

STUDIES OF SHOT-HOLE BORER OF TEA

1—DISTRIBUTION AND NOMENCLATURE

C. H. GADD

DISTRIBUTION

Occurrence in Ceylon.—The shot-hole borer beetle (*Xyleborus fornicatus*) was first noted as a pest of tea in Ceylon by Mr. G. Alston of Craighead estate, Nawalapitiya, in 1892; possibly the beetle had then been on the estate for a few years, more or less unobserved. In 1893, *vide* Green (1903), the infested tea area amounted to 500 acres only, but by 1903 the estimated acreage had become 50,000 acres, the pest having extended its range to surrounding districts.

In 1912 the borer was proclaimed a pest within the meaning of Ordinance No. 6 of 1907, and it became compulsory for its presence on any plantation to be reported to the Director of Agriculture. Speyer, in 1918, published the names of all estates and districts from which the beetle had then been reported. The list of infested estates at the Department of Agriculture, no doubt, has grown considerably since

then. It should be noted, however, that the presence of a name on that list does not mean that the beetle is a pest on that estate; it merely records that at sometime or other the beetles or their galleries have been seen there. For instance, St. Coombs estate does not appear on Speyer's list, but since its publication, beetle galleries have been observed on that estate and their presence reported to the Department. Still the beetle has not become a pest, and damage caused by it, if any, is negligible. A few galleries may be found when pruning, though rarely are living beetles found within them.

Of more interest than Speyer's list of infested estates are his observations on the distribution of the beetle. He summarised the position as follows:—

"The elevation of the Craighead estate is about 2,000 feet above sea level. It is at this elevation that shot-hole borer is now

particularly abundant.... There does not seem to be much doubt that shot-hole borer spreads gradually upwards attaining an altitude of 5,000 feet, but it becomes less common when 4,000 feet is reached, and above 4,500 feet it is no longer a serious pest.... At very low elevations, 100-1,000 feet, the insect curiously enough becomes again less abundant."

In the writer's opinion the above statement fairly represents the position today also. In other words, the beetle has not materially extended its range as a pest since 1918.

From time to time reports are received of the presence of the beetle on estates normally considered to be entirely free of the pest. This sometimes gives rise to the view that the beetle is "moving up the hill," and the prognostication at times creates a little alarm. The beetle undoubtedly moves "up the hill," but experience has shown that the move is only temporary. In 1918, Speyer wrote "Inquiries show that Shot-hole borer was found attacking half-an-acre of tea on the Glasgow boundary in August, 1903; the infected portion was pruned and all the prunings were burnt; this information comes from Mr. Jackson who was then Superintendent on the estate. The borer has not re-appeared here or on any neighbouring estate in the Dimbula district."

The final statement as it stands is not quite accurate at the present time, as several estates in Dimbula, e.g., St. Coombs mentioned earlier, have at sometime or other reported the presence of the beetle, but if the words "established itself" were substituted for 're-appeared' the statement would be as true today as in 1918.

Again, he wrote: "The most interesting point is the limitation of the distribution at certain places in well-marked valleys. In Dimbula the infestation comes to a somewhat abrupt end on the East Holyrood and St. Andrew's estates, and it seems likely that the insect is from time to time blown from the lower portion of the valley (Meddecombra) to the latter estate, but never becomes properly established there." The distribution of the beetle is still limited by elevation exactly as in 1918, as the beetles do not breed normally and increase numerically at altitudes above 4,000 feet or near sea level in Ceylon. The controlling factor is in some way connected with altitude and, as a guess, one might name temperature to be the important factor, the higher elevations being too cold and the lower too warm; but there is no direct experimental evidence to support that guess.

The beetle is also known to occur in South Indian tea areas, but there it has never attracted any great attention as a pest. In 1937 Rao stated: "Evidence is lacking as to whether there has been any definite and progressive increase in the infestation from year to year since its first appearance. There is evidence, however, to show that the pest does not exist on all fields of an estate but is yet confined to odd fields and even there only to certain patches." Since then no marked increase of the pest has been reported.

The mere bringing together of tea bushes and tea shot-hole borer beetles does not necessarily result in the beetle becoming a serious pest. Other conditions, which include climate, must also fulfil certain requirements of the beetle satisfactorily. Although it may not be possible to define those conditions accurately, it is evident

that through the greater part of the tea area in South India and at high and low elevations in Ceylon, the accessory conditions are not such that allow the beetle to establish itself and breed freely. Hence the beetle does not and cannot become a pest of major importance there, except when such conditions become temporarily favourable, or until a race of beetle which can accommodate itself to those conditions is evolved.

The distribution of Shot-hole borer as a pest of tea in Ceylon has not altered appreciably for many years. The borer appears to have established itself as a pest in all tea districts in which it can survive and multiply, and experience shows that the risk of the beetle establishing itself as a pest in new districts or in fields previously free of it is negligible. If that view is accepted, it will be evident that elaborate precautions to prevent further spread are unnecessary and unwarranted. Existing regulations restricting the movement of tea plants from any area, whether infested or not, without the Director of Agriculture's written permit serve no useful purpose and should therefore be rescinded.

World Distribution.—Reviewing the records of occurrence of the beetle, Speyer (1918) concluded that the only records of the insect outside Ceylon were of a collection made at Bangalore, India, from a castor-oil tree, and possibly Hagedorn's record (1913) from Penang, of the nutmeg tree as host.

Beeson (1925) has since shown that *Xyleborus fornicatus* is indigenous in India and given records from Bengal, Madras and Mysore. Tea, however, was not included in his list of Indian food plants as some doubt existed concerning its presence in South Indian tea. Bainbrigge Fletcher

(1914) had reported the presence of the borer in tea in Travancore in 1914 on information supplied by Anstead, who had observed it in 1910. Later, Anstead came to the conclusion that he had been mistaken and stated (1920) that *X. fornicatus* did not appear to occur in South India. In view of Rao's observations (1936) there can be no doubt that *Xyleborus fornicatus* does now occur in South India in tea, and that it has existed there for some years. Probably Anstead's original observation was correct.

The beetle is also known to occur in the Dutch East Indies (Van Heurn 1919; Kalshoven 1924 a and b) in Hevea and Tea; and in Northern Formosa (Sonan 1939) in Tea. Only in Ceylon does the pest appear to be of serious importance.

HOST PLANTS

Green (1903) pointed out that the borer beetle did not confine itself to tea, and that it could be found in other plants. He listed *Albizzia stipulata*, *A. moluccana*, *Bixa orellana* (Annatto), *Cinchona calisaya*, *Erythrina lithosperma* (Dadap), *Grevillea robusta*, *Lantana*, *Psidium guajava* (Guava), *Ricinus communis* (Castor oil) and *Theobroma cacao* (Cocoa) as hosts in Ceylon. In 1905 he added *Crotalaria striata* to the list. Rutherford (1914 a and b) added *Hevea brasiliensis* (Rubber), *Melastoma malabathricum*, *Persia gratissima* (Avocado Pear), *Photinia japonica* (Loquat) and *Tephrosia candida*. He mentions having seen also cases of invasion of *Poinciana regia*, *Bauhinia* sp., and *Aberia gardneri* when growing in proximity to infested tea; in *Poinciana* and *Aberia* the beetles were usually entombed in exudations of resin, whereas in *Bauhinia* the beetle made no headway. Speyer (1918) published a complete list

which in addition to plants already mentioned included *Allophylus cobbe*, *Caryota urens* (Kitu), *Cassia alata*, *Citrus aurantium* (Orange), *Clerodendron* sp., *Desmodium cephalotes*, *Petraea volubilis*, *Tephrosia vogelii* and *Terminalia catappa* (country almond). Since then a few more names have been added to the list, namely *Cedrela toona* (Jepson 1920) *Gliricidia sepium* (Light 1927) *Derris robusta* (Light 1928) and *Crotalaria anagyroides* (Hutson 1932).

Outside Ceylon the following additional plants have also been recorded as hosts:—*Myristica fragrans* (Nutmeg) in Penang, *Albizia odoratissima*, *Erythrina indica*, *Ixora parviflora*, *Odina Wodier*, *Gmelina arborea* and *Ficus nervosa* by Beeson (1930) in India; and *Schleichera trijuga* by van Hall (1920) in the Dutch East Indies.

The above list of plants in which *Xyleborus fornicatus* has been found at some time or other may appear impressive and suggest that there are numerous possible sources of infection for tea. The truth is probably very different. The fact that the beetle may be found in particular plants is no proof that they can live normally and multiply in those hosts. Mention has already been made of Rutherford's observation that in *Poinciana* and *Aberia* the beetles usually became entombed in resin. In 1903, Green expressed the opinion that the insect is not at home in *Grevillea* and attacks only sickly branches; the beetle is still found at times in *Grevillea* branches but there appears no reason for any modification of Green's opinion. Speyer said of the plants listed by him in 1917 that only three harbour the insect to any great extent, namely castor oil tree, tea and country almond, if the identification is correct in the latter case.

In India, *vide* Beeson (1930) "The principal food plant is *Ricinus communis*," i.e., castor oil. In Ceylon it is now undoubtedly tea, though in Speyer's opinion the true host plant of the beetle is the castor oil plant (*Ricinus communis*) (Director of Agriculture 1916).

Tea and Castor-oil Tree.—As a result of Speyer's opinion that the castor oil tree is the true host of the beetle *Xyleborus fornicatus* and of his observation that the beetle swarmed from castor to tea, it was decided that no measures for the control of the borer could be successful so long as castor existed in the tea area (Director of Agriculture 1915). The growing of the castor oil plant within the tea-growing area of Ceylon was prohibited by law in June, 1916. Time has shown this to be an unnecessary restriction. Yet it still exists. It is evident, however, that the failure to control beetle damage in tea cannot be attributed to reinfestation from castor.

Jepson (1920) started experiments using castor as a trap tree. He appears to have experienced considerable difficulty in growing castor amongst tea, not because of the beetles but because of other troubles. The experiments were discontinued in 1923 as they failed to indicate any reduction in numbers of the shot-hole borer beetle in the areas interplanted with castor (Jepson 1924).

Later, the question arose whether the castor beetle is really the same as that which invades tea. Observations on this question will be discussed in a later section.

NOMENCLATURE

The Beetle.—*Xyleborus fornicatus* was originally described and named by Eichhoff in 1868 from a specimen collected in Ceylon. The plant from which the beetle was taken is unknown. It may have

been tea, but there is considerable doubt about it. Whether the plant was castor is equally unknown.

What is generally considered to be the oldest field of tea under continuous cultivation in Ceylon is a 20-acre block on Loolecondera Estate, Hewaheta, which was cleared for planting towards the end of 1867 (Ekers 1935). There were at that time a few tea bushes in the Botanic Gardens, Peradeniya, in Nuwara Eliya and in a few other places. So it is not impossible that Eichhoff's specimen came from tea, but there is doubt about it.

The earliest known authentic specimens from tea were sent to the Indian Museum in 1895 (Barlow 1896) and they were examined and identified by Blandford as *Xyleborus fornicatus* (Eichhoff).

In 1903 Green published a short description of the tea shot-hole borer and used the name *Xyleborus fornicatus* in connection with it. His description is reproduced below:—

"The insect . . . is a minute cylindrical beetle, 2.25 millimetres (or a little more than one-twelfth-of-an-inch) long. It belongs to the family *Scolytidae*, and is known to Entomologists by the name of *Xyleborus fornicatus*. The mature beetle is of a black or very dark brown colour. Individuals that have recently emerged from the pupal condition are of much paler tint but after some hours the full colour is assumed. The head is almost concealed beneath the anterior part of the thorax, which is rounded in front and projects like a hood. The round part of the thorax is roughened like a rasp, and is probably employed as such in the excavation of the galleries formed by the insect in hard wood. The abdomen is completely covered by the elytra or wing

cases, which are minutely pitted in longitudinal lines and sparsely covered with fine erect hairs. The wings are well developed and capable of carrying the insect through the air in search of fresh breeding grounds in the neighbourhood. When not in use they are neatly folded away and concealed beneath the hard wing cases.

"The adult male is a still smaller insect, measuring only 1.50 millimetres, equal to exactly one-seventeenth of an inch in length. It is usually of a paler colour than the female, but of the same outer form. It has, however, no wings beneath its wing cases, and lives and dies within the galleries in which it has been reared. The work of excavation is probably carried on entirely by the adult female insect."

Its name.—In 1922 Eggers, an authority on the *Scolytidae* stated that he had examined specimens from Peradeniya, and that, although they agreed with Green's description they did not match Eichhoff's type, then in his (Eggers) possession. He therefore described the specimens from tea as a new species which he named *Xyleborus fornicator*.

Winn Sampson, in 1923, gave reasons for being unable to accept *X. fornicator* (Eggers) as a valid species. Beeson (1925) supported Winn Sampson in-so-far that *X. fornicator* could not be accepted as a good morphological species, but he considered the retention of the name in sub-specific rank to be desirable on biological evidence.

Speyer (1919, 1923) recognised two races of *X. fornicatus* in Ceylon which could be distinguished by their size. The larger type predominates in castor and dadap, and the smaller in tea. These two types correspond to the sub-species *X. fornicatus fornicatus* with a body length of 2.5 mm..

and *X. fornicatus fornicator* with body length of 2.2—2.35mm. Beeson also recognises *fornicator* not only by size but by the elytral curve, from scutellum to sutural apex, being more convex than in the larger *fornicatus*, which has the basal third of the elytra more or less flat and horizontal.

The elytral curvature is by no means a satisfactory character to work with; size is much better as it allows of accurate measurement. In Table I the measurements of five samples of *X. fornicatus* are summarised. Each sample consisted of 50 female beetles removed from galleries in castor, tea and *Mimosa bracaatinga* bran-

If, however, we attempt to classify individual beetles by their size, the problem becomes still more difficult. It may be seen from the range of measurements given in Table I that the largest specimens from Tea A and *Mimosa* are larger than the smallest specimens from Castor. If the 50 beetles from Tea A or *Mimosa* were mixed with the 50 from castor it would be impossible to separate them again into the two original groups either by size or any other character.

Speyer's explanation (1923) of this type of observation is that "the larger race in castor, (*i.e.*, *fornicatus-fornicatus*) gives rise

TABLE I

Summary of Length Measurements of 5 samples, each of 50 female *X. fornicatus* from different hosts.

	Range mm.	Mean mm.
Tea A (25 months from pruning)	2.2—2.4	2.33
<i>Mimosa bracaatinga</i>	2.2—2.4	2.34
Tea B (20 months from pruning)	2.3—2.5	2.39
Tea C (24 months from pruning)	2.3—2.5	2.39
Castor	2.3—2.6	2.45

(The mean values 2.34, 2.39 and 2.45 mm. are all significantly different).

ches. The three samples from tea were collected at different times and from different fields of one estate. The castor and *Mimosa* specimens were obtained from the same locality. The mean length of the specimens from castor was 2.45 mm., which immediately places them as belonging to the large type, *fornicatus*. The specimens from Tea (A) and *Mimosa* have mean lengths of 2.33 and 2.34mm., respectively, which show them to be of the smaller type *fornicator*. But the specimens from tea (B and C) both have intermediate values, viz. 2.39 mm. As judged by size they are neither *fornicatus* nor *fornicator*.

to the small race in other plants, and that this small race, (*i.e.*, *fornicatus fornicator*) is gradually predominating over the original one in Ceylon."

Speyer's earlier explanation (1919) was different. He then wrote "It would seem that, when the beetle has bred in castor for sometime, a distinct 'race,' but not a distinct 'species,' of slightly larger size than the insect usually found in tea, is evolved. The same applies to Dadap. At least one outbreak of this larger race has occurred in tea." The known fact, viz. that a large and a small race occur, will fit one explanation as well as the other, but if the castor race

evolved from the tea race, his own hypothesis that the castor oil tree was a main source of infection for tea is nullified. His later explanation better fits that hypothesis.

The measurements (2.25 mm. for the female) given by Green in 1903 show that the beetle he was acquainted with was the small one, *fornicator*. As the growing of castor in the neighbourhood of tea has long been forbidden, and consequently the infestation of tea by the larger beetle has long since ceased, the presence of intermediate sized beetles (Tea B and C in Table I) cannot be regarded as a stage in the evolution of the smaller type. It may here be stated that the probability of the intermediate type being a cross between *fornicatus* and *fornicator* is extremely unlikely, because so far as is known mating takes place in the parent gallery and the male cannot fly.

In South India where the beetle has not become a major pest of tea, Rao's observations indicate that there too beetles occur in tea which cannot readily be classified as either *fornicatus* or *fornicator*, but are intermediate in character. In his annual report for 1940-41 Rao states:—

"Through the courtesy of Dr. Beeson, an examination was possible of a series of beetles collected from estates near Vandiperiyar over a period of several years. The examination revealed that the majority of the specimens showed a mixture of features of *fornicatus* and *fornicator*. The typical *fornicatus* features were possessed by a small number of individuals while the number of individuals conforming to the *fornicator* type was equally small.

"The specimens of the beetles were all collected from tea bushes at different times and there could be little doubt that the beetle had bred in them for a number of

generations. From the above examination it would appear that the insect even after several years' breeding in tea (ten years as far as authentic records go and probably many more than this), has not produced a race which is exclusively *fornicator*."

So far, comparisons between *fornicatus* and *fornicator* have been made on morphological characters, and if we are to draw a conclusion at this stage it must be to support Winn Sampson's opinion that *X. fornicator* Eggers cannot be accepted as a valid species. Beeson, however, suggested the retention of the name with sub-species status on biological grounds. He clearly stated those grounds in a letter to Mr. F. P. Jepson in 1934. In it he said:—

"I have collected *fornicatus-fornicatus* Eich in many parts of India in the vicinity of tea gardens, but have never found a case of attack on tea. Here in Dehra Dun, the borer is abundant in castor oil but never spreads to tea a few hundred yards away. I have seen no specimen from Ceylon of *fornicatus-fornicatus*, that are labelled 'extea,' all the tea specimens being *fornicator*. I must admit that I have not tried to force *fornicatus* to attack tea."

Jepson himself had recorded (1920) a somewhat similar observation of the castor beetle not moving to tea. He wrote: "In April, an unusually severe infestation of castor by Shot-hole Borer was discovered in the Rakwana district, literally thousands, if not hundreds of thousands, of galleries occurring in a few plants. It was significant that the surrounding tea was comparatively free from attack."

King (1940) supported Beeson's views but on different grounds — not that the beetle from castor does not attack tea, but that the beetle from tea does not attack castor. He stated: "On biological grounds

the distinction is quite clear, since the tea borer does not attack castor; and while the castor borer may attack tea to a slight extent it only does so in the vicinity of attacked castor plants."

King's statement was based on the results of cross inoculation experiments (King 1941). His results showed that the beetle from tea could breed in two test plants, tea and *Mimosa bracaatinga*, whereas the beetle from castor could breed in at least five hosts in addition to castor. They are *Albizzia falcata*, *Hevea*, *Mimosa bracaatingu*, *Tephrosia candida* and Tea. Both beetles, (i.e., from tea and castor) were able to bore galleries in several other plants but were unsuccessful in breeding in them.

Later, King had reasons to doubt the accuracy of his statement concerning the inability of the tea beetle to attack castor. He discovered (King 1941) that castor is not susceptible to borer attack until the tree is at least two years old, and he therefore decided to repeat the experiment with castor of suitable age. This experiment (Gadd 1942) showed that the tea borer beetles entered the castor branches, and of 19 galleries dissected 5 were found to contain 33 inmates consisting of eggs, larvae, pupae and adults.

King's cross inoculation experiments clearly demonstrate that, at least in Ceylon, the borer from tea will attack castor just as the beetle from castor will attack tea. Unfortunately no measurements were made of the beetles used and obtained in these experiments. It would have been of great interest to know whether the offspring of larger beetle from castor were smaller when raised in tea, and vice-versa, as little or nothing is known of the effect of the host on this parasite.

Although the inoculation experiments lend support to Speyer's view that the

castor beetle will pass from castor to tea they afford no explanation of Beeson's observations, at Dehra Dun, India, where the beetle never spreads to tea. The experiments are not sufficiently conclusive to establish the biologic identity of the beetles normally found in castor and in tea. More information is required, not only of the effect of the host on the size of the parasite but of the life history and habits of both beetles. The borer from tea, as a pest, has been the subject of study for many years but the castor beetle has not been similarly studied. The writer is of the opinion that a comparative study of the two insects might disclose important differences.

Recently I had the opportunity of observing an infested castor stem. The males behaved in a manner quite different from those from tea branches. A discussion of this behaviour will, however, be reserved for a later section, as the observations are not yet completed. It will be sufficient here to state that biological differences between the beetles probably exist, and that in consequence there may be some justification for the retention of the two sub-specific names as Beeson suggested.

Strictly, the name *Xyleborus fornicatus fornicator* should be used only for the beetles as defined by Beeson, i.e., for the smaller race with the more arched back. Like other writers I have used the name *fornicator* to denote the beetle from tea. Such use is not strictly correct as a small number of beetles from tea, as stated by Beeson, exhibit *fornicatus* features, and an equally small number are typically *fornicator*. The majority are indeterminate. In later articles the writer will use the name *Xyleborus fornicatus ex-tea*, as that designation carries no implication that only the smaller type with *fornicator* characters is intended.

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