Shot-Hole Borer of Tea Plant in Japan

T. KANEKO

Chief, Pest Control Laboratory, Tea Agronomy Division, Tea Research Station

It has long been known that *Xyleborus fornicatus* EICHH., a kind of shot-hole borer of the tea plant, damages tea plants in Ceylon. In Japan, *Xyleborus germanus* BLANDF. and *Xyleborus compactus* EICHH. are very notorious for their heavy damage to tea plants, the former attacking roots (at 0—50 cm under the ground) while the latter injuring trunks and branches. It is well-known that these shot-hole borers belong to the so-called Ambrosia beetle and live in symbiosis with certain kinds of fungus. But little knowledge of ecological aspects was known. Based on the findings from studies which we have carried out since 1964, the ecological condition and control of borers will be explained as follows.

Breeding

The breeding is fundamental for entomological studies. In the case of Ambrosia beetle, it is no exception. As the shot-hole borers particularly have a wide annual fluctuation in their natural occurrence, breeding them is very important to obtain materials constantly for study. The successful method for breeding now under way is as follows. Some twigs of the mulberry tree, *Morus abla* L., are put in a test tube (20 cm long and 2.1 cm in diameter), which is then plugged with cotton. The tube is autoclaved (at 110°C with 1.2 lbs for 15 min.). In the meantime, surface sterilized female adults of borer are inoculated on twigs one by one. In the process of surface sterilization, it is advisable to dip the adults in a 1 to 1,000 mercuric chloride solution for 5 minutes because it is simple and successful. It is also very essential for the breeding of borers to keep them free from Aspergillus spp. and mites. Humidity in the tube can be no worth consideration.

Two kinds of shot-hole borer grow up through breeding in the test tube, the temperature in which has been kept constantly at 25°C, as mentioned below.

Interrelation between shot-hole borer and its symbiotic fungs

Although the interrelation of the shot-hole borer with symbiotic fungus has long been known, it was Francke-Grosmann who found out how it came out. She made a great contribution to the ecology of Ambrosia beetle by discovering for the first time that the beetle has a special organ of mycangia to carry the symbiotic fungi. It was confirmed that both *X. germanus* and *X. compactus* which are injurious to Japanese tea plants have this organ at the mesonotum of a female adult (Photo 1), elucidating characteristics of the symbiotic fungus.

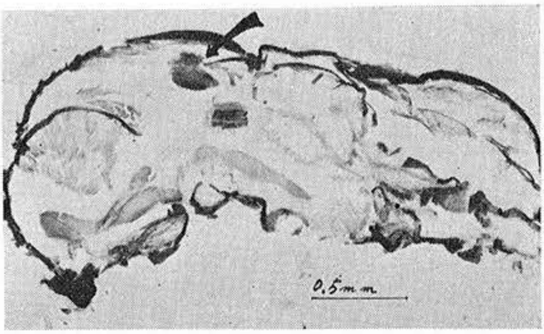

Fig. 1 Sagital section of whole beetle (Xyleborus germanus) The arrow indicates mycangia.

Namely, the fungus has two types of spore called stored spore and cultivated spore. The former can be seen only in the mycangia of beetle, playing a role of propagation and hibernation. The latter is found in a gallery which the beetle has bored, feeding larvae. It has been discovered that both of these two kinds of spore can be artificially produced. The stored spores can be produced in a liquid medium of peptone-yeast-glucose by shaking culture, while the cultivated spores in the same medium added by agar, by still culture. But the relationship between spores produced by artificial culture and the natural ones has not been clarified yet.

As for the symbiotic relation between fungus and beetle, it has long been a question whether the kind of symbiotic fungus is different according to different kinds of beetle and whether the same beetle has a symbiotic relation with different kinds of fungus. On this question, however, opinion has so far been divided so much. Before everything else, it should be made clear that is the symbiosis between beetle and fungus. After a pure culture of symbiotic fungus to *X. germanus* or *X. compactus* is made, it is artificially inoculated to the

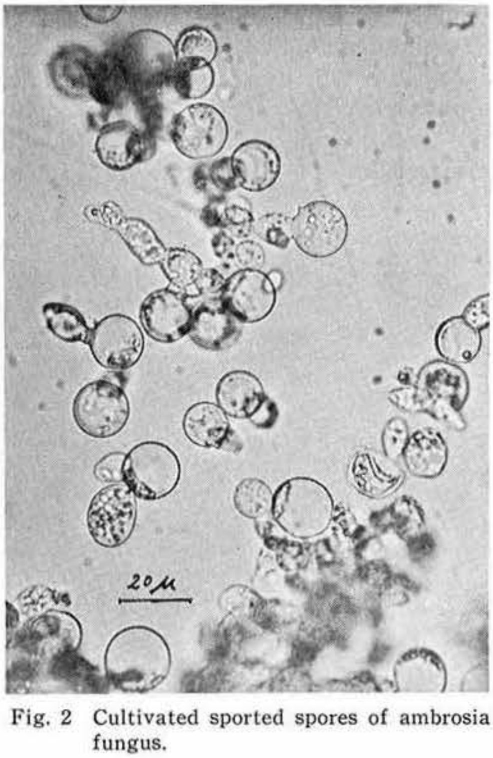

Fig. 2 Cultivated sported spores of ambrosia fungus.

beetle free frome any fungus. If the beetle thus inoculated makes normal reproduction and the pure culture of fungi of the same kind as inoculated is produced from the beetle, the fungus thus produced is considered as the symbiotic fungus. Any symbiotic fungus to other kinds of beetle should be confirmed after the same process as mentioned above had been taken. Through the improvement of the above process, symbiotic fungi to *X. germanus* and *X. compactus* have come to be artificially exchanged. Through this artificial exchange, these two kinds of fungus have been proved to be morphologically and physiologically just the same. In the course of the above research, another finding was brought forth. It is how the first generation of fungus produces the second generation: in other words, how a symbiotic fungus is brought over to mycangia of an adult beetle after moulting. A female beetle immediately after moulting moves its head actively. As it does so, the mycangia below meso-notum reverses and protrudes out from beetle's body. As symbiotic fungi remain on the wall of the gallery in which the beetle has moulted and spores stick to the inside of that part and then are brought over into the mycangia. Although other miscellaneous fungi will naturally get in together with the symbiotic fungi, only the latter propagate inside the mycangia. It is still unknown why such selection is performed between symbiotic fungi and others.

Reproduction

It is well-known that Xyleborinae have an abnormal sex ratio or that the population of male is much lower than that of female. Therefore some of the peoples assume that they may perform the female produce parthenogenesis. A study on *X. germanus* and *X. compactus* which do injury to tea plants, proved that both of them perform surprisingly enough the male produce parthenogenesis. If a female beetle is secluded and bring symbiotic fungi over to itself after it having moulted, it can lay eggs without fertilization and all its progeny grows up as male insects. In this case, a female beetle which does not bring over symbiotic fungi, does neither lay eggs nor develop its gonad. Thus a studyon chromosome has been started to make clear in what process such parthenogenesis is performed. As a result, it has been proved that a somatic cell of female *X. germanus* has 16 (2n) chromosomes while that of the male 8 (n) and that a somatic cell of female *X. compactus* has 20 (2n) chromosomes while that of the male 10 (n) chromosomes. Therefore, it is known that these two kinds of Ambrosia beetle make a whenotokus parthenogenesis, that is, all of their fertilized eggs become female beetles while nonfertilized become male beetles. But it is still unknown why male beetles (non-fertilized eggs) are so smaller in number than female ones (fertilized eggs).

Ecology and control of shot-hole borer

a) X. germanus

As mentioned before, the Ambrosia beetle likes to attack the root of tea plant. It reproduces twice a year in June to July and August to September and hibernates at the root. It is presumed that the beetle emerges once above the ground and then makes dispersion, one of the most important processes of its propagation. A study on particulars of the dispersion is now under way. It is also presumed that *X. germanus* attacks *Castanea crenata* SIEB et ZUCC. and*Biospyros kaki* THUNB. other than tea plant and bores into their trunks and branches but not into their roots. A further study should be made on this interesting fact that the two kinds of beetle which are considered to be taxonomically the same respectively attack different parts of their host.

In controlling the beetle, drenching tea plants with cyclodiene insecticides had been experimentally performed with little success. Now it is planned to study if a chemosterilant could control the beetle and if a fungicide could inhibit the growth of symbiotic fungi.

b) X. compactus

It is observed that *X. compactus* attacks trunks and branches of tea plants and occurs twice a year, first in July to August and then in August to September. Hibernation is made by female adults from the second occurrence in branches where they were born. The death rate of hibernated adults is very high in Japan perhaps because of the severe winter. The dispersion is made through flight. Since the extent of their attack is different according to different kinds of tea plants, there must be an interclonal difference among the plants.

The control of *X. compactus* had been considered to be much easier than that of *X. germanus* which attacks the root of the tea plant until the wide occurrence of tea tortrix and leaper moth was induced by the reduction of their natural enemy due to the application of dieldrin against *X. fornicatus* in Ceylon. Thus the control of *X. compactus* seems to be as difficult as that of *X. germanus.*

Under the situation as mentioned above, it will be very important to make a fundamental research into attractants of the Amrosia beetle and breeding of resistant varieties of tea plant in order to develop the study on control method of these noxious insects. In proceeding with such research, Scolytidae as a whole should be studied physiologically and ecologically.

Table 1. Mean lengths of egg, larval and pupal periods of two species of beetle (25°C)

	Mean egg period(days)	Mean larval period(days)	Mean pupal period(days)
X. germanus	3	7	5
X. compactus	5	9	4

References

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