units were collected and more than 50 were examined. In all such cases the average number of galleries per 50 standard units is given in column 8 of table 5.

The units were then checked up in the laboratory for size and appearance of bark (*i.e.* new or old); they were next dissected longitudinally into 4 parts and the number of galleries counted.

Comparison of results of the above examinations indicated that units with young bark had an average of only 0.57 galleries per unit (max. 2, min. 0), while those with old bark had 1.11 (max. 7, min. 0) galleries per unit. The percentage of units with young bark varied from 2 per cent to 66 per cent, with an average of 25 per cent for all examinations.

In view of these observations it would perhaps be advisable at future examinations to collect equal number of units with young and old bark.

An assessment of shot-hole borer infestation on any particular field can be undertaken for the purpose of studying the distribution of the pest in relation to climatic conditions, elevation, methods of cultivation, etc., or for purely statistical purposes. The data recorded in tables 5-8 can in no way be considered conclusive owing to the differences in the infestation of standard units of young and old bark, and because of the very small number of fields examined. It appears, therefore, that the data in tables 5-8 should be considered as very approximate indications of the assessment of shot-hole borer infestation.

The opinions of the Superintendents of estates examined regarding the influence of shot-hole borer infestation on the yield of tea are indicated in Table 5. Although numerous galleries were found in some of the fields where, according to the Superintendents, shot-hole borer causes loss of yield, this qualitative relationship should be considered only as an indication of the need for further detailed studies. The data assembled in tables 6-8 are taken from column (8) of table 5.

Table 6.—*Number of galleries in* 50 *standard units in relation to elevation.*

Elevation (feet)	50-1,000	1,000-2,000	2,000-3,000	3,000-4,000	4,000-6,000
No. of fields	14	5	6	1	4
Range	11-89	34-93	59-129	—	0-4
Average	34	62	96	84	1

Table 7.—*Number of galleries in* 50 *standard units in relation to age of tea from planting.*

Time after planting (years)	3-10	11-20	21-30	31-40	41-50	51-60	70
No. of fields	5	2	4	7	6	5	1
Range	32-68	30-31	0-129	4-95	11-84	0-108	—
Average	46	31	70	41	37	52	105

Table 8.—*Number of galleries in 50 standard units in relation to age of tea from pruning.*

Time after Pruning (Months)	0-5	6-10	11-15	16-20	21-25	31-35	39
No. of fields	8	6	2	5	3	5	1
Range	0—108	0-40	14—18	11—74	62—105	4—129	0
Average	65	22	16	41	78	66	0

Table 6 indicates that fields situated above 4,000 feet were either not infested or infested to a very small degree only. Fields situated below 1,000 feet were seldom infested to a high degree. The highest infestation was found in fields situated between 2,000-3,000 feet.

Table 7 indicates that tea plants below 10 years of age can sometimes be infested to a high degree, and that on the other hand, older tea can be infested to a small degree only.

Table 8 indicates that, on the average, the highest degree of infestation occurred in the fields examined in 0-5 and 21-35 months from pruning. The remaining fields were infested to a lower degree but it should be stated that all of them, except for three, were situated either below 1,000 feet or above 4,000 feet.

It can be seen from the data furnished in tables 6-8 that of the factors considered, elevation, age of tea from planting and age in the pruning cycle, elevation influences the degree of infestation to the greatest extent.

5. The assessment of shot-hole borer infestation in field experiments.

The purpose of an assessment is to estimate the influence of the treatment on the pest. The methods of assessment of shot-hole borer infestation hitherto adopted in this country by Gadd and Jepson, and others, are described in detail in their publications and only the main points are, therefore, discussed here.

The assessment of Jepson and Gadd (1922) consisted of periodical counts of the open galleries on 25 bushes from each experimental plot and an examination of the contents of galleries in the prunings.

Jepson and Gadd (1925 and 1926) in adopting their earlier method also counted the number of healed galleries on the 25 bushes from each experimental plot.

Gadd (1941 and 1942) clean pruned 10 bushes from each experimental plot at three week intervals and recorded the number of healed, vacated, abandoned, and occupied galleries in the prunings.

In a further experiment of Gadd (1943, 1944a, 1944b, 1944c and 1949) the assessment consisted of weekly counts of the number of broken branches from the whole experimental area. In some cases weight of the broken branches were determined and the number of empty and occupied galleries and their contents examined. Some of the prunings were also dissected and the number of open and healed galleries recorded.

While it is agreed that at normal pruning time the assessment of infestation of the pest should be carried out on a large quantity of prunings it is considered that the standard unit method might be found suitable for assessing the degree of attack

at various intervals between prunings. The applicability of this method can only be determined by experiments and hence only the general points are discussed here.

It would perhaps appear that, depending on the nature of the experiment, different parts of the standard units should be examined. If interest is in general infestation only, it would perhaps be sufficient to examine only the total number of galleries. On the other hand, in some experiments estimation of the direct influence of treatment on the insects can be important, *e.g.* in experiments where the bushes are treated with contact insecticides, so as to prevent the female beetles from making galleries, not only the total number of galleries but also the number of live adults and perhaps of "obviously open" galleries should be examined.

Two examinations were carried out to test the applicability of the method.

5.1. Examination at Ingiriya Estate

Field No 5 planted in 1930. The Tea Research Institute has been carrying out since 1952, experiments to determine the influence of the length of the pruning cycle on the yield of tea and on shot-hole borer infestation. Between 26th November and 3rd December 1956 10 experimental plots, 1/10 acre each were examined. For the purposes of the test, data from the $2\frac{1}{2}$ year cycle plots alone are shown. These are pairs of plots treated identically in different blocks. Data regarding yields were kindly supplied by Dr. A. W. R. Joachim, O.B.E. 45 standard units were collected from each plot, but only 40 were examined. It took five assistants an average of 17 minutes per plot to collect them.

According to the Superintendent shot-hole borer does not cause loss of yield in this field. Average data for the examined area per 50 standard units are as follows: live adults 4, total number of galleries 20. Comparison of the last figure with the data given in column (8) of table 5 shows that infestation was low. Results of the examination are recorded in Table 9.

Table 9.—*Results of examination at Ingiriya Estate.*

Plotnumbers	Yield from 9-6-1952 till 30-11-1956		Number of Standard units examined	Units with young bark		Galleries				Live Adults	
						Total		Obviously open only			
	Lbs/ acre	Ratio		No.	Ratio	No.	Ratio	No.	Ratio	No.	Ratio
A5, B5, C5, D5, E5	2,231	100%	200	46	100%	76	100%	16	100%	19	100%
A6, B6, C6, D6, E6	2331	105%	200	46	100%	85	112%	16	100%	9	47%

5.2. Examination at Galbode Estate, Galkondura Division

Field No. 9, planted in 1947 and last pruned in August 1955. 10 plots, 1/10 acre each, were marked on this field. They were placed in one row and numbered successively. Standard units were collected on the 5th and 6th February 1957. Although only 40 units were examined, in order to find out how long it would take to collect a larger number of units, 65 were collected from each experimental plot. It took 5 assistants on an average of 21 minutes per plot to collect these. According to the Superintendent, shot-hole borer caused loss of yield in this field. Average data for the examined area per 50 standard units were as follows: live adults 58, total number of galleries 65. Comparison of the last figure with the data given in column (8) of table 5 shows that the infestation of the examined area can be considered as high. Results of the examination are recorded in Table 10.

Table 10.—*Results of examination at Galbode Estate.*

Plot numbers	Number of standard units examined	Units with young bark		Galleries				Live adults	
				Total		Obviously open only			
		Number	Ratio	Number	Ratio	Number	Ratio	Number	Ratio
1, 3, 5, 7, 9	200	114	100%	261	100%	204	100%	245	100%
2, 4, 6, 8, 10	200	125	110%	268	103%	196	96%	230	94%

In both examinations standard units were collected at random. As the early emergence of adults from the units was possible, they were examined on the days of collection. In the laboratory the sizes of the units were checked up, and after an examination of the bark, they were dissected into 4 longitudinal parts and the number of galleries and live adults counted.

The data given in Tables 9 and 10 show that there were no significant differences in the total number of galleries and of "obviously open" ones in the two sets of plots. In other words there is an indication that, in the case of the experiments described above, the method described furnishes an assessment of the degree of shot-hole borer infestation by examining 40 units per plot. The same tables show that there were also no significant differences in the number of units with young bark between the two sets of plots. As for the number of live adults, no differences between the two sets of plots appeared in the examination carried out at Galbode. In the case of the examination carried out at Ingiriya the number of beetles were too small to make any positive deduction.

Only such treatment of the tea bushes as would both decrease the total infestation of the shot-hole borer and increase the yield, can be considered as satisfactory. Examinations carried out at Ingiriya (Table 9) show that there were no significant differences either between the yields of the two sets of plots or the number of galleries per 200 standard units. It would therefore appear that this method is likely to be of use in experimental work.

Any disadvantages of the method may be realised with further trials, but some of its limitations can be pointed out here. Firstly, the method is not applicable to tea plants younger than three years and, as for older bushes, only branches with 6/16 inch diameter at base and top can be utilised.

6. Summary and Conclusions

(1) A piece of live branch, 4 inches long, 6/16 inch in diameter at base and top, and free of any secondary branch or green shoot, is taken as a standard unit.

(2) Trial assessments of 30 fields indicated that fields situated above 4,000 feet elevation were either not infested or infested to a small degree only. Fields situated below 1,000 feet were in general infested to a small degree. The highest infestation was found in fields situated between 1,000-4,000 feet.

(3) It appears that the standard unit method may be suitable for assessing the degree of shot-hole borer infestation in field experiments at intervals between prunings.

(4) This method of assessment needs further investigation.

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References

GADD, C. H.—Observations on an attack by shot-hole borer on tea. Tea Quarterly **14,** 1941: 132-146.

GADD, C. H.—The effect of plucking on shot-hole borer attack in tea. Tea Quarterly **15,** 1942: 31-40.

GADD, C. H.—Does manuring reduce the damage caused by shot-hole borer? Tea Quarterly **16,** 1943: 30-39.

GADD, C. H.—Shot-hole borer damage and tea yields. Tea Quarterly **17,** 1944: 2-11.

GADD, C. H.—An unusual correlation between insect damage and crop harvested. Annals of Applied Biology **31,** 1944: 47-51.

GADD, C. H.—A further note on an unusual correlation between insect damage and crop harvested. Annals of Applied Biology **31,** 1944: 250-254.

GADD, C. H.—Studies of shot-hole borer of tea. V. Borer population. Tea Quarterly **20,** 1949: 66-74.

JEPSON, F. P. AND GADD, C. H.—The control of shot-hole borer of tea (*Xyleborus fornicatus*). Department of Agriculture, Ceylon, Bull. **72,** 1925: 1-46.

JEPSON, F. P. AND GADD, C. H.—Manuring in relation to the control of shot-hole borer of tea. Department of Agriculture, Ceylon. Bull. **79,** 1926: 1-49.

JUDENKO, E.—Research work on shot-hole borer. October 1955 to August 1956. Tea Quarterly **27,** 1956: 103-105.