PRELIMINARY ECOLOGICAL STUDIES ON THE SHOT-HOLE BORER AND THEIR RELATION TO THE CONTROL OF THE PEST

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Ecological studies on the tea Shot-hole Borer, *Xyleborus fornicatus* Eich., in the mid-country, were attempted to gather more information on the pest, and with a view to facilitate and improve control measures. The factors governing the growth and decline of borer populations in a tea field are discussed. The availability of suitable young tea stems, for the borers to make galleries in, appears to regulate the pest population in the field. In the mid-country, susceptible wood is most abundant in about the first half of the second year from pruning. Because efficient control of Shot-hole Borer damage will depend on the successful protection of new wood, it is possible that satisfactory control may be obtained by the application of an insecticide which need not be as persistent as dieldrin, in about the 10th to the 14th month after pruning.

Changes in weather appeared to have little influence on the borer populations within the tea. However, weather influenced the periods of migration of the beetle populations, which mainly occurred in March-April-May and again in October-November. Borers can fly far and they can also be transported by air currents to great distances, so that beetles migrating from one field will not only infest the neighbouring fields but also far off tea fields. It is suggested that the main source of infestation of tea fields is by the deposition or re-settlement of these air-borne borer populations. In deciding the most suitable times for control measures, it is, therefore important to consider, not only the age from pruning, but also the seasonal peaks of aerial migration so as to achieve the maximum protection of the new wood against attack. It is likely that the most suitable months for spraying in the mid-country will be March-April or September-October; preferably early March or late September of the next year following pruning wherever the tea has reached the 10th to the 14th month after pruning. This has yet to be tested by field experimentation. Other details concerning the ecology of borer populations and its relation to the control of the pest are discussed.

Introduction

A clear knowledge of the ecology of any pest is essential for the successful development of efficient control measures. Earlier studies (Gadd 1949; Cranham 1963) on the populations of the tea Shot-hole Borer, *Xyleborus fornicatus* Eichh., were confined to the study of the pest within the tea plant. Our knowledge of some salient points such as the mode of reinfestation of tea fields, the effect of the dispersal of the population in the tea bush, and the effect of weather factors on population fluctuations, still remains incomplete. An ecological approach to the study of the borer populations in a tea field both in the tea bushes as well as in the air above it was, therefore, adopted. This paper presents additional information about the above points and discusses their significance in the control of the pest.

Materials and methods

The Shot-hole Borer breeds in tea bushes which are usually pruned once every three years in the mid-country. Although the tea plant is a perennial, there is renewed growth of wood after each pruning. The present investigation covers one pruning cycle from May 1962 to July 1965 of a mid-country, 70 year-old tea field at Hantane Estate, Kandy, situated at an elevation of about 2,500 ft. The experimental area covered 11 acres and was divided into two sections. The tea in both sections was 'cut-across' 18 inches above the ground in April 1962. One section covering 5.8 acres was sprayed with dieldrin at the rate of 6 pints (1½ lb active ingredient) in 80 gallons of water per acre on the 9th February 1963, *ie* ten months after pruning. The other section covering 4.5 acres was left unsprayed. Only the lower frames received the spray, and the flush from the sprayed section was discarded for six weeks. This 'mid-cycle' spraying was done in order to compare the growth of the borer populations in the sprayed field with that of the unsprayed field.

Sampling

The borer populations in the tea were sampled by the 'standard unit' method (Judenko 1958) in which lengths of tea stems 4 inches long and 0.35 inch in diameter were used. Three samples each of 100 such units, were collected freely without conscious bias from the sprayed and untreated sections. The number of all stages of borers (eggs, larvae, pupae and adults both male and female), and the number of galleries (open and occupied by the beetle; open but vacated; and healed) per sample were recorded. In order to reduce errors in sampling, means per sample (100 'standard units') of tea stems were calculated from this data. The sampling was done fortnightly until the 18th month, after which it was done monthly. In addition, five groups of 15 entire branches each, were collected from the tea fields each month from the 23rd month onwards. The branches were split down the middle into two halves and the number of galleries recorded. Monthly 'line sampling' in the tea was done to investigate the progressive infestation of the sprayed section from the borders of the untreated section. Twenty five 'standard units' from each contiguous group of 5 × 5 tea bushes were collected in transections (or lines of sampling) from the borders of the sprayed and untreated sections towards their centres.

The aerial populations of both the sprayed and untreated sections were assessed by trapping with 9-inch Vent-Axia suction traps placed at the level of the plucking table in the centre of each section of the field. In addition, a vertical series of four other 18-inch propeller type suction traps at 6, 9, 23 and 45 ft was erected in the centre of the untreated section in order to study the flight and migration of the borers. All the suction traps were changed daily at 08.00 hours to 09.00 hours, for the entire duration of the pruning cycle. Further, from the 7th April to the 15th June 1964 they were changed hourly from 08.00 to 16.00 hours which is the period of maximum flight of the borers. The catches were preserved in 70% ethanol from which *X. fornicatus* was identified and recorded.

Anemometer readings were recorded at 45 ft at the trapping site. Rainfall, temperature and the duration of sunshine were recorded daily. The mean yields of tea per acre for the entire field (46 acres) were obtained from the records of the estate and are used here only as an index of the growth periods of the tea.

Treatment of samples

As all galleries made by the beetles become a permanent feature in tea stems, the number of galleries recorded using the 'standard unit' method represents a cumulative total of all the galleries formed per unit length of stem. In order to indicate trends in gallery formation succinctly, probability distributions have been fitted to the observed time sequence of samples, and, thereafter, curves drawn through the points are transformed (see Harding 1949). The rate at which new galleries are formed is estimated from this fitted curve, by calculating the difference between two successive months.

Results

Factors regulating borer populations in the tea field

Synchronous growth of crop and pest populations

As with most pest populations and their host plants, there is a close relationship between the growth of the tea after pruning and the development of the borer population. The synchronous growth of the tea and the borer population is reflected in a decline of the population immediately after pruning, a steady increase until about the middle of the second year and a gradual fall in the third and final year. This, however, is only the general trend in the population. Other factors, such as the quality and quantity of suitable wood, and the weather, also have an influence on the populations. Figure 1 shows a comparison of the fluctuations in numbers of borers in the air above the sprayed and the unsprayed sections. Figure 2 shows the influence of weather factors on the populations. The tea yield is shown here in order to indicate the synchronous growth of the tea and the population of the pest.

Relation of borer numbers to the numbers of new galleries

There is a high correlation ($r = +0.895$) between the rate of formation of new galleries in tea stems and the growth of borer populations in the tea. The rate at which new galleries are formed increased rapidly in the first half of the second year of the pruning cycle, reached a maximum around 18 months and then gradually decreased until the end of the cycle. This trend is also seen in the growth and decline of borer populations of all stages, and of young and adults considered separately (Figure 3). For any one period within the pruning cycle the proportion of new galleries formed in the tea stems were related to the proportion of borer numbers; for instance between the 14th to 20th month after pruning about 42% of all new galleries for the 3 year cycle were formed by approximately 40% of all adult borers. For the whole of the second year 67% of the total number of new galleries were formed by 63% of all adult borers.

Migration of the borers

There was a correlation ($r = +0.797$) between the mean numbers of adult female borers in the crop per hundred 'standard units' of tea stems and the total numbers of adult females caught in flight above the tea in the suction traps. A simple regression calculated with the same data, was highly significant ($P < 0.001$ $b = +1.1402 \pm 0.1661$***). From this it can be assumed that the aerial population is partially dependent on the terrestrial population in the tea below it; which means that most of the beetles caught in flight above the tea came from the galleries in the tea stems, rather than from elsewhere. Figures 1 & 3 indicate that migrations occur mainly at particular periods, *ie* just after the middle of the 2nd year, at the end of the 2nd year, just before the middle of the 3rd year and at the end of the 3rd year.

The influence of weather factors

Simple regressions of the mean monthly adult borer populations in the tea (mean per 100 'standard units'), on mean maximum temperature and total rainfall for the month were not significant. A regression with the same data of the populations in the tea on monthly mean hours of sunshine was significant at the 5% level ($b = -0.133 \pm 0.060$). Simple regressions of total monthly numbers of borers in flight over the tea, on mean maximum temperature and mean hours of sunshine were not significant. The regression of aerial population on rainfall was just significant at the 5% level ($b = +0.054 \pm 0.027$), but there was no relation between the number of wet days and the catches in the suction traps, over a period of 2½ years.

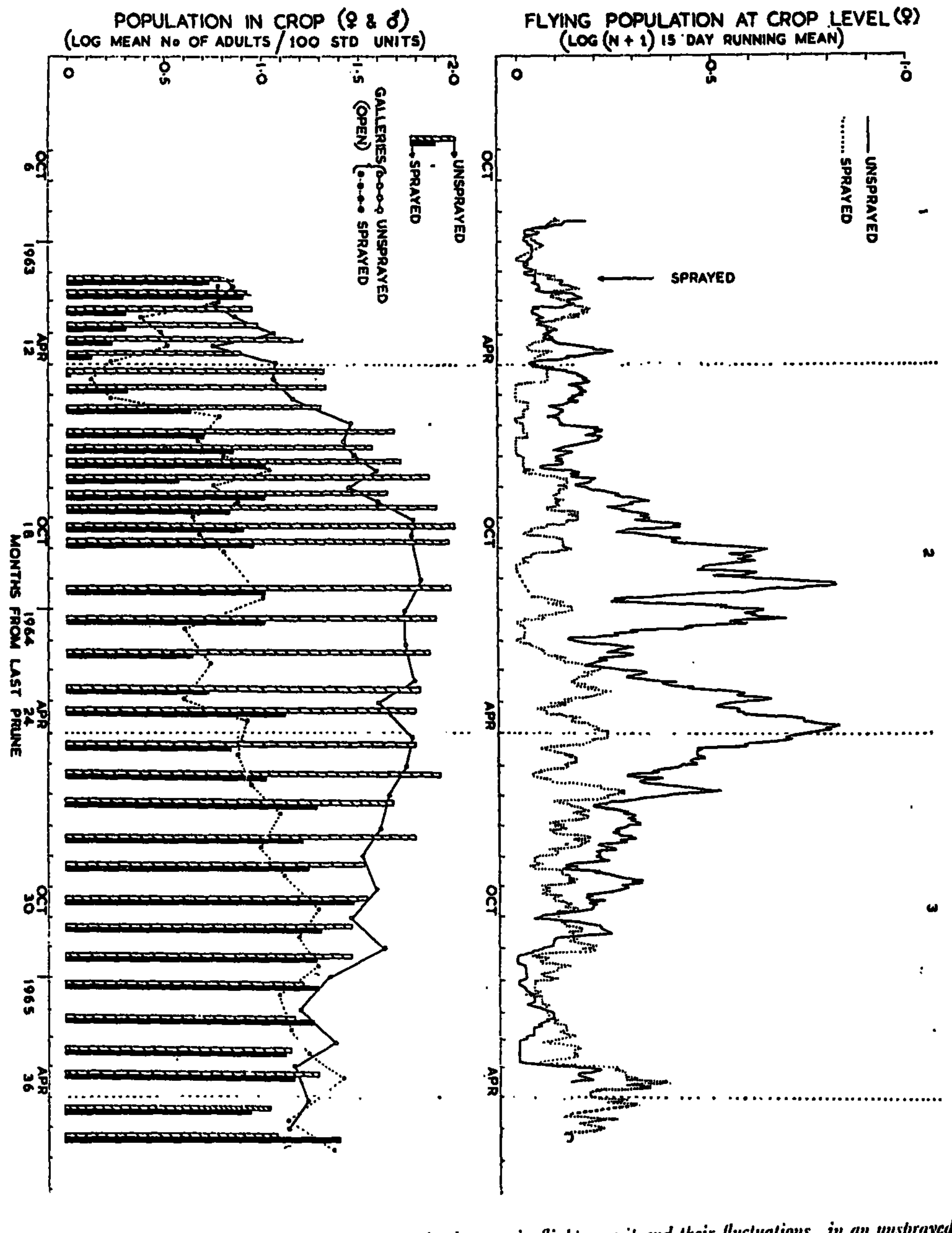

FIGURE 1—*A comparison of borer populatons in the tea, in flight over it and their fluctuations, in an unsprayed tea field with that in a field sprayed with dieldrin in the 10th month from prune — A 15 point moving average is used*

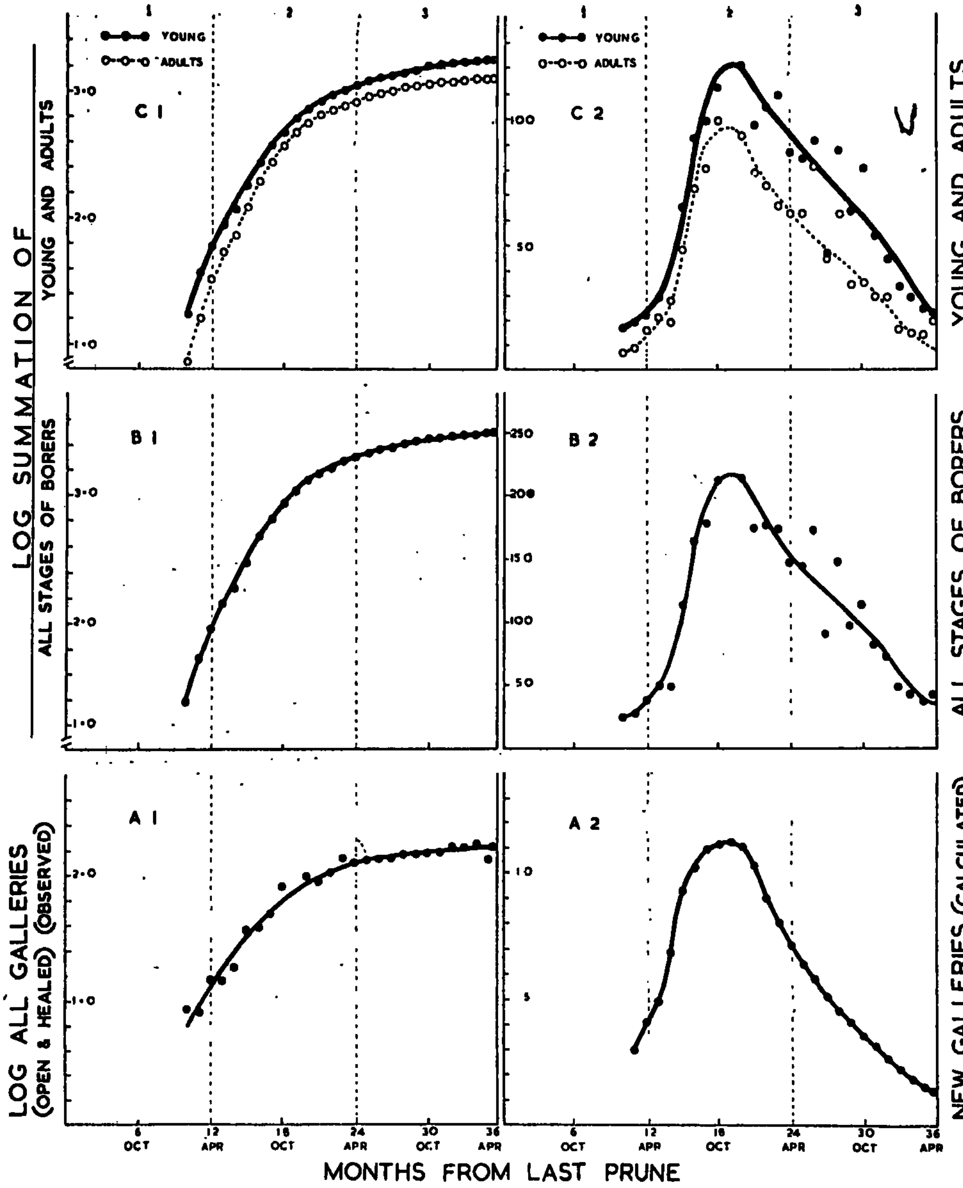

FIGURE 2—*The relationship of galleries in tea stems and their borer populations—A_1, all galleries (observed); A_2, new galleries (calculated); B_1 & B_2, all stages of borer (eggs, larvae pupae and adults); C_1 & C_2; young stages and adults—The data are means/100 standard units of tea stems*

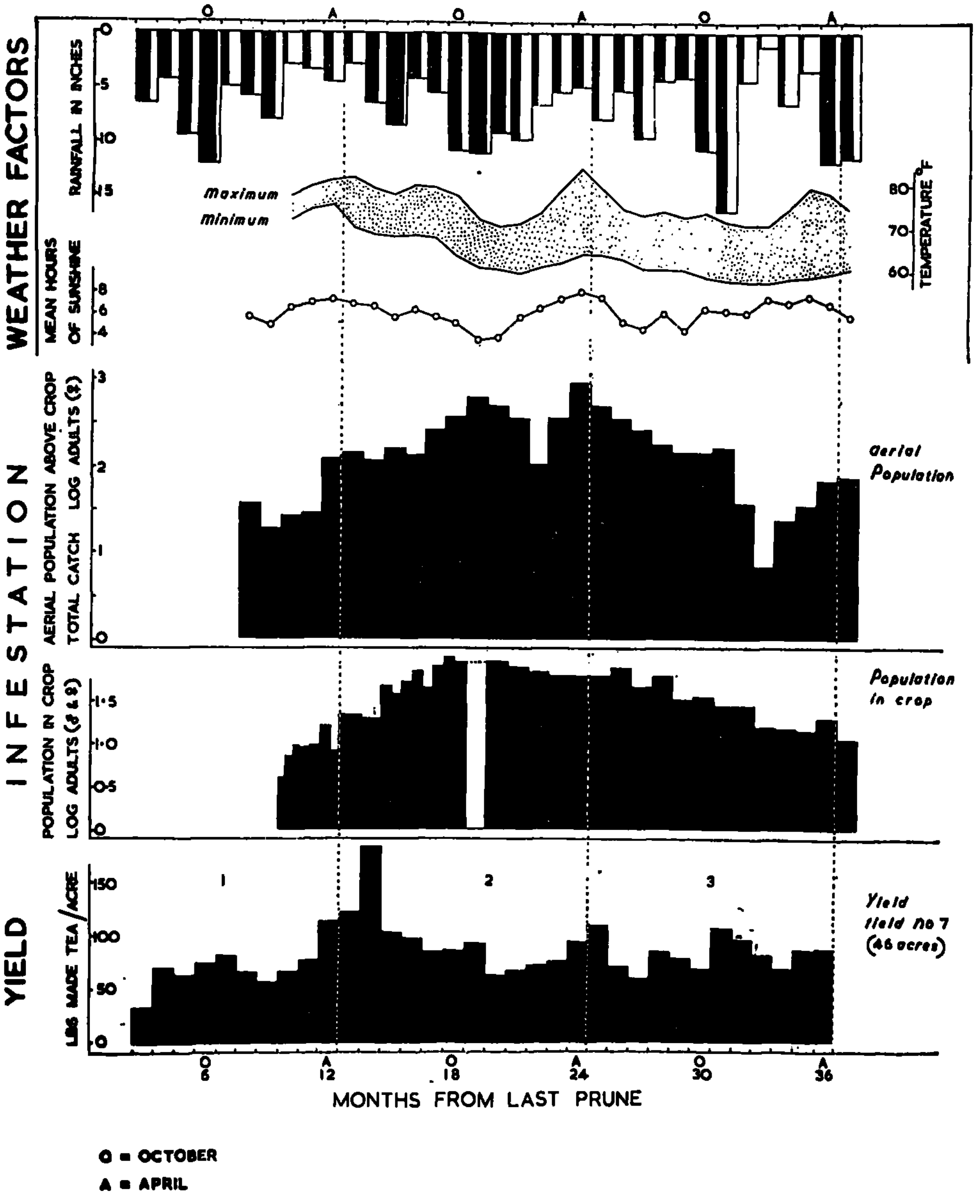

FIGURE 3—*Fluctuations in yield, borer infestations (populations in crop and that above it) and weather factors in a tea field in the Mid-country — The yield is only meant to indicate growth periods in the tea — (The shaded portions in the histograms of rainfall indicate the number of wet days)*

It is, therefore, concluded that in this experiment the fluctuations of any one of the weather factors did not directly regulate the growth of borer population to any marked extent. However, there appears to be a relationship between the growth periods of the tea, as indicated by yield, and the times of aerial migration (Figure 2). The yield of tea is rather dependent on weather, which might, therefore, have an indirect effect on population fluctuations.

The percentage distribution of numbers of borers in flight at different temperatures is shown in Figure 4. The diurnal rhythm of flight is regulated by the true flight threshold temperature of 26°C (=78.8°F), when light intensity did not limit the times at which flight started and ceased for the day. In addition regression of the mean maximum temperature on the mean flight occurrence for the months from May 1963 to April 1965, was significant at the 1% level ($b = 0.724 \pm 0.226$). Further, there are regular depressions of aerial numbers of borers in flight, in the months of January and February (Figures 1 & 5). These are relatively dry months at Hantane, with low temperature, averaging 18.7°C (65.7°F). These results and the day to day observations of the catches in the suction traps and the weather of the day indicate that the depression in aerial numbers in these months of January and February of each year are mainly due to the low temperatures.

Patterns of attack within the pruning cycle

The primary damage the borers cause to the tea results from the galleries that they construct in the tea stems. Figure 3 illustrates the rate at which these galleries are made. Relatively little of the attack is made in the first year, then the rate of attack rises sharply to a peak about the middle of the 2nd year, after which there is a gradual decline of the attack in the third year to very low levels.

Figure 5 shows trends in gallery formation for both, the sprayed and unsprayed sections, measured by the 'standard unit' method, throughout one pruning cycle. As the tea ages, more galleries are made on more tea stems, and the average number of galleries per 'standard unit' continues to increase, both in the sprayed and untreated areas. Further, at the end of the 3rd year about 10% of the units collected were free from attack. The number of galleries per unit increased as the tea aged, so that the percentage of units with two, three and even four to six galleries showed a regular increase as shown in Figure 6.

The proportion of galleries occupied, vacated, and healed, throughout the entire pruning cycle, for the untreated tea, are shown in figure 7, where the trends in occupied galleries also indicate the growth and decline of the borer populations within the tea bush.

The effect of the dieldrin spray on the borer populations

A comparative study of the build up of borer populations in the sprayed and unsprayed sections indicates the possible ways in which the 'mid-cycle' spray of dieldrin affected the growth of the borer population in the tea (Figures 1 & 5).

Table 1 shows the infestation based on the number of new galleries formed on sprayed and untreated tea for each year of the pruning cycle.

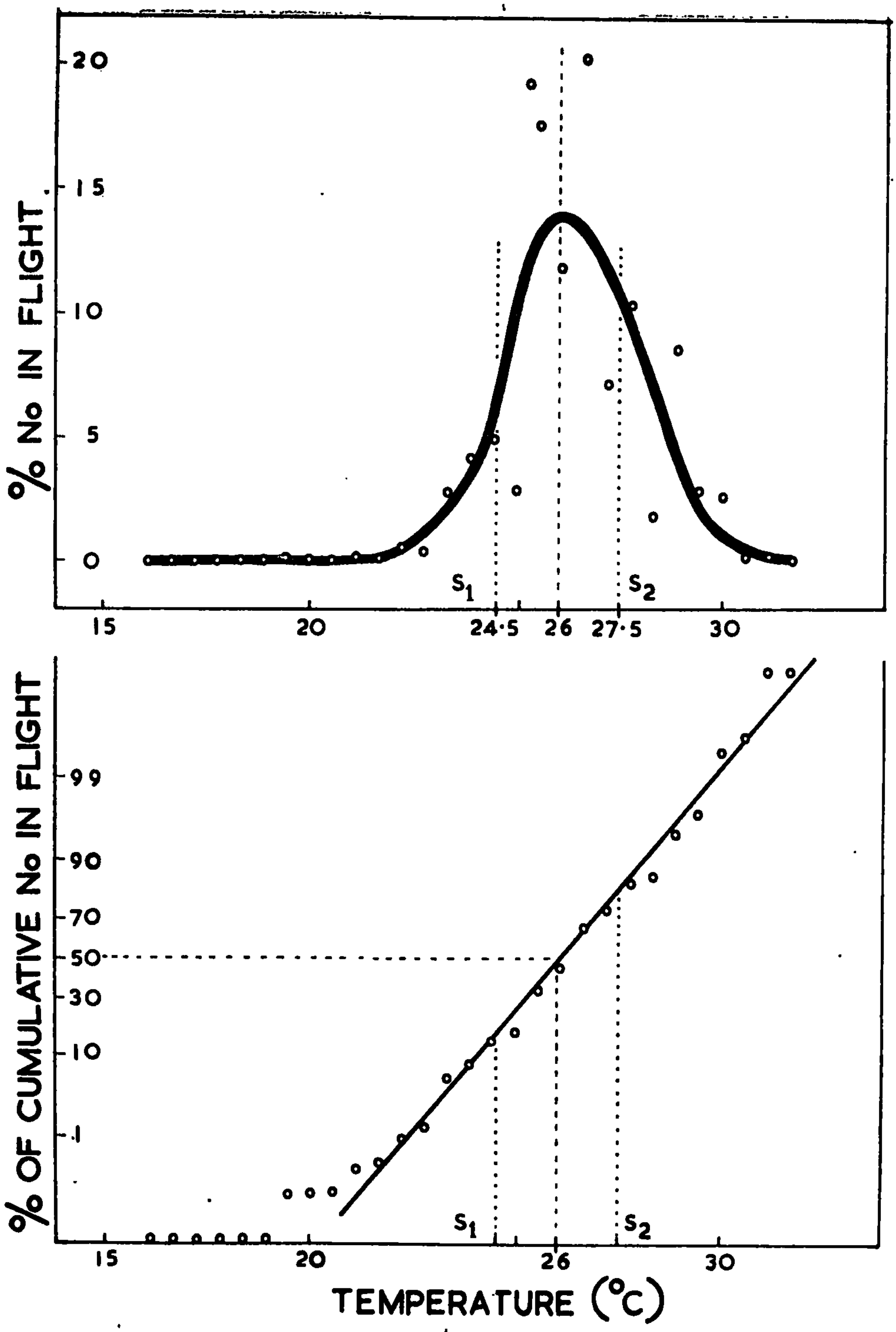

FIGURE 4—*The percentage distribution of numbers of borers in flight at different temperatures—The true temperature threshold for flight of Tea Shot-hole Borer is 26°C (78.8°F)—(Standard deviation = ½ ($S_2 - S_1$ = 1.5°C)*

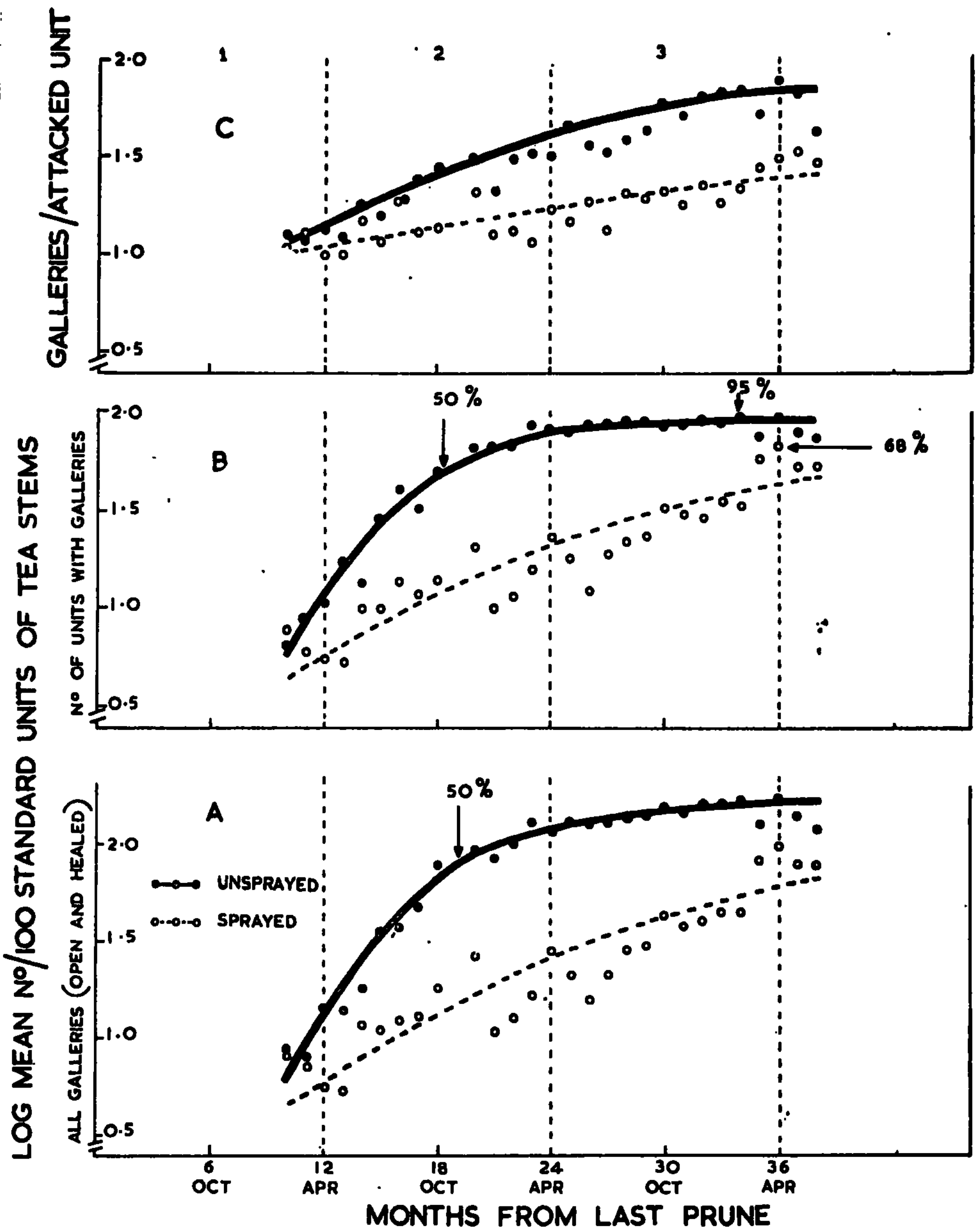

FIGURE 5—*Comparative trends in gallery formation in unsprayed tea field with that sprayed with dieldrin in the 10th month from prune—Trends in the build up of all galleries (A) and the number of units attacked (B) for both the sprayed and unsprayed tea are illustrated—The average number of galleries/attacked unit (C) is calculated from the mean monthly values plotted in graphs A & B*

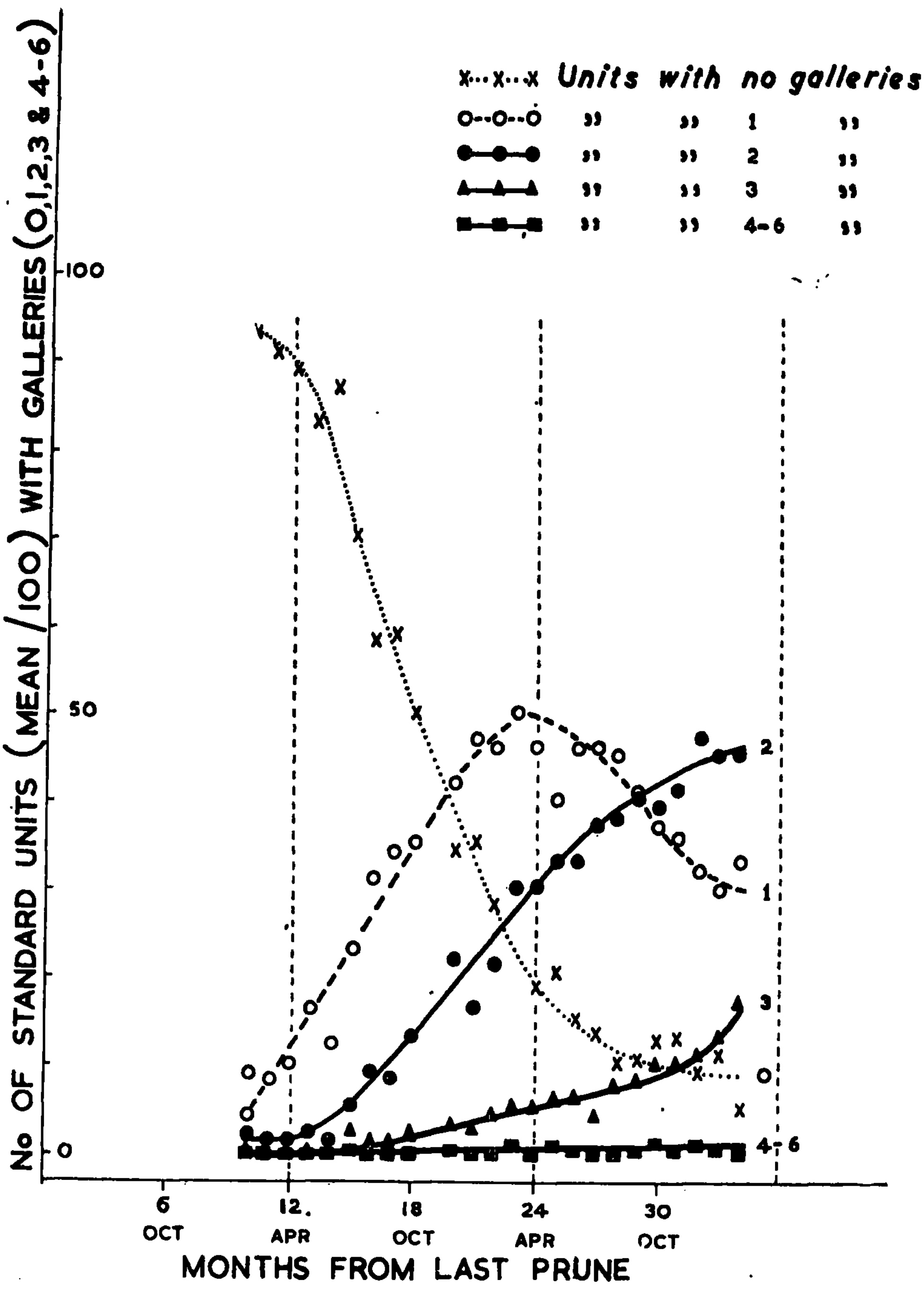

FIGURE 6—*The density of galleries in the standard units of tea stems—The average rate at which units are attacked and the mean number of galleries formed (either 1, 2, 3 or 4-6 galleries) in each unit are illustrated in the time sequence, so as to indicate trends*

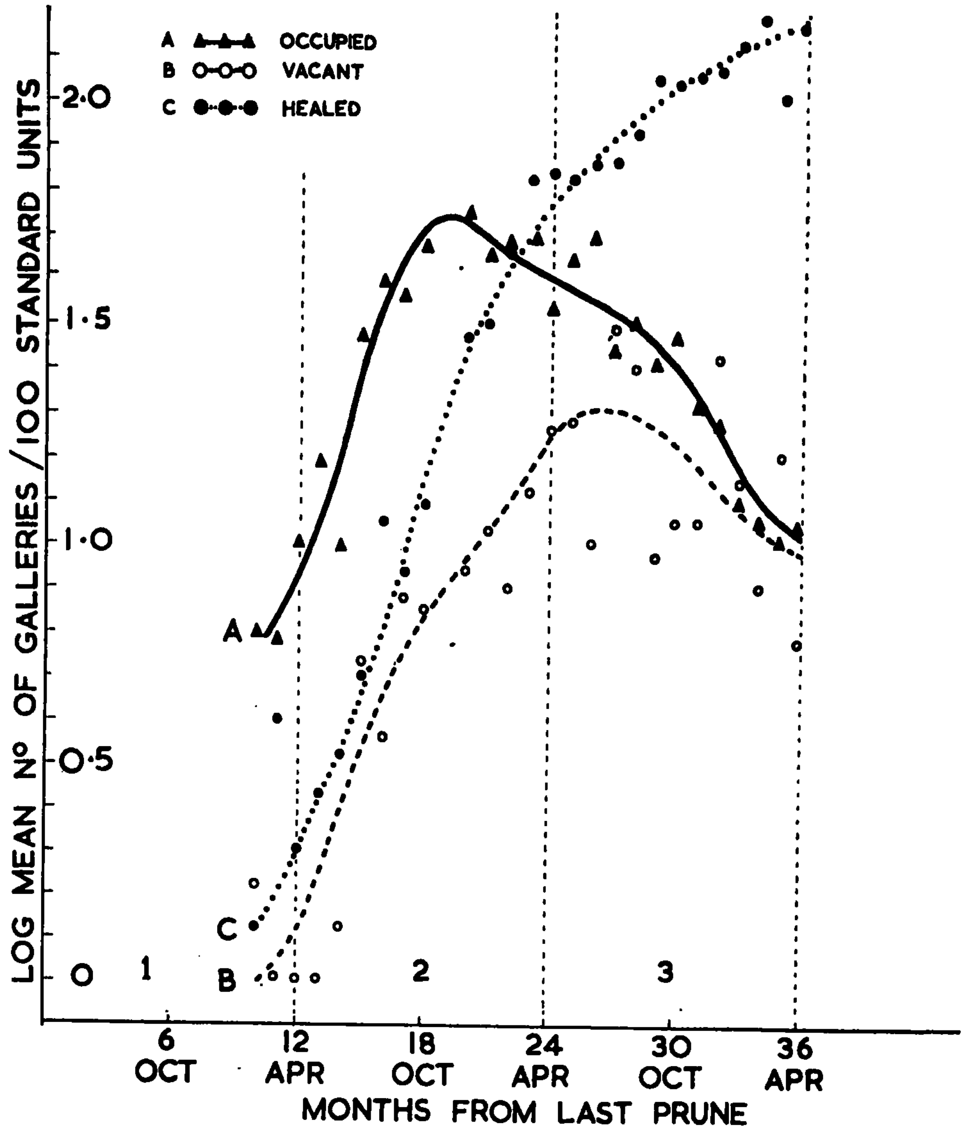

FIGURE 7—*The fate of galleries in tea stems—The proportions of galleries occupied, vacant and healed throughout the pruning cycle are shown*

TABLE 1—*Shot-hole Borer infestation on fields sprayed with dieldrin and on untreated fields*

	Treatment	PERIOD IN PRUNING CYCLE 1st year	2nd year	3rd year	Total
Mean No & % of *new* galleries/ 100 Std units	untreated	13 (8%)	110 (67%)	42 (25%)	165 (100%)
	sprayed	6 (10%)	20 (33%)	35 (57%)	61 (100%)
Estimated % of attack in sprayed area, taking unsprayed as 100%	untreated	100	100	100	100
	sprayed	46	18	83	37
Control obtained		—	good	bad	moderate

From Table 1 it is seen that the dieldrin spray brought about good control in terms of the number of *new* galleries formed in the second year after pruning, but the control in the third year was poor. The control of the attack on the whole, in the first, second and third year, can be regarded as only moderate. However, since the damage from the galleries has a lasting and accumulative effect, it is most likely that the benefits in the form of increased yields brought about by the control of attack during the second year could result in a further increase in the third year.

Discussion

The determination of the factors that affect the numbers of insects and the clarification of important regulatory mechanisms are useful both in the prediction of pest infestations and the manipulation of control methods. The ability to predict may lead to more sensible pesticide use, and a knowledge of the regulatory mechanisms may enable us to manipulate the control of the pest more effectively. This study evaluates some factors that regulate borer numbers in tea fields, provides information on the periods of the pest out-breaks, and suggests that judicious timing of spray applications may help achieve better control of the pest.

It must be noted that this study was limited to only one location, for a short period of about three years. These results may be valid for tea in the Kandyan mid-country. Similar studies in other major climatic zones need to be initiated.

Gadd (1941; 1944) and Cranham (1963) have suggested that the amount of suitable wood available affects the growth of borer populations. The present investigation has provided circumstantial evidence in support of this. It is possible that the moisture content in the wood, acting as a limiting factor on the growth of the Ambrosia fungus, may affect not only the development and survival of the borers, but it may also play an important part in the initial invasion and successful infestation of the tea stems. Although the amount of suitable wood decreases in the third year the wood does not seem to be saturated with galleries. A self-regulatory mechanism of the borer population due to saturation of the wood with galleries does not, therefore, seem to exist.

It has been observed in breeding experiments that adult females bore more readily into young sappy tea stems than into older mature wood. Gadd (1941) found that many beetles in 3-year-old tea abandoned their galleries before they were completed possibly because the wood is too mature for breeding. These observations along with the correlation between the growth of borer populations and the proportions of new galleries formed, indicate a possible relationship between the fluctuations of the borer populations in the tea and the changes in the amount of suitable young sappy wood available. Observations in the field and the examination of the samples indicate that the maximum amount of young sappy tea stems were available from about the 14th to the 20th month. With the progressive maturation of the wood, the stems become harder, drier and more fibrous and are less likely to be attractive to the beetles.

Gadd (1944) also showed a correlation between the growth of tea in terms of yield, and the intensity of borer attack as indicated by the number of breakages of the stems. He presumed that the increase in the damage resulted from the increase in the number of galleries formed. The present work indicates that there may be a relationship between the availability of young sappy wood suitable for the formation of new galleries and the growth of borer populations.

Gadd (1941) found it difficult to correlate the numbers of beetles emerging from the galleries with the population remaining in the tea. He suggested that there might be a heavy mortality rate of the adult beetles emerging from galleries. It is now known that most of the borers emerging from the galleries do not flit or hover over the tea but fly upwards in a slow fluttering manner, resulting in mass migration away from the breeding site (Calnaido 1965b).

It is likely that periodic flights are mainly determined by the numbers of post-tenerals (newly matured adults) in the tea and the changes in the weather factors (see below). It is suggested, therefore, that one of the factors regulating the borer population in a tea field is the periodic migration of beetles from the infested tea. It would follow that in any one tea field the fluctuations of the borer population in the tea will also depend to some extent on the numbers immigrating into the field and emigrating from it, but the facility with which beetles entering a tea field are able to successfully recolonize and breed will depend on the amount of suitable young sappy wood available.

During peak periods of migration there is high temperature, much sunshine and high humidity. It is not known to what extent, if any, the periodicity of aerial migration is related directly or indirectly to the growth of the tea. It may, however be possible that these growth periods are also indicative of times of abundant sap flow within the tea stems, which may in turn encourage the growth of the Ambrosia fungus (the borers' food supply) within the galleries in the stems, and thus bring about an increase in the successful breeding, emergence and migration of the borers.

An important observation with regard to the pattern of attack was that as the tea aged from pruning there was a progressive thickening and maturing of the tea stems upwards, with the result that the height above the ground of maximum infestation in the tea bush rose. In the third year, it was mainly the upper parts of the tea stems, which had now thickened to about the 'standard unit' size, that carried the maximum attack. Samples of split branches collected at the end of the 3rd year from the untreated and sprayed fields, showed the history of the attack in these two fields. Most of the branches from the untreated field were heavily riddled with galleries in their entire length; whereas the majority of the branches from the sprayed field had fewer galleries in them, and most of these, were found in the upper parts of the stems. Samples taken at the end of the third year, also showed that the branches from the heavily infested untreated field were generally dilapidated while those from the sprayed field were healthier in appearance. It can, therefore, be assumed that when the second year attack is controlled by spraying, the small third year attack would be relatively less harmful, particularly because the next prune would remove the third year damage in the branches, as was found to be the case in the sprayed field.

It is the authors' contention that the 'mid-cycle' application of dieldrin has affected the growth of the borer population in the sprayed field in three ways. Firstly, the dieldrin spray, by its initial insecticidal action has almost completely reduced the borer population in this field about three months after spraying (see Figure 1). Secondly, the initial kill and consequent reduction in the borer population appear to have brought about a reduction of the growth rate of the population. Thirdly, the insecticide persists long enough to make the environment unsuitable for the borers, particularly at the most crucial period in the pruning cycle (from about the 14th to the 20th month) at which time the tea stems are most susceptible for attack and most suitable for the vigorous breeding of the borers.

At the time the insecticide was applied, *ie* in the 10th month, the population level was very low, being one tenth that of the peak at the 18th month. In the middle of the third year the populations in the sprayed and unsprayed sections were about the same. This is probably a result of the persistence of the insecticide subsiding, and also of the maturation of the wood which becomes unsuitable for the borer. An explosive increase in the population is thereby prevented. It is, therefore, assumed that the protection the insecticide affords young susceptible wood from being attacked, is the most important action of the insecticide in limiting the otherwise heavy infestations of borer populations in the tea. In these experiments the 'mid-cycle' application of dieldrin was used only to facilitate a comparative study of the growth and decline of borer populations. We have attempted to give a provisional explanation for the possible ways in which the dieldrin spray could have affected these populations; nevertheless, detailed investigations on the mode of action of this insecticide on borer populations in tea are desirable. Especially, in view of the adverse experience of some estates, resulting from dieldrin spraying, it is important to consider pest control in tea from an ecological standpoint. A study of the fundamental relationships that exist between host plant, pest populations and other biotic and physical factors operating in the *ecosystems* (Odum 1964) of tea estates is essential for the successful development of future research on pest control problems.

Sources of infestation

There are three possible sources of recolonization of tea fields; firstly, by the growth of the remnant population left after pruning or after the application of an insecticide; secondly, by the infestation from nieghbouring infested fields. The third is by the deposition of adult females in flight from great distances.

It is shown that pruning itself initially reduces the borer population to low levels and the application of dieldrin reduced it further. The monthly line sampling from the unsprayed to the sprayed sections did not reveal any evidence of progressive infestation from the unsprayed section into the sprayed section. However, varying degrees of progressive infestation from the borders of fields may occur in crops, particularly those in a susceptible stage for infestation. The results obtained in these experiments, however, do not indicate that such infestations from the edges of neighbouring tea fields are an important source of recolonization and reinfestation. On the other hand, all evidence on the flight and migration of the beetles indicates that the aerial deposition of borers on their dispersive flight may be a more important source of infestation of the tea fields. Calnaido (1965a) worked out a possible rate of deposition of approximately one beetle per square yard per day. In addition, observations of the beetles caught in suction traps, placed in sprayed areas and on the laboratory roof, away from any immediate sources of beetles, provided evidence of considerable aerial deposition. Further, the repeated occurrence of peaks of attack in the sprayed section around April and October (Figure 5) coincide with the periods of maximum migration of the beetles (Figures 1 & 3). It can, therefore, be assumed that the main source of infestation of the tea fields is by way of aerial migration and scatter, but the successful colonization and breeding of the aerially deposited adult females will depend on the availability of suitable wood and this in turn would be regulated by the age of the tea from pruning.

The relation of these studies to the control of the pest

One of the most important practical aspects of these studies is the evidence of the aerial migration of the beetles and its bearing on the modes of recolonization and reinfestation of the tea fields. We have suggested that borers enter new tea fields or re-enter old sprayed fields mainly by flying in. It is also known that borers in addition to their considerable powers of flight, are dispersed by wind (Calnaido 1965b) which could transport them to distant tea fields. It is, therefore, unlikely that spraying of large divisions of estates will give complete control of the Shot-hole Borer. On the other hand the spraying of larger areas with a persistent insecticide may aggravate the undesirable side effects of such sprays. Thus, as long as we use a persistent insecticide, it would be advisable to adopt the procedure of the treatment of individual tea fields. This is in accordance with current recommendations.

These studies indicate that the most important factor that regulates the borer populations in a tea field is likely to be the availability of soft suitable wood, which is abundant about the first half of the second year. It has also been pointed out that it is in this period of the pruning cycle that the maximum rate of gallery formation and build-up of the borer population take place. Further, the galleries are the primary damage that the pest causes and it is the second year attack that is most economically significant.

It would, therefore, appear that the control of the borer would be primarily a question of protecting the young wood from attack. Control could, therefore, be achieved more effectively in the mid-country by the application of a less persistent insecticide around the 10th to the 14th month after the prune. This is in accordance with the idea of 'mid-cycle' application of insecticides for Shot-hole Borer control (Cranham 1966). Further, the efficacy of repellants and perhaps suitable fungicides on the young sappy wood, so as to make them unsuitable for borer attack, is also worthy of investigation.

The effectiveness of a spray application against a pest will be enhanced if it is applied at the crucial times in the life of the pest. The knowledge of the times of migration of the pest and the periods of susceptibility of the host plant would, therefore, be useful in determining the most suitable times of application of an insecticide. These studies in the mid-country have revealed that the Shot-hole Borer has two peaks of migration—a major peak in March-April-May and another in October-November. It would appear, therefore, that the best time to spray would be early March or late September. It is also important to spray about the 10th to the 14th month, so as to protect the young susceptible wood from attack. It is likely that the maximum control could be achieved by adjusting the dates of spray applications to 10th to 14th month and to the months of March-April or September-October, early March and late September being preferable. These observations, however, have yet to be tested and they point to the need for experimentation on the accurate timing of spray applications.

In order to build up a good healthy basal frame, the protection of young tea, especially vigorous-growing vegetatively propagated tea, is of the utmost importance. New tea fields could be reached by the aerially dispersed borers. It would, therefore, be advisable to protect tea in new clearings in the mid-country by chemical control, in early March and early October, for at least a period of 3 to 5 years or until such time as the basal part of the tea bush is mature enough and is no longer susceptible to borer attack.

It has also been suggested that the Shot-hole Borer damage is lasting and cumulative, in that the consequences of gallery formation in tea stems are not only dieback and wood-rot but also the eventual dilapidation of the tea bush. It is suggested that dilapidated bushes could be improved by the complete removal, by the use of a saw, of about one decayed branch per pruning cycle, so that in the course of a few pruning cycles all the decayed branches could be eliminated and an healthy frame redeveloped. In all such severe prunings, it would be advisable to maintain more lungs than usual and care should be taken not to remove too many whole branches at any one pruning.

Further, it would be advisable to look out for tea fields with histories of severe incidence of the Shot-hole Borer, where the yield remains low in spite of advanced cultural methods. A good test as to whether this is due to past attacks of Shot-hole Borer would be to examine the bush frames and also a few samples of entire tea branches, split down the middle. If these examinations reveal much damage, it would in the long run be economical to uproot and replant such areas with VP tea.

Summary and conclusions

Some aspects of Shot-hole Borer populations in tea, in the mid-country, were studied for a period of about three years, covering almost an entire pruning cycle. A major factor that regulates borer numbers in tea appears to be the quantity of young, soft, sappy tea stems as suitable breeding material for the borers. The borer populations in the tea were not dependent on current weather. The populations in flight above the tea, although associated with weather, were not directly correlated with it. Borers are capable of flight over long distances and they are also subjected to considerable dispersal by air currents. There are two peaks of migration of the beetles for the year, March-April-May and October-November. It is suggested that the main source of infestation of tea fields is by the aerial deposition of adult female borers. It is likely that, in the mid-country, effective borer control may be obtained by the application of an insecticide in early March or late September, of the next year following the prune, wherever the tea has reached the 10th to the 14th month after the prune because this is the time when the wood is most suitable for the pest. The insecticide need not, therefore, be as persistent as dieldrin. Lines for future research have been outlined.

Acknowledgements

We wish to thank Messrs R.S.S.N. Fernando and A. Vincent for their assistance and Messrs J. Bandaranayake and D. J. M. Hettiarachchi for the drawings and the photography of the figures, respectively.

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