

THE TEA LEAF-EATING TORTRIX CATERPILLAR (*HOMONA COFFEARIA*) NIETN.) AS A LIMITING FACTOR IN INSECTICIDAL APPLICATIONS ON TEA

B. A. Baptist

INTRODUCTION

The natural populations of many insects are controlled by biological factors, especially the presence or absence of other insects which may destroy them through parasitism. These parasites are very much smaller and more delicate than the hosts which they destroy and are thus more liable to be destroyed by any insecticidal applications given to the host crop. One of the most important leaf-eating pests of tea, the tortrix caterpillar, is kept in check by such a parasite under natural and normal conditions. Any routine, repeated, insecticidal applications on tea, such as may be used for the control of shot-hole borer, a small ambrosia beetle which bores into the stems of the plant, will, therefore, include the potential danger of upsetting the natural and desirable balance between the tortrix caterpillar and its controlling parasite. Hence, it is desirable to follow up any repeated applications of insecticides on tea for whatever purpose they may be made, from the point of view of possible tortrix caterpillar pest damage. In the present work this is done in connection with specific insecticidal applications carried out for the control of the shot-hole borer beetle of tea, *Xyleborus formicatus* Eich.

THE PEST INSECT

Occurrence and Distribution.—The tea tortrix caterpillar, *Homona coffearia* Nietn., is an indigenous insect, first recorded by Nietner in 1861 on coffee. Subsequently, when coffee was replaced by tea, the insect transferred its activities to this host plant, acquiring the status of a serious pest. In 1889 an extensive outbreak occurred in the Dimbula and Dickoya districts (Green, 1890). Ten years later it again became serious and subsequently acquired the status of a major, chronic, pest (King, 1933). Its distribution as a pest in Ceylon was chiefly confined to the south west monsoon zone, being most severe in the Maskeliya area, but since about 1937 it has lost its importance as a pest in Ceylon owing to the activities of a parasite from Java, introduced into Ceylon in 1935. The tortrix caterpillar also occurs on tea in North and South India, Indo-China, Java and Formosa.

Life-history and habits.—The detailed life history of the insect in Ceylon, which has been observed by several workers, (Green 1903, Jardine 1918, Hutson 1927, King 1933) occupies approximately 8 weeks from the laying of the eggs to the emergence of the adults, being somewhat longer at higher elevations and shorter at the lower. The actual leaf-eating caterpillar stage occupies 4 to 6 weeks. There are probably 5 generations per year. A characteristic feature about the caterpillar is its habit of webbing leaves together to form a sort of nest within which it feeds. If disturbed it quickly leaves its cover. The feeding of the caterpillar is mainly confined to the young leaves and flush, a large quantity of which may be destroyed by its activities.

Biological relationships.—In an investigation of the pest in 1933, King came to the conclusion that the chief check upon its numbers was a virus or wilt disease, which may account for more than 50 per cent. of the natural mortality found. He also listed several parasites, 1 egg parasite, 14 larval parasites and 2 pupal parasites. Since 1933, 8 more larval parasites and 1 pupal parasite have been recorded (Rana-weera, unpublished). King did not consider any of the indigenous parasites of any economic significance. Attempts were made by Light (1928) and King (1930) to rear egg parasites, *Trichogramma* spp. under artificial conditions and liberate them in the infested areas, but these were not successful.

The idea of importing larval parasites from Java, where the caterpillar was of no significance as a pest, was first mooted in 1931 by King, but it was not until November 1935 that a consignment of parasites was received, among which was the *Macrocentrus* parasite. A further consignment of parasites was received in September 1936. These consignments of parasites were liberated at St. Coombs, Talawakelle, and since then, aided perhaps by a few small liberations in other districts, the *Macrocentrus* parasite has spread extensively and become established in all the tortrix affected tea areas of Ceylon (Gadd 1946).

So effective has this parasite proved to be as a natural controlling agent of the tortrix caterpillar, that the latter is no longer a serious or chronic pest, and by 1939, the Tea Research Institute was able to request the Board of Agriculture to rescind the notification of April 1928, under the Plant Protection Ordinance, No. 10 of 1924, which made it compulsory for affected estates to have the eggs, larvae and pupae of the tortrix collected and destroyed. On the rare occasions on which it has occurred in noticeable numbers since, the degree of parasitism by *Macrocentrus* has been well over 75 per cent. (Gadd 1941).

THE CONTROLLING PARASITE

Macrocentrus homonae Nixon (*Hymenoptera, Braconidae*) was described by Nixon in 1938. It is a minute wasp with a body length of about 4 mm. The female has a long, needle-like ovipositor (5.5 mm.) which projects from the posterior extremity. It deposits its eggs, one at a time, in the bodies of caterpillars, the tea tortrix caterpillar being the normal host in Ceylon. Gadd (1946) gives a detailed description of the bionomics of the parasite. The egg is polyembryonic, one egg giving rise to several parasite grubs inside the body of the host caterpillar. The total life-cycle from egg to adult occupies about 7 weeks. Under laboratory conditions the adult life ranges from 6-24 days, the insect being very active and very industrious in its search for host material throughout its adult life. Any stage from one quarter to three quarters grown caterpillars are quite successfully parasitised. The life-cycle of the parasite and its host are almost coincident, the generations of both insects running more or less parallel.

INSECTICIDAL APPLICATIONS

With a view to eliminating the ravages of the shot-hole borer beetle on tea, routine insecticidal applications were given in certain areas in which also the tortrix caterpillar and its controlling parasite occurred naturally. The details of such applications and the consequent occurrence of the tortrix caterpillar are described in a number of specific cases and the results recorded in tables 1 and 2.

Trial No. 1. (Galbode).—The application was made on a block of $\frac{1}{2}$ acre in a $15\frac{1}{2}$ acre field of 4 year old tea. One acre of this field was blocked out in $\frac{1}{10}$ acre plots, 5 of which were sprayed with insecticide and 5 kept as controls. The plots were scattered at random in the block, two rows of bushes being left as a buffer between individual plots. The insecticide application consisted of a spray emulsion of the insecticide dieldrin, at an insecticidal concentration of 0.025 per cent. The

actual product used was Shell Company's Dioldrex 15 at a dilution of 1 in 800 and at the rate of approximately 100 gallons per acre. The first application was given in August 1953 and thereafter applications continued at 10 day intervals up to January 24th, 1955, when the 51st application was given. Thereafter 5 more applications followed at 2 week intervals and subsequently at 3 week intervals up to September 15th. From June 23rd. to September 15th. the strength of the application was doubled. The application was primarily directed against the frame of the bush but in the process the lower foliage and to a lesser extent the flush also received a certain amount of spray.

No tortrix attack was noticed in the experimental area during the first year of application. In July 1954 the bushes were pruned to 12" and tortrix caterpillars appeared in October-November about 3 months after pruning. The caterpillars were present both in the treated and the control plots, but to a somewhat greater extent in the treated plots. This attack persisted for about 6 months, no special action being taken to control it. In March, April and May of 1955 applications of the insecticide were carried out so as to cover the flush as well as the frame, but these applications did not in any way control the caterpillar. In June a strong foliage application of D.D.T. in the form of a water-dispersible powder at a 0.125 per cent. strength was given. This was effective in nearly wiping out the caterpillar, which subsequently almost disappeared. The next appearance of the caterpillar in appreciable numbers occurred in early September nearly 3 months later.

At various periods during this cycle collections of caterpillars were carried out and observations made on the degree of parasitism by *Macrocentrus*. These are recorded in table 1.

Trial No. 2. (Galbode).—In this trial dieldrin dust (2 per cent. active ingredient) at the rate of 30 lb. per acre was used on a block of 5 acres in a field of 25 acres of recently pruned tea. The first application was made one week after pruning and the second application 12 weeks later. No caterpillars appeared between the first and second applications, but 4 weeks after the second application, tortrix caterpillars were found on the treated block, while the surrounding tea appeared to be free. A 0.125 per cent. D.D.T. application was given at this stage on the flush to destroy the caterpillar. Two weeks subsequently there were few caterpillars, but collections showed that the percentage parasitism obtained was negligible up to 8 weeks after the application of the insecticide.

Trial No. 3. (Galbode).—In this trial, a block of 3 acres of recently pruned tea in a field of 20 acres was given an application of dieldrin at a 0.1 per cent. strength in 2 doses. The first was given two weeks after pruning and the second six weeks later. Four weeks after the second application tortrix caterpillar was present on a small scale. A 0.125 per cent. D.D.T. application was given at this stage to destroy the caterpillar. Collections made six weeks after application gave a parasitism of 20 per cent.

Trial No. 4. (Ingiriya).—In this trial, 10 plots of 1/10th. acre each in a total field of 33 acres were treated with 0.1 per cent. dieldrin, the first application being given 2 weeks after pruning, and 2 subsequent applications following at 3 week intervals. There was evidence of a very slight outbreak of caterpillar in 2 plots at the time of the last application which was 2 months after pruning. In an examination 6 weeks later there were still a few caterpillars evident and collection revealed a parasitism of only 2 per cent.

Trial No. 5. (Sanquhar).—In this trial, a 2 acre block in a field of 24 acres of 6 year old tea was treated with a 0.1 per cent. dieldrin spray, the first application being given 1 week after pruning, the second three weeks after the first, and the third three weeks later. Tortrix caterpillar was evident 2 weeks after the last application and collections in the 12th. and subsequent weeks after pruning (the 6th. and subsequent weeks after the last application) showed negligible parasitism.

Table 1. *Parasitism of tortrix by Macrocentrus in a 1 acre block of which half the area was treated with routine insecticidal spray application of dieldrin 0.025%*

Date of collection	Quantity of material obtained		Number parasitised by <i>Macrocentrus</i>		Percentage parasitism		Remarks
	Treated	Control	Treated	Control	Treated	Control	
20- 1-55	251	104	6	5	2%	5%	Routine application once in 10 days
25- 3-55	261	254	20	16	8%	6%	Routine application once in 14 days from 3-2-55
22- 4-55	139	123	7	23	5%	19%	Routine application once in 21 days from 21-4-55
13-5- 55	68	84	5	7	7%	8%	—do—
18-5- 55	264	140	12	15	5%	11%	—do—
27-5- 55	15	27	1	3	7%	11%	—do—
23-6- 55	62	49	1	2	2%	4%	Additional application of 0.125% DDT given on 22-6-55
14-9- 55	282	109	2	1	1%	1%	Conclusion of routine application 0.05% dieldrin from 23-8-55
21-9- 55	79	64	2	0	2.5%	0%	Additional application of 0.125% DDT given on 15-9-55
28-9- 55	41	36	0	0	0%	0%	
5-10-55	146	63	0	0	0%	0%	

Table 2. *Insecticidal applications on tea in the post-pruning period and subsequent tortrix caterpillar appearance.*

Trial No.	Insecticide used	Area treated	No. of applns.	Period of appln.	Period after pruning	Age of tea	Occurrence of caterpillar after pruning	Intensity of occurrence	Percentage parasitism	Remarks
1	Dieldrin 0.025% spray	½ acre	18	6 months	6 months	5½ yrs.	3rd-6th month	Heavy	5%	No measures taken for caterpillar control
1	Dieldrin 0.025% spray	½ acre	4	12 weeks	9 months	5½ yrs.	6th-9th month	Medium	5.5%	Appln. of 0.125% DDT given in 9th month for caterpillar control
1	Dieldrin 0.05%	½ acre	4	12 weeks	12 months	6 yrs.	9th-12th month	Slight	1.3%	Appln. of 0.125% DDT given in 12th month for caterpillar control
2	Dieldrin 2% dust	5 acres	2	12 weeks	13 weeks	20 yrs.	15th week	Heavy	0%	2 Applns. of 0.125% DDT given in 16th week. Attack subsided
3	Dieldrin 0.1% spray	3 acres	2	6 weeks	10 weeks	8 yrs.	12th week	Medium	0%	2 Applns. of 0.125% DDT given in 12th week. Attack subsided
4	Dieldrin 0.1% spray	1 acre	3	6 weeks	8 weeks	20 yrs.	14th week	V. slight	10%	Attack disappeared
5	Dieldrin 0.1% spray	2 acres	3	6 weeks	8 weeks	6 yrs.	10th week	Medium	0%	Attack persisted for 3 months
6	Dieldrin 0.1% spray	2 acres	4	6 weeks	7 weeks	4 yrs.	10th week	V. slight	—	Attack disappeared
7	Dieldrin 0.1% spray	2 acres	4	3 weeks	3 weeks	2 yrs.	8th week	V. slight	—	Attack disappeared
8	Dieldrin 0.1% spray	1 acre	4	4 weeks	4 weeks	40 yrs.	None	—	—	—
9	Dieldrin 0.1% spray	1 acre	4	3 weeks	4 weeks	5 yrs.	None	—	—	—
10	Chlordane 0.1% spray	1 acre.	3	6 weeks	10 weeks	4 yrs.	12 weeks	Heavy	0%	Appln. of 0.125% DDT given in 12th week

Trial No. 6. (Sanquhar).—In this trial, a 2 acre block in a field of 30 acres of 4 year old tea was treated with a 0.1 per cent. dieldrin spray. Four applications were given, the first, one week after pruning, the second, three weeks after the first, the third one week after the second, and the fourth one week after the third, the entire spraying treatment falling within a period of 7 weeks. There was slight caterpillar attack within a month of the last application and a collection of caterpillar made 4 and 5 weeks after this application (12 weeks after pruning) gave negligible parasitism. There was, however, no subsequent attack by the caterpillar.

Trial No. 7. (Sanquhar).—In this trial a 2 acre block in a field of 23 acres of 2 year old tea was treated with a 0.1 per cent. dieldrin spray. Four applications were given, the first 2 days after pruning and the subsequent applications at weekly intervals. About 5 weeks after the last application (8 weeks after pruning) there was evidence of very slight tortrix attack with no trace of parasitism. The attack, however, faded out subsequently without any special action being taken.

Trial No. 8. (Peradeniya).—In this trial, 1 acre of old tea, comprising four $\frac{1}{4}$ acre plots, was treated with 4 applications of 0.1 per cent. dieldrin spray, the first being given about 4 days after pruning and 3 others following at weekly intervals, the entire spraying being confined to a period of 3-4 weeks after pruning. The pruning adopted in this case was a rim-lung prune. Caterpillars did not appear in this case.

Trial No. 9. (Endane).—In this trial, a block of approximately 1 acre in a field of 40 acres of 5 year old tea was treated with four applications of dieldrin at a 0.1 per cent. strength, given at weekly intervals, the first being given 5 days after pruning. No caterpillar attack appeared subsequently in this case.

Trial No. 10. (Endane).—In this trial a 1 acre block in a field of 40 acres of 4 year old tea was treated with a cholordane (Intox 8) spray at a 0.1 per cent. insecticidal concentration. The first application was given 4 weeks after pruning, the second 3 weeks later, and the third 3 weeks after the second. Caterpillar attack was severe within 2 weeks of the last spraying or 12 weeks after pruning. An application of 0.125 per cent. D.D.T. was made at this stage to control the caterpillar.

DISCUSSION AND CONCLUSIONS

General observations on the occurrence of the tortrix caterpillar have shown that since the introduction, establishment and distribution of the *Macrocentrus* parasite, which can be assumed to have been effected by 1939, it is extremely uncommon for a tortrix caterpillar outbreak to occur. The life cycles of the host caterpillar and the parasite are almost coincident, the generations of both insects running more or less parallel. This no doubt contributes to the efficiency of the parasite and to the practical lack of divergence in fluctuation of populations of host and parasite. As a result of this close relationship between the life cycles of host and parasite, fluctuations of the physical factors of the environment have an almost equal effect on both insects.

On the other hand chemical factors such as insecticidal spraying, which have an unequal effect on the two insects, may be normally expected to upset the biological equilibrium quite easily. This unequal effect of the insecticide is produced by the relatively greater toxicity of the insecticide to the parasite, which is a very small and delicate insect, as compared to its toxicity to the caterpillar. This is accentuated by the strong residual effect of the insecticide. This very conspicuous difference in toxicity between host and parasite can partly be attributed to the fact that dieldrin as an insecticide appears to have a specially low toxicity towards the tortrix caterpillar.

The main factor which contributes appreciably in producing the conspicuous divergence of the effects of the insecticide on the host caterpillar and parasite populations is the difference in actual habit or behaviour of the insects in question. The tortrix caterpillar usually encloses itself in a protective nest of leaves, inside which it feeds, and thus to some degree avoids the full effect of the insecticidal application. The parasite, on the other hand, not only exposes itself to contact with the treated foliage, but is specially active in searching the foliage for its host; and, having found its host, the indirect approach it has to adopt on account of the concealment of the host caterpillar brings it into still more active and continuous contact with the treated foliage. Such behaviour must necessarily increase mortality of the parasite, caused by the residual effect of the insecticide, very appreciably over that of the host insect, with a consequent preponderance of the caterpillar population. These effects are seen in the persistence of the caterpillar when routine and regular application of insecticide is continued with as in trial No. 1. But even when applications are few and confined to a short period, if these are carried out at a time where there is abundance of young and fresh foliage, the period during which tortrix is normally attracted, an effective reduction of parasitism with consequent increase of caterpillar appears to follow almost invariably. The reduction of the parasitism to practically zero in the majority of cases, even though the treated areas only comprise a fractional part of the pruned field, indicates that the parasite, while very closely following its host, has its effectiveness as a parasite, not just partially reduced as might be expected, but almost totally so. This destruction of the effectiveness of the parasite is likely to persist as long as the residual effect of the insecticide is present. It follows, therefore, that if relatively large, continuous areas, comprising entire fields, are treated with insecticide, there is a strong probability of the upset of the balance persisting for even longer periods, since the restoration of balance would depend on the invasion of parasites from fresh areas outside the treated areas.

From these results, it appears that, if persistent insecticides with highly residual properties are to be used on tea, it will be essential, if subsequent tortrix caterpillar damage is to be avoided, either that the period of application of the insecticide be confined to that period immediately following pruning, when fresh foliage is still not available, or that the application be accompanied or immediately followed by a specific application of an effective insecticide for the destruction of the caterpillar, such as the D.D.T. application given in some of the outbreaks described. In the former case the safe period for application in the case of dieldrin would appear to be limited to the 2-3 weeks immediately following the pruning of the tea. Allowing for a residual effect of a further 2-3 weeks, it may be expected that any parasite coming in 6 weeks or later after pruning is not likely to be affected. It is also unlikely for tortrix to be attracted to fields which are less than 6 weeks from pruning so that no destruction of parasite need be feared within this period. This position is borne out by the cases listed, as the variation in the damage sustained by tortrix caterpillar becomes reduced as the period of application is shortened and taken closer to the pruning time.

In the case of young tea, where some quantity of young foliage may be left behind after the very light pruning which would be normally given, the use of persistent insecticides on it would necessarily have to be carried out in conjunction with a special application of insecticide for tortrix control. It must be remembered, however, that such an application, while effectively destroying the tortrix caterpillar, must have an equal or more intensive effect on the parasite. The most practicable procedure will, therefore, be to give the special application of insecticide for tortrix control within the period in which the residual effect of the primary insecticide, while having no effect on the host caterpillar, is still fatal to the parasite. An alternative will be the restriction of the use of the primary insecticide intended for the shot-hole borer control to such an insecticide as will be more destructive to the caterpillar than to the parasite, or at least equally so. But such an insecticide is hardly likely to be found amongst the persistent group.

Finally, to conclude, the limitation imposed by the tortrix caterpillar on insecticidal applications having highly persistent effects can be summarised as comprising a restriction of insecticide applications to not more than 3 weeks of the immediate post-pruning period in the case of old tea, a similar restriction in application for young tea, in this case accompanied by a surface foliage application of D.D.T. for the control of possible tortrix caterpillar outbreak.

SUMMARY

1. The status of the tea tortrix caterpillar as an economic pest of tea and the biological relationship existing between it and its controlling parasite are briefly given.

2. Ten cases of specific applications of persistent insecticides on a field scale are described with special reference to the subsequent appearance of the caterpillar.

3. The factors relating the insecticide applications to the caterpillar outbreaks are discussed in the light of field observations.

4. Conclusions are drawn that insecticidal applications for the control of shot-hole borer, which are limited to 3 weeks of the immediate post-pruning period, are relatively safe and unlikely to initiate tortrix caterpillar outbreak, except in new clearings where a simultaneous application of a special insecticide for tortrix control is desirable.

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