THE TEA TORTRIX (*HOMONA COFFEAREA* Nietn).

C. B. REDMAN KING

INTRODUCTION.

After Termites, the Tea Tortrix may be considered the most important pest of tea in Ceylon. When severe, the bushes have a ragged, untidy appearance, and a large proportion of the flush is attacked by the caterpillars which web together the buds and young leaves, so rendering them unfit for plucking; and the worst attacks usually take place at a time when the best quality tea is expected.

As methods of control must be based on facts connected with the habits, life and seasonal history of Tortrix, the more important information about these is set forth. Control methods in the past have been concerned with handpicking the eggmasses and larvae, "flight breaks" and spraying, and in the present with biological control. These are discussed in some detail.

A systematic description of the male and female moths of Tortrix is not given here, but the reader interested in the technical aspect will find it at the end of Jardine's paper on Tea Tortrix [10].

HISTORY.

The insect known as Tea Tortrix was first described by Nietner in 1861. It was at that time found on coffee, but did not apparently do much harm. Subsequently, coffee in Ceylon was replaced by tea, and in 1889 came the first extensive outbreak [4], confined to Dimbula and Dikoya. Ten years later, there was another extensive attack in the same districts, and also in Pundaluoya and Ambegamuwa. After this, it appeared in numbers every year up to 1906, being worst in Maskeliya in 1903. From 1907 to 1910 there was a lull, but since then it has reigned as a first class pest of tea. The record shows that severe attacks are limited to some of those tea districts which are subject to the south-west monsoon rains.

DISTRIBUTION.

Although the distribution of *Homona* in Ceylon is fairly wide, it has only appeared as a severe pest in the denser part of the tea belt between Adam's Peak and Nuwara Eliya, and northwards to the Hewaheta district. It does occur in most other tea districts, but is comparatively scarce, so that in a great many places it hardly attains the status of even a minor pest. It does not appear on estates about Nuwara Eliya itself, so that its range as a pest would lie somewhere between 3,000 and 6,000 feet.

Apart from Ceylon, it appears in Formosa as a pest of first importance on tea, and in Northern and Southern India, Java and Indo-China as one of the lesser importance. The "flushworm" of South India is not the same as Tea Tortrix, being an Eucosmid moth, *Laspeyresia leucostoma* Meyr.

LIFE HISTORY.

Adults.—The female moths, of variable shades of brown, are considerably larger than the males. When common, they may be often seen resting on the upper surface of the tea leaves, and are readily taken by hand. The males are much more lively, and on approach dart rapidly away, coming to rest a few bushes off, in a characteristic zig-zag flight which may be repeated as often as the observer draws near.

Eggs.—Mating probably takes place soon after emergence, which mostly occurs at sundown or a little after. Fertile eggs may be laid the first evening after emergence in compact masses, and the eggs being flat overlap one another. The number laid in one mass is very variable, being as low as 10 or as high as 500, but the average is about 130. However, the females are capable of laying two egg-masses though I have never had one which laid on more than two occasions. The eggmasses are always laid on the upper surface of leaves where they are quite conspicuous. The female moths appear to like shiny surfaces on which to oviposit, for they have been found on such plants as arum lilies and palms, on which the larvae make no attempt to feed. Eggmasses are also commonly found on window glasses, to which the moths may have been attracted by light in the first place.

The colour of a freshly laid eggmass is a pale-yellow, more or less uniformly distributed to the naked eye. As the age increases, the embryos grow, making the whole mass become darker, and later the yellow colouration becomes deeper with a tint of orange. Later still, a day or two before hatching, rows of little black dots appear, which are the heads of the caterpillars within, and after a total period of about eight days (but the period varies with the temperature from six to eleven days) the larvae hatch out.

Larvae.—Once out of the eggs, they race away in all directions, the agility they display only being equalled by the urgent need they appear to feel to remove themselves as quickly as possible from the scene of their birth. The majority fall over the edge of a leaf and hang by silk threads, and so may reach a lower part of the bush, but if any reach the petiole they crawl along the stem. Owing to their vigour and speed of movement they may travel a long way from their starting point. After reaching a suitable spot they may start to feed within three hours of hatching, but they are capable of holding out for a long period without food.

Owing to their rapid migration it is a difficult matter to trace all the individuals which have hatched from an eggmass, but subsequent observations lead one to suppose that a considerable number become casualties at an early stage. A few will find their way to young shoots, where at first they pass quite unobserved, owing to their small size and to their colour. It seems probable that they may then suffer considerable losses at the hands of pluckers who remove them with the shoots unnoticed.

The survivors, having webbed round themselves the edge of a leaf, or two leaves together, feed inside the shelter thus made. This retreat helps to serve as a protection against the ills that may befall them. Their leafy home soon gets eaten out and discoloured, and the caterpillars then remove to some other place and repeat the process. If the spot happens to be a shoot, they web together the bud and first leaf, and perhaps the next leaf or two, according to the size of the caterpillar. If the caterpillars are numerous, the bush shows the characteristic untidy appearance, evidence of their recent presence, and there will be some loss of crop.

The majority of larvae have black heads, but a small proportion are brown in this respect. There does not appear to be any significant difference between the two varieties. The body colour is at first yellow, later becoming either green and translucent, or white and opaque, and when full grown measure about one inch in length. During the period of growth the caterpillars cast their skins several times; the number is somewhat variable, but five is the commonest. Hutson [6] gives 4-6 times in the case of potential males, and 5 or 6 times for potential females.

As a whole the larval stage lasts five or six weeks at elevations over 4,000 feet. Jardine [11] gives four to five weeks and Hutson [6] 18-37 days at Peradeniya (1,500 feet).

Pupae.—When full grown the larvae stop feeding and presently pupate where they are, without making cocoons. This stage at high elevations lasts from 7-10 days. Jardine [11] gives one week and

Hutson 6-7½ days at Peradeniya. These authorities give 6-8 weeks and 5-10 weeks respectively for the full life cycle. At high elevations, 8-10 weeks may be taken as the period.

Emergence.—When the time approaches for the emergence of the adult, the pupa wriggles its way out of its leafy cell until about three-quarters of it is free, and in this position the moth emerges. It may take place at most times of the day or night. I have found sundown and shortly after to be the most frequent, but Hutson [6] gives the early hours of the morning as being the commonest, and sometimes the morning or early afternoon.

An excellent coloured plate of all stages, except the ova, is given by du Pasquier [19].

FOOD PLANTS.

The following is a list of host plants of *Homona coffearea*:—

Tea.	Sword bean.
Crotalaria species.	Amaryllis.
Dadap.	Cowpea.
Grevillea Robusta.	Red Guava.
Acacia sp.	Citrus spp.
Eucalyptus sp.	Cacao.
Hibiscus spp.	Jak.
Roses.	Duranta.
Chrysanthemum.	Apple.
Acalypha.	Quince.
Camphor.	Strawberries.
Pelargonium.	Cabbage.
Inga saman.	

The above list can probably be very much extended. Larvae have been taken from all the plants mentioned above, but it does not necessarily imply that moths have laid on all of them; indeed it is often a puzzle to find out whence solitary specimens of the larvae have come.

SEASONAL HISTORY.

From observations made during the four years 1930-1933, supplemented by notes on the subject previous to this time, the annual cycle is taken, for the sake of convenience, as beginning about the middle of the year, when Tortrix is not as a rule common in any stage, but caterpillars will be reaching maturity in August. At this time there usually occurs a break in the weather with sunny periods and higher daily temperatures; this is closely followed by an emergence of moths, and a sudden increase in the number of eggmasses. We may call this the first generation of moths, and it lasts but a few days. Some eight or nine weeks later the second generation is produced, lasting a week or two, the third generation following at about the same distance of time and arising at the end of December or the beginning of January. This third generation is the important one of the year, not only on account of the large number of eggmasses which may be laid, but also, and chiefly, because the attack which follows corresponds in point of time with the flushing of the highest quality tea of the year.

The oviposition period of the third generation lasts from three to four weeks, the number of eggmasses rising suddenly at the start, and falling away as quickly afterwards. In the 1931-1932 season, the period lasted from January 2nd to January 22nd, and in the 1932-1933 season from December 24th to January 23rd. If the third generation is very heavy, a fourth can be discerned in March and a small fifth in May or June, but in the first half of the year, as soon as thundery weather begins, parasites and Wilt make their appearance, so that the caterpillars of the third generation are considerably reduced in numbers. This reacts on the parasites, so that they, too, become numerically weak, and the lag so produced enables the Tortrix to get away again as the year advances.

A full knowledge of the appearance of the different generations should enable the collection of eggmasses to be carried out with greater effect, and this is discussed below under Artificial Control measures.

NATURAL CHECKS.

Wilt.—The chief check on Tortrix appears to be the mysterious disease known as Wilt, which perhaps is to be classed as a virus disease [8]. It occurs chiefly in the warm, moist weather of March onwards, although it is to be found at almost any time. It may be responsible for killing considerably more than half the population; it is very difficult to get reliable figures for this, since caterpillars, if kept in confinement, are very susceptible to the disease if any Wilt is about, and this confinement appears to aid very materially the spread of infection.

Parasites.—There are several parasites, most of which attack the larval stage.

Trichogramma erosicornis is a tiny parasite which develops completely inside the Tortrix egg. Jardine [12] reported the presence of two egg parasites, apparently on the ground that while in some cases only one parasite was reared from one egg, in others more than one were obtained. *T. erosicornis* commonly develops one per host egg, but I have several times reared more than one from a Tortrix egg, the maximum being six, and have never come across another species.

The following is a list of parasites known to date:—

1. Egg Parasites.

Fam. **Trichogrammatidae**
Trichogramma erosicornis.

2. Larval Parasites.

Fam. **Ichneumonidae**
Phytodiaetus capuae Morley.
Stictopisthus sp.
4 unidentified.

Fam. **Braconidae**
Microdus sp.
Apanteles sp.

Fam. **Eulophidae**
Tetrastichus sp.

Fam. **Elasmidae**

Elasmus homonae Ferrière.

1 unidentified.

In addition to the above are three undetermined parasites, and two hyperparasites.

3. Pupal Parasites.

Fam. **Chalcididae**

Brachymeria euploae Westwood.

1 unidentified.

The egg parasite is extremely rare when the third generation of moths appears, but may be found from time to time up to about May. Natural parasitism by *Trichogramma* rarely exceeds 0·1 per cent. which is no doubt largely due to the short periods of time when eggmasses are abundant.

The larval and pupal parasites are more common from March to May than at other times. An exceptional season in this respect was the period December, 1932 to February, 1933, when several species were numerous. The commonest at this time appeared to be the pupal parasite *Brachymeria euploae*, which could be seen flying about amongst the bushes in large numbers, a somewhat unusual sight. *Phytodiaetus capuae* was also fairly common then, along with two other unidentified Ichneumonids.

January, 1933, was excessively wet, although this month is most often fairly dry, and appeared to favour parasite propagation. On the other hand, dry weather appears to operate in some way against Tortrix parasites, so that a long spell of dry weather would seem to provide conditions conducive to a Tortrix outbreak.

BIRDS.

A great many birds consume insects as part of their diet, a few perhaps entirely so. Agricultural areas in close proximity to bird sanctuaries, natural or artificial, are kept reasonably free from pests by the inhabitants of these retreats. But the wholesale destruction of jungle in Ceylon to make place for coffee and then for tea has undoubtedly been responsible for a great loss of bird life in these areas, and may partly account for the prevalence of some insect pests; hence the encouragement of birds by means of sanctuaries would go some part of the way to assist Nature in restoring the previous balance of life. Very large numbers of birds of the right sort might solve the Tortrix problem, but it is questionable whether there is enough unwanted land on estates to provide sanctuaries sufficiently commodious to contain them. On the other hand, small ones might help considerably, and with a view to finding out their possibilities, a sanctuary of about two-thirds of an acre has been started at St. Coombs. It will, of course, take some years to mature. A census of birds taken from time to time should be very instructive, and should throw light on the question of the effectiveness of birds in connection with Tortrix.

ARTIFICIAL CONTROL.

Flight Breaks.—Methods of artificial control must be based on the habits, life-history and seasonal history of an insect. In his papers on Tea Tortrix [13, 14], Jardine recommended the extensive planting of "flight breaks" as a means of coping with the pest. The idea was to create barriers of trees at right angles to the wind, presumably in order that the trees would act as a sort of strainer, and become littered up with the insects borne along in the air. This is based on the supposition that the moth is blown from one place to another by the wind. In the first reference given [13], he states that "The South-West Monsoon is responsible for the distribution of the insect"; in the second reference, "Tortrix Flight Breaks", the first sentence is: "It is known that the South-West Monsoon is responsible for the general dissemination of Tea Tortrix." Unfortunately, no data, nor even a hint of the evidence, is given in support of these statements. If reference be made to the remarks on the history of Tortrix as a pest, at the beginning of this paper, it will be seen that the first recorded outbreak was in Dimbula some fourteen years before Maskeliya suffered in the same way. As Maskeliya is south-west of Dimbula, it is difficult to see how the South-West Monsoon could be responsible for blowing the moths in the opposite direction.

The next sentence after the second quotation above is: "All ridges exposed to this wind are liable to infestation." The inference here is again that the wind drives the moths along, and that they get combed out by the bushes on the ridges. If we suppose for a moment that the wind is responsible for this, whence are the moths blown ? If from sheltered positions, it is hard to see how they could remain in exposed positions. On the other hand, if they are blown out of the exposed positions, how do the latter become most liable to infestation ?

The fact is that there is considerable misconception as to the part that wind plays in distributing insects. Generally speaking, the stronger the wind, the harder do insects cling to their supports; whereas in mild airs winged insects become active, other conditions being favourable, and their tendency, if affected by wind currents at all, is to fly against them. This is not to say that no winged insects whatever are blown along by wind. As an instance, when aphids, or plant lice, grow wings, their migration is certainly assisted by air currents; and in all probability, as they are very feeble fliers, the function of their wings may be, perhaps, more suitably compared with a parachute than anything else. They constitute, however, a rare exception. Even a small insect like *Trichogramma* appears to owe its spread more to direct flight than to the assistance of wind [20]. Tortrix moths appear to follow the general rule, and fly when and where they want to, resisting the wind. If flight breaks were ever attempted they must have been doomed to failure from the start.

The statements about the spread of Tortrix by wind refer to the moth stage. It should be mentioned that the wind is sometimes responsible for blowing recently hatched caterpillars from bush to bush by means of the silk fibres spun by them. Hutson [7] remarks that they may in this way be removed three and four bushes to leeward of their starting point. The rate of spread on a large scale in this manner would, of course, be very slow. Apart from wind, they may be carried considerable distances by people working through the bushes, as when suspended by threads, the caterpillars may be easily caught on clothing.

Spraying.—A very large quantity of poisonous material is used against insect pests every year all over the world. The saving in the quantity of crop produced, and the improvement in quality, is pronounced, and regular spray programmes are part of the routine work of farms and orchards. The peculiar nature of the tea crop, however, precludes the use of virulent poisons against leaf-eating insects, so that in this particular case the utilisation of a powerful weapon is prevented. To find an ideal substance which, while killing nearly 100 per cent. of Tortrix for a reasonable outlay, is at the same time both harmless to the plant and of no effect on the made tea, is probably beyond the bounds of possibility at the present time. An effort was made some years ago [15] to use lead chromate in a spray to kill the caterpillars. In the report of this experiment issued afterwards, a large amount of space is devoted to the layout of the experiment, the manufacture of leaf plucked on different plots, and the preparation of the sprays. The effect of the sprays on the tea bushes and on the manufactured product, and of weather on the sprayed bushes is also given. The remainder of the space is devoted to the examination of samples of made tea by experts, and it seems clear that the lead chromate spray had no effect on the tea. Unfortunately, no details are recorded of the effect of the poison on the caterpillars. However, this hiatus is filled by Hutson [8], who states that in some experiments of his with this poison, it had no effect at all on Tortrix caterpillars.

Spraying is an extremely laborious business on tea estates and is not to be lightly recommended. In other parts of the world it sometimes happens that the crop is a total failure from insect ravages. In such desperate cases there would be ample justification for spending money in destroying the pests in every way possible. In the case of tea, however, although there may be a reduction of crop by Tortrix, it is never so serious as to warrant enormous sums of money being spent to eradicate the pest responsible for it. If Tortrix showed signs of destroying over ninety per cent. of the crop, then it would be necessary to adopt extensive spraying programme with arsenicals. As things stand at present, there would not appear to be any likelihood of the pest being so destructive, so that one can try means that are simpler and cheaper, if not so effective.

Collection of eggmasses.—The collection of eggmasses has several times in the past been officially recommended, and is a form of control well-known to planters, and carried out by most. But it is a measure that must be carried out correctly to give good results. In the account of the seasonal prevalence of Tortrix given earlier, it will be seen that the August generation has been taken, quite arbitrarily, as the beginning of the annual cycle. Some time then moths emerge and lay eggs, and it is at this time that eggmasses should be collected and destroyed. The peak oviposition period of the first generation may only last a few days, and if an endeavour is made to collect thoroughly then, it would save much anxiety at a later date. It would be to the advantage of most estates to have a pest gang employed to collect eggmasses and report any sudden increases; such knowledge could also be obtained if collections were regularly recorded. As the incubation period of the egg is generally seven or eight days, it does not do a great amount of good to collect eggmasses every ten days or so, as is sometimes done. They should be collected every five days during the peak periods. If the August period can be noted, the next one will occur about two months later, and as soon as a rise in egg population is again noted or reported, an intensive collection should be instituted every five days. In the case of the August generation, probably two or three such collections would suffice. The second generation oviposition period might last a little longer and require perhaps four or five collections. The third occasion is again obtained by means of adding two months to the date of the second. The number of eggmasses laid by third generation moths will be a rough inverse measure of the thoroughness of previous collections. Although the time for collecting may be to a certain extent gauged by the calendar the appearance of male moths in the field about that time is a further index of what is to follow; for, owing to a rather shorter life-cycle than the females, their appearance anticipates by some days the rise in numbers of eggmasses deposited.

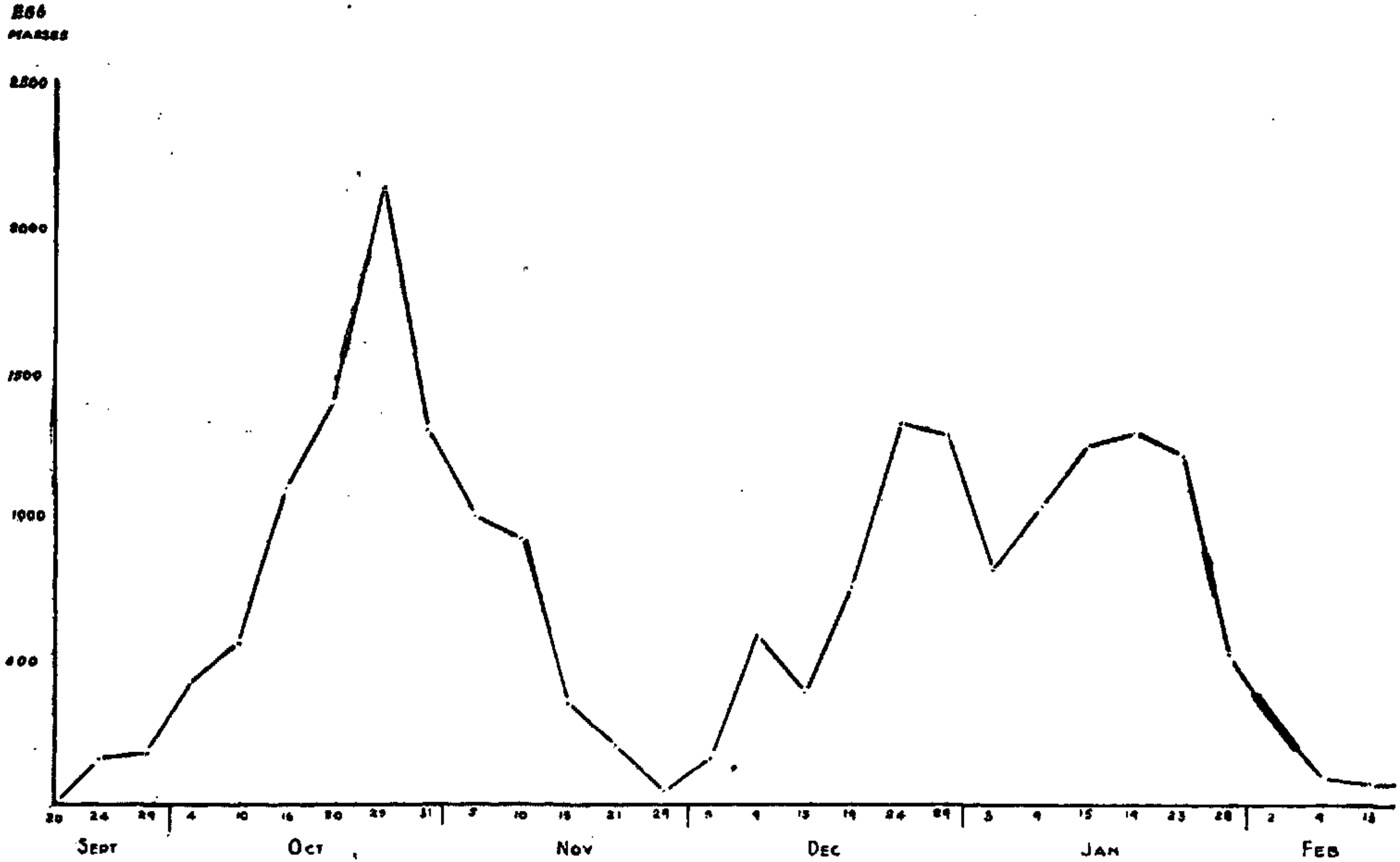

Fig. 1—Graph showing number of eggmasses of Tea Tortrix collected on a block of 4½ acres at St. Coombs.

As an instance of the value of prediction in this connection, it may be mentioned that a parasite test experiment was prepared in 1932 to begin when the third generation of moths began to oviposit. Eggmasses were collected from a small area about every five days, and the results of the collection were recorded and graphed, as shown in Figure I.

The period shown covers the second and third generations, and shows the peak period of each. The maximum of the second generation occurred during the 21st to the 25th of October, so that everything was ready just before Christmas, which, as a glance at the figure will show, was the correct time.

The intensive collection of eggmasses should be confined to the peak periods, which do not last very long, to get the maximum benefit from this form of control, and should be undertaken even if the numbers prove to be small, for one can never tell when a combination of factors favourable to the development of a much larger percentage of larvae than usually takes place may occur.

PARASITES.

Trichogramma.—The employment of parasites for control purposes may be extremely difficult owing to the fact that the large majority of them are hard to breed in captivity. An exception is provided in the case of the egg parasite, *Trichogramma.* It is a comparatively simple matter to raise very large numbers of these parasites in the laboratory. The theory of their utilisation is that they should be liberated in the field when the period of maximum oviposition is about to begin, which date can be foretold, as indicated above, so that by their natural increase afterwards they will kill at an early stage such a large percentage of individuals that the subsequent caterpillar attack will be only of a mild character; but extermination is not to be expected.

Before discussing the possibilities of success, it may be as well to draw attention to the magnitude of the problem involved in the production of large numbers of these parasites.

Let it first be assumed that the parasite will be successful in controlling Tortrix. It will be necessary to produce enough to supply about 200,000 acres of tea, which is roughly the area most subject to Tortrix. The number required per acre will be about 10,000. This is a figure worked out in 1930 as being the probable requirement, and is about the same as used in other parts of the world. One would have to cater for 1,000 eggmasses per acre at least, which means about 120,000 eggs per acre, counting 120 eggs per eggmass. Of the 10,000 parasites, about 5,000 will be females, which are capable of stinging 10 eggs apiece. It is probable, at the start, that a high proportion of parasites will fail to find eggs, but assuming that 50 per cent. do so, then 25,000 out of 120,000 will at first be killed. The next generation of parasites should produce about 13,000 females, which could dispose of 130,000 host eggs. As this generation would be due about 15-20 days after liberation (the parasites may live for a few days, and sting eggs some time after liberation), it should be capable of more effective work, owing to the increased spread. Nothing is at present known about the amount of spread, but it seems unlikely that so early the parasites will have completely covered an acre. If the first field generation is fairly successful in finding egg-masses, the second field generation should be numerous, but it is due to emerge at a time when eggmass numbers are already on the down grade.

To revert to the problem of supply. For 200,000 acres, 2,000,000,000 parasites will be required, and for this number, a similar number of host eggs will be necessary. For this purpose, it is the usual plan to utilise one of the moths which infest grain and dried products, as being easy to rear a large population. In the laboratory of the Institute, the flour moth, *Ephestia kühniella* has been found the most satisfactory, and it is reared in a mixture of bran and wheat meal. On a large scale, it is found that the maximum out-turn of moths to be expected is 10 per cent. of the eggs originally put in. Also, parasitism of eggs will not average more than about 80 per cent. As, side by side of producing *Ephestia* eggs it is necessary also to increase the number of parasites, and as a number of *Ephestia* eggs is required to continue the propagation of these moths, we must aim at a production of about 3,000,000,000 moth eggs. The female moths lay about 100 eggs each, and a production table may be made out as follows: Starting with 50,000 eggs:—

50,000 eggs produce 2,500 female moths (½ x 10% of 50,000) which lay 250,000 eggs.

250,000	,,	,,	12,500	,,	,,	,,	1¼	million.
1¼ million	,,	,,	say 60,000	,,	,,	,,	6	,,
6 ,,	,,	,,	300,000	,,	,,	,,	30	,,
30 ,,	,,	,,	1½ million	,,	,,	,,	150	,,
150 ,,	,,	,,	7½ ,,	,,	,,	,,	750	,,
750 ,,	,,	,,	37½ ,,	,,	,,	,,	3,750	,,

As the life cycle of this moth is about 2 months, at 70-75°F. it would take a year to produce the required number of eggs, starting with 50,000.

Allowing 6 pounds of meal per square foot, the space needed for total production would be about 20,000 sq. feet, or about half an acre of actual meal space. A fair sized building would be necessary to cope with the work, and many rooms would be required, equipped with racks to hold thousands of trays of meal. In addition, rooms would be required for breeding the parasites and for cold storage; also for storage of meal and apparatus, for dealing with large numbers of parasite cards, packing, addressing and mailing. A varied assortment of apparatus would be needed connected with the production of moths and parasites, and to deal with the whole, a numerous staff would have to be engaged.

Owing to the fact that Tortrix becomes scarce at certain times of the year, the parasite would almost die out in the field, as it does at present, so that the production as outlined above would have to be carried out every year. The annual cost of the undertaking would probably lie somewhere between Rs. 30,000 and Rs. 60,000.

Efficiency of Trichogramma in the field.—We have now to examine the probability of this parasite successfully controlling Tortrix. As remarked before, the plan initially depends on the release of the parasite at the right time, and thereafter on the ability of the parasites to propagate in the field in the eggs provided there by Nature. The more of the latter there are, the easier it will be for the parasite to find and oviposit in them and rapidly to build up a large population.

There is little difficulty in choosing the right time; everything depends on the second proviso.

But in order to appreciate the possibilities of *Trichogramma*, it may be useful to refer to results experienced in other countries:

1. [19] In 1928 experiments were carried out in vineyards in Germany against the vine moths *Clysia ambiguella* Hb. and *Polychrosis botrana* Schiff with *Trichogramma evanescens*. The report says that although the parasites were observed to emerge normally, no noteworthy reduction was secured in the second generation of moths. This is attributed to unfavourable weather causing delayed oviposition by the moths resulting in a too scanty supply of eggs.

2. [1] *T. minutum* was released in peach orchards in New Jersey during 1930 and 1931 against the Oriental Fruit moth, *Grapholitha molesta* Busck. The rate of liberation was over 40,000 per acre at a cost of £4. In areas unprovided with parasites there was 47·7 per cent. infestation of the fruit; in the treated areas the infestation was 41·1 per cent. Such a small difference was considered not to justify the expense incurred.

3. [17] An account is given of the employment of *T. minutum* against Codling Moth in Colorado.

In "Myers" orchard, 10,000 parasites were placed on ten trees in the centre of an eight-acre block every other day throughout the season (length of season not stated) from May 29th onwards. The first parasitised eggs were found on June 16th, and the percentage parasitism is given as follows:—

July	2nd	25·45	per cent.	(after	34 days)
,,	22nd	90·83	,,	,,	54 ,,
,,	28th	85·3	,,	,,	60 ,,

at end of season 70·27 per cent.

In spite of the heavy parasitism towards the end of July, and of the fact that a regular spray programme was carried out as well, 85 per cent. of the fruit was, nevertheless, found to be infested by caterpillars.

In another orchard, "Kapaun", there was 46·26 per cent. parasitism at the end of the season, after liberations of parasites had been made every other day, as in the case of Myers orchard. Notwithstanding this, the crop was a total loss from Codling Moth injury.

In a third orchard, "Harvey", 500 parasites were liberated on each of twenty trees on July 13th. The spread of the parasite was observed to be even greater than in orchards where many more were liberated. Parasitism of Codling Moth eggs at the end of the season was 57·4 per cent. Result—the whole crop destroyed by Codling Moth.

In general, it is shown that a good percentage of parasitism, whether natural or induced artificially, has little effect on fruit infestation.

4. [10] In Colorado, during the five years 1928-1932, *T. minutum* was liberated for control of Codling Moth on apples, in addition to the usual spray programmes. Light parasitism was obtained in the early part of the season, developing as it progressed, sometimes up to 80 per cent. and 90 per cent. The author concludes by saying " . . . . in no case has the reduction of the Codling Moth been such that there has been a marked increase in the protection of the fruit. So, after these several years, we are forced to the conclusion that the use of the parasite does not show a great deal of promise as a solution for our difficult problem."

5. Experimenting with a species of *Trichogramma* against Codling Moth in Australia, I have received a private communication to the effect that the work was given up some time back (1930), as the indications were that the parasite would be ineffective, and the authorities would therefore afford no further grants for it.

6. [5] *Trichogramma minutum* has also been tried against the sugarcane borer, *Diatraea saccharalis*, in Louisiana, U.S.A. In 1932, fields colonised with this parasite showed much improved yields. Eggmasses were available for the insect from the beginning of June to the first week in September (about fourteen weeks), and the rate of liberation was 6,000 parasites per acre at a cost of 4/- (Rs. 2·70).

7. [9] On the other hand, when a similar experiment was carried out in Antigua on the same crop, and against the same pest in 1931 and in 1932, the conclusion was that it was ineffective.

8. [18] In Malaya, plot experiments were carried out in four different places against stem borers in paddy during the season 1931-1932. Sixteen-acre blocks, divided into sixteen plots of one acre each, were used in the experiments. Data were secured from areas of one-tenth of an acre in the centre of each plot. Eight of the plots, chosen at random, were colonised with 20,000 parasites each. Tables are given, comparing on the one hand the number of tillers damaged by borers in the colonised and control plots, and on the other hand the results of parasitism. In the first experiment, the number of tillers attacked was found to be 73·84 per cent. in the colonised plots, and 77·21 per cent. in the others, although in the latter case the number of larvae found was about double that in the former; and yields of grain were about equal. In another similar block of sixteen plots, the respective percentages of bored tillers was 71·2 per cent. and 67·5 per cent., the larvae found in the uncolonised plots being somewhat numerically superior to the others.

The second experiments show that there was a greater increase of parasitism in the colonised plots than of natural parasitism in the controls, but even so, with the great numbers employed the parasite was put down as ineffective.

The second author summarises the position by saying: "The results of investigations made during the past two years indicate that *Trichogramma* cannot be considered as an effective parasite in the control of paddy stem borers, even when liberated in large numbers."

In the literature available, there are many more references to the liberation of this parasite for control purposes. While they do not give sufficient data to warrant additions to the list made out above, it seems abundantly clear that *Trichogramma* fails to perform what is demanded of it, except possibily in the case of the sugarcane borer, *Diatraea saccharalis*. It might have been thought that, given sufficient parasites, there should be little difficulty in them accounting for nearly 100 per cent. of the egg population; yet when small areas have been flooded with them, the result has been disappointing.

It may be pertinent at this stage to enquire just exactly what is required. The answer is that the parasite must lower the population of the pest to such an extent that the benefit derived from extra crop on that account shall more than compensate for the total cost of the operation. It is necessary that the parasite rapidly overtakes the host in point of numbers so that the chances of control are increased. In order to give it an opportunity of doing so, a large number of parasites must be liberated at a time when the host population is beginning to get numerous. That is nearly as far as we can go. The matter then entirely rests with the insect itself to propagate in the host eggs. It is possible to go a step further, and to keep liberating large numbers at frequent intervals, as in the case of the Myers orchard referred to above, but the breeding problem then assumes such vast dimensions that it is very unlikely that it would be undertaken, even if successful. There would be no justification for trying it, unlesss the annual crop was a total loss and there was a very strong probability of success. In our view, there is no likelihood of either.

We come now to the question—what is the parasite likely to do for us in the case of Tortrix on tea ? We have seen above that Codling Moth eggs are available in some numbers for at least nine weeks; the period for the sugarcane borer was similarly fourteen weeks. This period is an important matter, since the longer an abundant supply of eggs is present, the better the chances of a large parasite population; and the more parasites there are, the more parasitized eggs there should be. *Unfortunately*, this is just where *Trichogramma* disagrees with our calculations; and we can do nothing about it, since the parasite must have the last word on the matter. Recurring to the period of maximum oviposition, the corresponding time for Tortrix is three to four weeks. Since the life cycle of the parasite is about 15-20 days at the time of year it would be required, the time is not sufficient for a third generation to develop itself before the number of host eggs rapidly decreases, and inevitably the number of parasites must also decline. Moreover, at the start when the parasites are liberated, a large number of eggs will infallibly be missed, since it takes time for the insects to disperse, and in addition they will not parasitise eggs more than three days old. Therefore, to answer the question set at the beginning of the paragraph, the chances of a successful campaign are not very bright.

Other Parasites.—An alternative method of attempting to deal with Tortrix on biological lines is to introduce some parasite or parasites of the larval or pupal stages which are only to be found elsewhere than Ceylon, and which give a considerable degree of control. This would necessitate a survey of some places where Tortrix is found as a minor pest of tea, and where the climate approximates to that governing the area in Ceylon which suffers most from this pest. If an opportunity arises for making an investigation in some such place as Java, it should not be allowed to pass by.

Wilt.—It has been observed by many people that at times this disease is severe among a caterpillar population. On that account proposals have occasionally been put forward to make use of it in some way in order to increase the death roll. Apart from the fact that it appears to be highly infectious, next to nothing is known about the malady, in particular how the victim becomes infected. It was supposed that if wilted caterpillars were mashed up in water, and the resulting fluid sprayed over the bushes, the insects would take the disease and die. But in order to do this, infected caterpillars must first be obtained from the field, in other words wilt must already be present, and there is no method of finding out whether the operation of spraying the bushes will improve on the activity of the disease if left to itself. Even in small scale experiments using controls, it is not possible to discover whether apparently healthy caterpillars selected for the trials have contracted the disease before the experiment begins. Until some definite information about Wilt is forthcoming, sprays made up as suggested cannot be recommended for inclusion in contra-measures. Hutson [9] records the fact that numerous experiments over thirty years in America have failed to yield any means for increasing the natural destructiveness of Wilt.

SUMMARY.

1. Notes on the history and distribution of Tea Tortrix are given.

2. A brief account of the life-history of the pest shows that the life cycle lasts some two months. The different stages are described, and the periods of development are roughly one week for incubation, 6 weeks for the larval period, and about one week for the pupa.

3. A sketch of the seasonal history throughout the year shows that there are about five generations, that occurring in December or January being the most important.

4. Notes on natural checks, including wilt disease, parasites and birds, are given. Wilt appears to be the most important limiting factor, but none are capable, either alone or taken together, of consistently reducing the destructive power of Tortrix to reasonable limits.

5. Of the methods of artificial control, flight breaks and spraying are discussed and shown to be of doubtful value.

6. The problem of breeding *Trichogramma* and its application as a means of control are discussed in detail, and examples of the results of experiments in other parts of the world are added.

REFERENCES.

(1). Allen, H. W. and Warren, A. J.—*Jl. Econ. Ent.* Vol. 25, p. 374,

(2). Box, H. E.—*Bull. of Imp. Inst.* XXXI No. 2. p. 221,

(3). Glaser, W. R. and Chapman, J. W.—*Jl. Econ. Ent.* Vol. 6, p. 479,

(4). Green, E. E.—*Administration Report, Royal Botanic Gardens, Ceylon*, 1899.

(5). Hinds, W. E. et al.—from *Rev. App. Ent.* Vol. XXI, p. 224,

(6). Hutson, J. C.—*Yearbook of Dept. of Agric. Ceylon*, 1927, p. 11.

(7). ,, *ibid* p. 13.

(8). ,, *ibid* p. 16.

(9). ,, *ibid* p. 18.

(10). Jardine, N. K.—"Tea Tortrix", *Bull. 40, Dept. of Agric. Ceylon*, 1918.

(11). ,, *ibid.* p. 15.

(12). ,, *ibid.* p. 31.

(13). ,, *ibid.* pp. 4 and 27.

(14). ,, —"Tortrix Flight Breaks", *Bull. 45, Dept. of Agric. Ceylon*, 1919, p. 1.

(15). ,, —"Field Experiments with anti-Tortrix Fluids", *Bull. 46, Dept. of Agric. Ceylon*, 1919.

(16). List, G. M.—*Jl. Econ. Ent.* Vol. 26, p. 376.

(17). List, G. M. and Davis, G.—*Jl. Econ. Ent.* Vol. 25, p. 981,

(18). Pagden, H. T. and Corbett, G. H.—*Malay. Agric. Jl.* XXI, p. 362,

(19). du Pasquier, R.—*Principles Malades Parasitaires du Théier et du Caféier en Extrême-Orient*, Hanoi, 1933, p. 72.

(20). Schread, J. C.—*Jl. Econ. Ent.* Vol. 25, p. 373,