Biology of Some Scolytid Ambrosia Beetles Attacking Tea Plants

I. Growth and Development of Two Species of Scolytid Beetles Reared on Sterilized Tea Plants

By Takeshi KANEKO

Tea Research Station, Ministry of Agriculture and Forestry,
Kanaya, Shizuoka Pref.

There are two species of *Xyleborus* attacking tea plants in Japan. The tea stem borer, *Xyleborus compactus*, occurs twice a year and overwinters in tea twig in the adult stage. The first generation appears from July to August and the second from August to September. The adult females usually bore into slender twigs (5 to 8 mm in diameter) just under the surface of tea bush. But in the case of high population density, the beetles also attack trunks at ground level.

Xyleborus germanus occurs twice a year and overwinters in tea root in the adult female. The first generation occurs from June to July and the second from August to September. Adult females bore into tea roots, but scarcely attack tea twigs under field conditions.

According to the observations in the laboratory (KANEKO *et al.*, 1965), the optimum temperature range for the development is from 25° to 26°C in *X. compactus*, and from 21° to 23° C in *X. germanus*. Number of eggs laid by a female ranges from 14 to 16 in *X. compactus*, and from 30 to 80 in *X. germanus*. It takes about 25 days from invasion of the next generation in both species.

In this paper are described the successful rearings of these two species of beetles on steam-sterilized twigs or roots of the tea plants, and their growth pattern and behavior

under the artificial rearing conditions.

MATERIALS AND METHODS

Food For *X. compactus* tea twigs (7-8 mm in diameter) were collected in fields, cut into pieces of 12-13 cm long, and placed in test tubes (18 × 180 mm) (Plate I, A). For *X. germanus* fresh tea roots (about 15 mm in diameter) (Plate I, C) or tea twigs (13-15 mm in diameter) (Plate I, B) were cut into 8-10 cm long, and placed in test tubes (18 × 200 mm). The test tubes were stoppered with cotton plugs, and steam-sterilized in an autoclave at 122-123°C for 10-15 minutes. Totally, 200 test tubes for *X. compactus* and 700 tubes for *X. germanus* were prepared.

Insect Hibernating adult females of respective species were collected from fields in December or January, surface-sterilized with 0.1 per cent aqueous solution of mercuric chloride, and inoculated aseptically in the test tubes containing sterilized tea plant materials. Five adult females of *X. compactus* or one female of *X. germanus* were placed in each test tube.

Rearing The rearing was carried out in an incubator at temperatures of 25°-26°C for *X. compactus* and 23°-24°C for *X. germanus* in the dark. Throughout the rearing period, each 3 to 5 test tubes were chosen at random for daily observation, and growth and development of insects were examined. Tea

twigs or roots were taken out from the test tubes and dissected, and the number of individuals in each stage of growth was recorded.

Generation by generation rearing

Successive rearing was undertaken in *X. germanus*. Upon emergence of active adults, the beetles were collected from the rearing tubes, and placed in petri dishes with a piece of moist filter paper, male to female ratio being adjusted to 1:2 or 4:11 in a dish. The dishes were kept in an incubator at 23°-24°C for 4 to 5 days for copulation. The resulting gravid females were inoculated into the test tubes containing steam-sterilized roots or twigs, and the rearing of the second generation was carried out according to the procedures described above.

In order to evaluate the effect of inbreeding and outbreeding on growth and fecundity of successive generations, a series of rearing experiments was programmed. In outbreeding test, female adults emerged from a test tube were mated with male adults from another tube; and in inbreeding test, copula-

tion was made among adults from one test tube.

RESULTS AND DISCUSSION

Xyleborus compactus

The results obtained from the rearing experiments are summarized in Table 1. The adult females bored into the twigs and made galleries within two days after the inoculation. From 3 to 5 days after the inoculation, ambrosia fungus formed spores on the wall of galleries and females began to oviposit. The oviposition continued for about 5 days, from 5th to 10th day after the inoculation. The number of eggs laid by one female ranged from 14 to 16. The eggs were laid separately or in clusters on the spores of ambrosia fungus. Each cluster consisted of 5 to 6 eggs. The average period of egg stage was 4 days.

The larvae were found in the twigs until 23rd day after the inoculation. The growth rate was variable with individuals, and all stages from egg to last instar larva could

Table 1. Growth and development of *Xyleborus compactus* fed on steam-sterilized tea twigs (The values show average numbers of individuals per brood)

Day after inoculation	Egg stage	Larval stage			Pupal stage	Adult stage	Total
		First instar	Second instar	Last instar			
1	0	0	0	0	0	0	0
2	Boring Period	0	0	0	0	0	0
3	0	0	0	0	0	0	0
4	Growing period of ambrosia fungus spores	0	0	0	0	0	0
5	1.0	0	0	0	0	0	1.0
6	4.7	0	0	0	0	0	4.7
7	14.8	0	0	0	0	0	14.8
8	—	—	—	—	—	—	—
9	15.0	0.5	0	0	0	0	15.5
10	14.0	0.8	0	0	0	0	14.8
11	12.0	1.8	1.3	0	0	0	15.0
12	7.0	5.0	4.0	0	0	0	16.0
13	7.0	3.0	6.0	0	0	0	16.0
14	1.5	1.5	4.3	7.8	0	0	15.0
15	—	—	—	—	—	—	—
16	1.3	1.0	5.0	6.0	0	0	13.3
17	0	2.0	4.5	4.0	0	0	10.5
18	0	4.0	3.0	4.0	4.0	0	15.0
19	0	0	3.2	5.0	5.0	0	13.2
20	—	—	—	—	0	—	—
21	0	0	3.0	3.3	8.3	0	14.7
22	0	0	0	4.3	2.3	5.7	12.3
23	0	0	0	2.0	4.6	6.2	12.8
24	—	—	—	—	—	—	—
25	0	0	0	0	5.3	6.3	11.7
26	—	—	—	—	—	—	—
27	0	0	0	0	6.7	6.3	13.0
28	—	—	—	—	—	—	—
29	0	0	0	0	4.0	9.0	13.0

	Repli- cation	Egg stage	Larval stage			Pupal stage		Adult stage		Total
			First instar	Second instar	Last instar	♀	♂	♀	♂	
Mean	19	0	0	2.8	7.8	1.1	0	21.8	2.3	35.9
Maximum		0	0	10	15	13	0	33	4	46
Minimum		0	0	2	4	1	0	8	1	24
Sex ratio							.	9	:	1

Table 4. Comparison of growth and development between the inbreeding and outbreeding tests. (The values show average numbers of individuals per brood at 22nd day after inoculation)

	Repli- cation	Egg stage	Larval stage			Pupal stage		Adult stage		Total
			First instar	Second instar	Last instar	♀	♂	♀	♂	
Inbreeding	10	0.3	1.0	11.4	12.0	14.1	2.1	1.2	0.6	42.7
Outbreeding	3	0	0	4.7	12.0	12.7	2.0	7.3	0.7	39.3

Table 5. Comparison between sterilized tea roots and tea twigs as food materials of *Xyleborus germanus*. The first generation. (The values show average numbers of individuals per brood at 25th day after inoculation).

Wood material	Repli- cation	Egg stage	Larval stage			Pupal stage		Adult stage		Total
			First instar	Second instar	Last instar	♀	♂	♀	♂	
Twigs	6	1.5	0.5	12.0	11.0	23.3	2.5	0	0	40.8
Roots	5	7.0	1.2	6.8	34.4	9.2	2.8	0	0	61.4

2 and 3),

Under the condition of 23°–24°C, beetles copulated during 4 to 5 days after emergence. It was often observed from outside that the beetles in the test tubes were copulating in the superimposed position, the male above the female and facing the same direction. According to comparison of outbreeding and inbreeding tests on steam sterilized twigs, there was no significant difference in the growth and development of the second generation (Table 4).

Numbers of laid eggs, matured larvae, and newly emerged adults per brood varied with the sort of wood materials. In the case reared on twig, average number of individuals per brood was 40.8; while on root as many as 61.4 was recorded (Table 5). The beetle seems to prefer root, natural food material, to twig. Without their natural food material, however, they bore into twigs in the rearing tubes and propagate normally. Root is usually more moist than twig, and appears to be favorable for growth of ambrosia fungus spores on which the larvae feed. Desiccation of wood material resulted in decline of growth of ambrosia fungus. The beetles did not necessarily select the wood

materials by size or diameter, but they seemed to prefer the root in moderate size, about 15 mm to 20 mm in diameter. The mother beetle seems to adjust the number of eggs to be laid according to the space of gallery. The number of eggs laid vary with the diameter and relative humidity of wood. The rate of growth and development of the insect, and number of individuals reaching maturity, seem to vary considerably even in the same climatic conditions. It is reasonable to assume that such variations depend on the growth of ambrosia fungus, as well as on the conditions of wood material.

The mother beetles crawl to and fro in the irregularly branched gallery, and usually take care of broods throughout her life. They always seem to intend to keep the galleries clean, and continue to inoculate ambrosia fungus spores on the wall of galleries during the growing period of larvae. It was observed that the dust of wood material and other refuse were pushed out in soft cylindrical form, which are soon broken down and removed from the entrance of gallery.

Relative humidity in the gallery appeared to be kept as constant as possible under

Table 6. Growth and development of *Xyleborus germanus* fed on steam-sterilized tea twigs. The third generation in outbreeding test. The values show average numbers of individuals per brood.

Day after inoculation	Egg stage	Larval stage			Pupal stage		Adult stage		Total
		First instar	Second instar	Last instar	♀	♂	♀	♂	
12	28.0	10.0	0	0	0	0	0	0	38.0
14	18.0	13.0	13.0	0	0	0	0	0	43.5
15	19.5	14.5	7.5	4.0	0	0	0	0	45.5
17	10..	10.0	7.0	7.5	0	0	0	0	34.5
18	3.0	5.0	10.0	14.5	2.0	0.5	0	0	30.0
20	9.0	6.0	6.0	8.0	6.0	0	0	0	35.0

the different temperatures employed. The mother beetle often turns her back to the entrance of gallery and closes the entrance with a sacrifice of her own body.

After emergence, young adult female usually feed on the mycellium of ambrosia fungus growing on the surface of wood material in the test tube.

Virgin adult female was able to puncture the surface of wood material, but only shallow pits were observed, and no growth of ambrosia fungus spores was found there. Generally, growth and development of *Xyleborus germanus* fed on steam-sterilized tea root and twigs are normal during first two generations, but the growth and vitality of ambrosia fungus spores rapidly decline in the third generation under rearing test conditions (Table 6). Sterilized tea roots and twigs maintaining excellent growth of ambrosia fungus spores accounted to only 20 per cent of total in the third generation. The boring activity of beetles and growth activity of ambrosia fungus, however, were recovered by offering fresh roots as food material. It could be suggested that some stimulus of unknown substance contained in fresh wood material promote the activity of newly-emerged adult female.

SUMMARY

1. Two species of ambrosia beetles, *Xyleborus compactus* and *Xyleborus germanus*, were successfully reared in test tubes under the laboratory conditions. *X. compactus* was supplied with steam-sterilized tea twigs, and *X. germanus* with steam-sterilized tea roots

or tea twigs as food materials; then the growth and development of the beetles was observed.

2. The overall development of *X. compactus* from egg to adult requires about 17 days at temperature of 25°-26°C. The egg period was about 4 days. The larval period was 9 days (the first instar, 2 days; the second, 3 days; and the last, 4 days). The pupal period was 4 days. The sex ratio in one brood was 3:2 (♀:♂). Approximately 14 to 16 eggs were laid by one female.

3. The overall development of *X. germanus* from egg to adult required 15 days at temperature of 24°C. The egg period was about 3 days. The larval period was 7 days (the first instar, 2 days; second, 2 days; last, 3 days). The pupal period was 5 days. Sex ratio of emerged adults was 9:1 (♀:♂) in the first generation and 8:1 (♀:♂) in the second.

4. Growth, development, and oviposition of *X. germanus* varied with the kind of wood material. The beetle seems to prefer root to twig. Roots are more moist than twigs, and may be favorable for growth of ambrosia fungus spores on which the larvae feed.

5. The number of eggs laid by a female of *X. germanus* was ranging from 33 to 50. The mother beetle adjusts the number of eggs to be laid according to space of her gallery and diameter of wood material. The growth rate and size of a brood reaching maturity vary considerably even in the same climatic conditions, and it is believed that such variations depend on the growth of the ambrosia fungus which depends on the

conditions of wood material.

6. Comparison between outbreeding and inbreeding rearing tests on *X. germanus* showed no difference in growth, development, and fertility of the insect. None-copulated young female was able to puncture the surface of wood material, but the pits were shallow and growth of ambrosia fungus spores did not occur.

7. The boring activity of *X. germanus* in the third generation was rather declined, and growth of ambrosia fungus became poor in this rearing tests. Some unknown substance contained in fresh wood material seems to stimulate growth of ambrosia fungus and promote the vitality of newly

emerged female adults.

REFERENCES

- KANEKO, T., Y. TAMAKI, and K. TAKAGI (1965)
Japanese Jour. Appl. Ent. Zool. 9: 23~28.

EXPLANATION OF PLATE

Plate I.

- A. Rearing of *Xyleborus compactus* on steam-sterilized tea twigs.
B. Rearing of *Xyleborus germanus* on steam-sterilized tea twigs.
C. Rearing of *Xyleborus germanus* on steam-sterilized tea roots. Matured larvae and ambrosia fungus spores are observed on the wood surface.

摘 要

茶樹を加害するキクイムシ類の生態

I シイノコキクイムシおよびハンノキキクイムシの茶樹 殺菌材による飼育とその経過習性について

金 子 武

農林省茶業試験場

1. 茶樹の材を殺菌したものを飼料としてシイノコキクイムシ (*Xyleborus compactus* EICHHOFF) およびハンノキキクイムシ (*Xyleborus germanus* BLANFORD) を飼育し、これらの経過習性を調べた。

2. シイノコキクイムシは 25~26°C 恒温下で飼育した場合、卵から成虫まで17日を要した。すなわち、卵期間が約5日、幼虫期間が9日(1令--2日, 2令--3日, 3令--4日)で、3令から蛹となり、蛹期間は4日であった。越冬中の雌成虫を殺菌茶枝に接種すると、22日目に最初の成虫が羽化した。雌雄比はほぼ3:2, 1頭当たりの産卵数は14~16粒であった。

3. ハンノキキクイムシは24°C 恒温下で飼育すると、卵から成虫まで15日を要した。すなわち、卵期間が3日、幼虫期間が7日(1令--2日, 2令--2日, 3令--3日)で、3令から蛹化し、蛹期間は5日であった。雌雄比は第1世代成虫で9:1, 第2世代成虫で8:1であった。

4. ハンノキキクイムシの生育虫数は、殺菌根を飼料とした場合は61.4頭で、殺菌枝を飼料とした場合には

40.8頭であった。これは根の水分含量が枝より高くアンブロシヤ菌のはんしょくが旺盛であるためと考えられる。

5. ハンノキキクイムシの雌成虫1頭当たりの産卵数は33~50粒と考えられた。この雌成虫は、材の太さ、孔道の大きさ、およびアンブロシヤ菌のはんしょくの良否によって産卵数を調節しているようである。

6. ハンノキキクイムシについて outbreeding と inbreeding の次世代におよぼす影響をしらべたところ、生育虫数においては、これら両者間にほとんど差異は認められなかった。

7. ハンノキキクイムシの殺菌材による累代飼育の結果では、第1~2世代とも生育は順調であったが、第3世代ではアンブロシヤ菌のはんしょくが、きわめて悪かった。しかし、第3世代を生鮮根で飼育するとアンブロシヤ菌のはんしょくは順調であった。すなわち、殺菌材による累代飼育では、何らかの物質不足によって雌成虫が不活性化されるようである。