

## AN INTEGRATED MANAGEMENT STRATEGY TO MINIMIZE THE ECONOMIC DAMAGE TO MATURE TEA, CAUSED BY THE SHOT-HOLE BORER BEETLE (*XYLEBORUS FORNICATUS* EICHH.)

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### INTRODUCTION

The shot-hole borer beetle, *Xyleborus fornicatus* Eichh., was first observed in tea in Sri Lanka at Craighead estate, Nawalapitiya, in 1892. Since this initial early observation, this insect has been a subject of intense study for the past nearly ninety years. No other insect pest in this country has received such close attention and continued careful detailed study by a galaxy of entomologists, as much as this particular insect pest had received to-date. Amongst the numerous entomologists who investigated this problem, three of them came to be appointed at various times as "special entomologists", working entirely on this particular problem, including Speyer (1914 — 1919), Jepson (1924 — 1926) and Judenko (1956 — 1961).

Thorough studies of its biology, ecology and behaviour were made by several eminent entomologists and various forms of control measures, including several cultural practices were tried out, with hardly any economic benefit. Besides the entomologists, several plant pathologists, plant physiologists and agricultural chemists, including Gadd, Tubbs, Eden, Webster and Tolhurst had helped in assessing the various cultural practices with no positive benefit in curtailing the infestation or damage.

With the appointment of the third "special entomologist", Dr. E. Judenko in 1956, further detailed biological studies were made and he pronounced the insecticidal approach, using persistent organochlorine compounds like Dieldrin, as the most promising line of control, despite the risks of ecological disruptions (Cranham, 1961; Judenko, 1961). However, the continued use of such potent insecticides over a period of five years proved to be too disastrous leading to very serious ecological disruptions and consequently, this unilateral chemical approach came to be abandoned (Danthanarayana, 1966, 1967). Limited applications of less persistent insecticides were recommended as "interim measures" and these too were not found to have any specific economic advantage.

Attempts were made to investigate the biochemical basis of natural resistance in tea clones to shot-hole borer colonization. Some relationship was observed between the level of Saponin and the degree of resistance (Wickremasinghe *et al.*, 1976). In order to facilitate detailed biochemical studies under controlled conditions in laboratory culture, a semi-defined artificial diet was developed to successfully rear the beetles in test tube culture, through successive generations (Sivapalan and Shivanandarajah, 1977a). Investigations on the effects of Saponins from different plant sources and that of certain promising azasterols and non-steroidal amines on brood development did show some promise in such controlled laboratory studies in test tube culture (Sivapalan and Shivanandarajah, 1977b).



*Fig. 1 — A fractured primary lateral branch.*



*Fig. 2 — Pruned primary branch stump exposing early stages of wood-rot setting in through shot-hole borer gallery.*



*Fig. 3 — Tea bushes debilitated by wood-rot on main frame.*

However, attempts to induce the tea plant to stimulate the additional synthesis of such deterrent substances with possible precursors, failed to show any effects on the borer population. Field trials with appropriate amounts of zinc acetate and potassium acetate (as possible precursors of Saponin synthesis), incorporated with potassium acetate (as possible precursors of Saponin synthesis), incorporated with the regular fertilisers, failed to show any effects on beetle population in treated tea bushes, even after a full pruning cycle with such regular treatment applications (Sivapalan, 1981, 1983; Senaratne, 1983).

Several attempts at biological control were made from time to time, with advice from some eminent entomologists overseas and this approach came to be ruled out as not being a promising line of control. The entomogenous fungus, *Beauveria bassiana*, showed promise as a strong mortality agent in laboratory culture, but several attempts at control under field conditions proved a failure (Danthanarayana, 1968). Appropriate species of insect parasites of other related scolytid beetles imported from different countries also failed to take on to this borer species under our conditions (Danthanarayana, 1970; Sivapalan, 1976).

The natural mortality within galleries and the suppression of population as a result of ageing of branches would not be significantly augmented further, even if a non-specific broad-spectral parasite or predator proved to feasibly attack this pest. It is most unlikely that a true population regulation could ever be achieved by such means.

One promising line of management was in the selection of planting material that showed varying degrees of resistance or tolerance to borer attack (Judenko, 1960; Calnaido and Kanapathipillai, 1967; Thirugnanasuntheran and Calnaido, 1968, 1969). Another promising practical line of management of borer population and its damage, was in the harnessing of certain natural phenomena of resistive forces that developed during the growth and maturation phase of the tea plant itself (Sivapalan, 1975, 1976, 1977).

## NATURE OF DAMAGE TO TEA

Shot-hole borer beetle infestation of the tea plant leads to two forms of damage:

### (a) Initial damage

A direct mechanical damage as a result of gallery formation on both primary and secondary branches. In instances of severe infestation, entire branches fracture readily and the fracturing of such basal sections of primary branches can lead to some loss of crop. The fracturing of upper sections of lateral primary and lateral secondary branches, however, do not result in a loss of crop. In fact, the cutting of such lateral branches to form "plucking lanes" is encouraged for better agronomic efficiency. On the other hand, there is no evidence of any effect on crop, when branches remain unbroken, even when these are heavily infested with borer galleries.

Prevention of the above fracturing and the consequent marginal loss of crop has proved to be uneconomical, especially when this is attempted with the environmentally acceptable short-persistent insecticides. The longer persisting organochlorine insecticides have proved to be ecologically very disruptive and unacceptable from the point of view of residues in made tea (Danthanarayana, 1966, 1967).

### (b) Secondary damage

The second-stage damage that follows shot-hole borer infestation is the more alarming long-term protracted debilitation of frame wood, caused by wood-rot that

sets in through the fractures on the main primary branches (Fig. 1) and through exposed galleries on the larger prune cuts (Fig. 2). This debilitation of frame wood, if allowed to proceed unchecked over successive pruning cycles, leads to a weak frame that reaches a condition when recovery from prune would be very poor, with the resulting emergence of a passenger bush (Fig. 3) or, the bush may not recover from prune. This situation leads to death of bushes and the consequent vacancies and the inevitable dramatic decline in crop over a phased out period of time of three or more cycles (Fig. 4).

The above protracted debilitation caused by wood-rot is possible only through the avenues provided by the fractures on the *primary branches* and not through the fractured secondary branches, since the bulk of the latter is removed at every prune (Sivapalan, 1975).

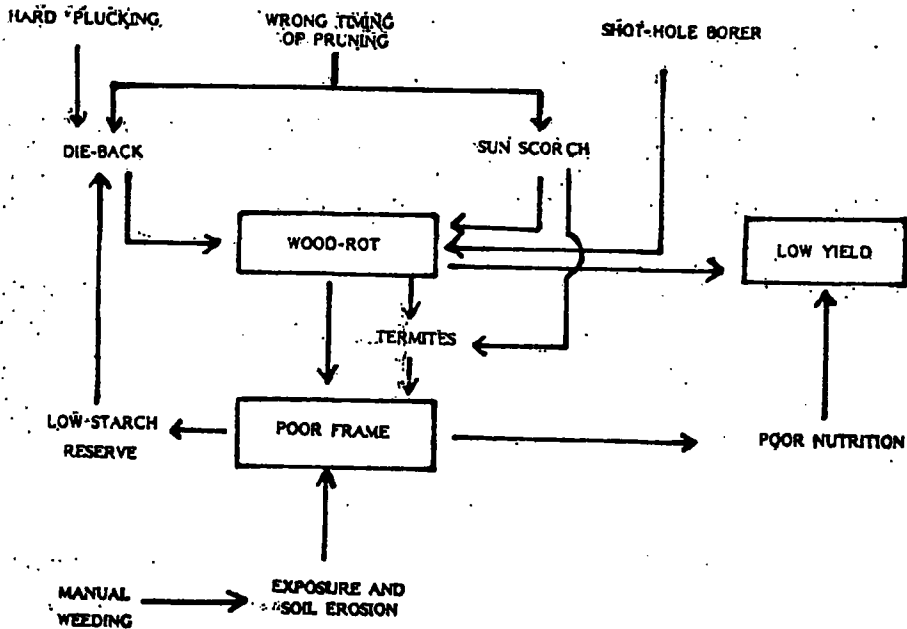


Fig. 4 — The sequence of events leading to the setting in of wood-rot and debilitation of frame-wood.

## SUGGESTED MANAGEMENT STRATEGY

### A. Minimizing Current Infestation

1. The most important step in this strategy is to minimize the incidence of borer infestation on the early maturing primary branches. The borer infestation on the later maturing secondary branches can be ignored since this does not lead to any economic damage (Sivapalan, 1975).

2. During a pruning cycle, every portion of a newly-formed tea branch matures to a critical stage of susceptibility and remains susceptible for a specified period of time and then becomes less susceptible with progressive maturity (Fig. 5).

3. The basal portion of the newly-formed *primary branches* reach the susceptible stage of ready infestation from about the 12th to 14th month from prune and continue to remain susceptible for an additional 12 to 16 weeks during the course of the cycle. This is the most critical period of susceptibility (Sivapalan, 1975).

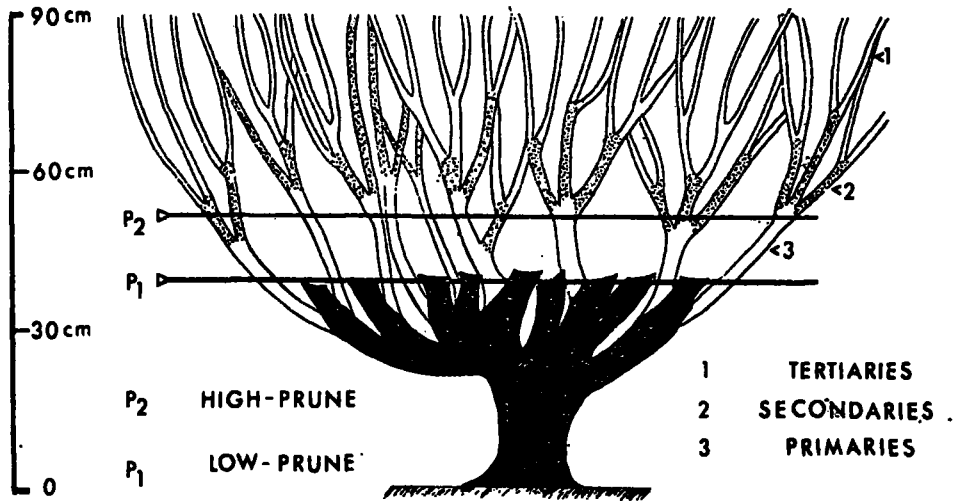


Fig. 5 — Diagrammatic representation showing the basal foundation frame (in black) and branch development following pruning indicating the different classes of branches.

4. The infestation capability of beetle population also varies during the course of a given year — including an active infestation period and a passive period. Detailed studies have shown an interesting inverse relationship between cropping pattern and beetle population levels within a year (Sivapalan, 1977). During peak cropping months the infestation level is low, whilst this potential is the highest during the slump phase and at a time with adequate atmospheric moisture (Fig. 6). The migration of beetles and new colonizations also follow this pattern. Thus knowing the annual cropping pattern in a given locality, one could predict the peak active period of beetle infestation and colonization. This period could range from 12 to 16 weeks.

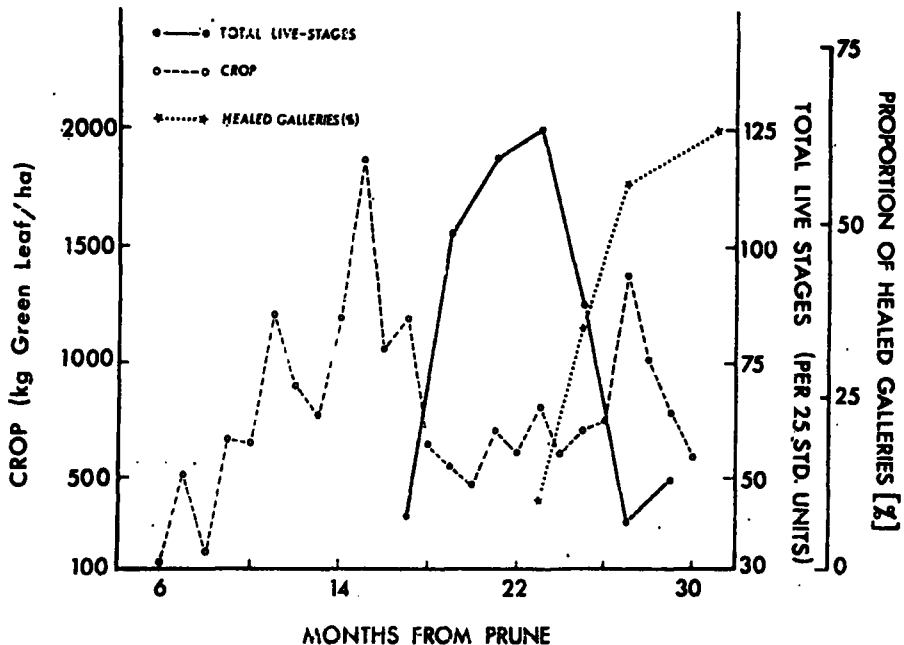


Fig. 6 — Cropping pattern and borer population dynamics.

5. *The vital strategy that needs to be adopted, therefore, is to adjust the pruning time in such a way as to prevent the overlapping of the critical primary branch susceptible stage with that of the peak active period of beetle infestation in the given locality (Sivapalan, 1979a).* It is unfortunate that the pruning times in most areas prone to shot-hole borer damage have been such that the above two stages have often overlapped, resulting in severe damage, cycle after cycle. By adopting this "escape strategy", one could almost completely do away with any other form of artificial control.

6. In addition to the above strategy, as a measure of additional insurance, a short-persistent, ecologically non-disruptive insecticide may be sprayed on to the basal frame, at 12 - 14 months from prune in the low-country (at elevations of 600 m and below) and at 14 - 16 months from prune in the mid elevation (600 - 1200 m). The recommended insecticide at present is Fenthion 50% EC at the rate of 4.5 l in 1000 l of water per hectare. The spray solution should be directed towards the base of the frame, giving adequate coverage.

It must be clearly borne in mind that this treatment by itself is not adequate to give good protection and should be coupled to the strategy mentioned above.

#### **B. Minimizing the Subsequent Protracted Debilitation**

Having adopted the above simple and vital strategy to minimize current infestations on the early maturing primary branches, the next vital strategy is to minimize the setting in of wood-rot through shot-hole borer induced fractures of main primary branches as well as through exposed unhealed galleries on the larger prune cuts. This is achieved by carefully adopting the following sanitary procedure:

1. Shave off the fractured ends of all affected primary branches.
2. Keep shaving off the stumps of main primary branches that expose old unhealed galleries (Fig.7a), until a clean surface is revealed (Fig.7b).
3. Paint all surfaces of the larger prune cuts (2 cm and over) with an appropriate bitumen-based wound dressing. A cheap wound dressing like TB 192 is adequate for this purpose.

#### **C. Use of Resistant Planting Material**

One is often confronted with the problem of a "Hobson's Choice" when a decision is to be taken in respect of the right clone having the virtue of being tolerant or resistant to a particular restraining factor to higher productivity. When a clone is ideally resistant to a particular restraining factor, be it drought, nematodes, shot-hole borer or canker, the same clone could be very susceptible to one or the other or the rest of the above restraining factors. On the other hand, when one is satisfied with the clone's ability to restrain all the above limiting factors (as the case may be in a given region or locality), one will, therefore, have to take a decision from the point of view of an overall satisfactory performance potential, over the long-term period, rather than go for one with a higher productivity potential alone.

#### **D. Resistance to Shot-Hole Borer Damage**

1. A tea plant's ability to resist or be susceptible to shot-hole borer attack is two-fold :

(a) the ability to resist or be susceptible to gallery formation and brood colonization and development;

(b) the ability to resist or be susceptible to subsequent setting in of wood-rot through the fractures of broken primary branches or through exposed unhealed galleries on prune cuts (secondary damage).



*Fig. 7a — Primary branch stump exposing wood-rotted gallery.*



*Fig. 7b — Stump with wood-rotted gallery shaved off to expose clean cut surface.*

From the point of view of a protracted debilitation of bush frame, the above secondary damage through wood-rot is the more critical one. In this sense, even when the gallery percentage by ordinary branch sampling is high, if the frame could resist the ready setting in of wood-rot, then the more critical protracted debilitation of bush frame would be minimal and there would be no significant impact on crop productivity (Sivapalan, 1979a, b).

(c) An ideal clone is one that will resist borer colonization as well as the setting in of wood-rot. One is yet to come across such a clone that has a combination of both these virtues and at the same time be capable of producing at least a modest yield, if not with a higher productivity potential.

(d) It must also be remembered that, wood-rot is caused not only as a result of a pre-disposition to shot-hole borer attack. Wood-rot could be induced through various other means, including wrong timing of pruning, at a time when the root reserves are low and with inadequate lungs, a condition leading to excessive die-back and consequent setting in of wood-rot; exposure to sun-scorch leading to death of wood tissue and the consequent setting in of wood-rot. Prevention of the setting in of wood-rot by the adoption of proper cultural practices is an important management requirement. In this sense, the shot-hole borer attack is only one such pre-disposing factor to wood-rot, even though in areas that are prone to this insect attack, the latter is the more common pre-disposing agency. It is, therefore, imperative to lay particular emphasis to adopt the right management strategy to reduce the setting in of wood-rot by other factors, in areas prone to borer attack.

2. A clone like TRI 2025 is very susceptible to borer colonization and brood development and the consequent branch breakage. However, the ability to resist wood-rot is what may be described as being very average or marginally above average in this clone.

Clones like TRI 2016 or TRI 2027 are susceptible to borer colonization and the consequent branch breakage. However, the better-virtue is their ability to resist wood-rot and the consequent prevention of the long-term debilitating effect.

A clone with a high productivity potential like TRI 2023 is very resistant to borer colonization and brood development. However, this clone is extremely sensitive to die-back from prune and the setting in of wood-rot through such snags. By the proper adoption of sanitary methods at prune, this clone would serve as a very good one, especially in areas with good soil conditions and where the live-wood termite problem is not very serious.

Clones like DG 39, DG 7 and CH 13 have average resistance to both, and hence are acceptable as much as TRI 2016 and TRI 2027.

Rather than depend on a single clone, it is best to use a combination of different clones, in clonal blocks.

## CONCLUSION

An integration of all the above management strategies, together with the choice of the right clones during replanting or infilling, would result in a better and ecologically acceptable management programme of this pest, with no economic loss of crop. This is the most sensible approach to manage a perennial pest of this nature in a plantation mono-cropping system like tea. Attempts at biological

control with the aid of parasites, predators or disease-causing organisms have all proved futile and this insect has proven to be a poor candidate for such forms of population regulation (Danthanarayana, 1970; Sivapalan, 1976). The best form of population regulation originates from the physiological response of the tea bush itself and the strategy that is recommended at present is based on a very careful study of this aspect, taking the maximum possible advantage of this natural phenomenon.

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