Studies on the Rice-Borer. V.

On the Prolonged Emergence Period of the Moth in the Spring. iii.

By

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[January 15, 1936.]

Introduction.

The writers have shown, in two of the previous papers of this series, that the temperature of the hibernacula and contact water which moistens the hibernating rice-borers are at least two causes of the marked variation in the time of appearance of the moth in the spring[1),2)]. However, these two factors alone do not seem to be sufficient to explain why the emergence of the adults of hibernating larvae occurs for such a long period as almost two months.

Insects overwinter in different developmental stages according as their taxonomic positions are different. It has been generally believed that the rice-borers overwinter in the full-grown larval stage. In Hokkaido and Aomori Prefecture, however, a part or the majority of the second generation larvae are still in an earlier larval stage when the winter comes, and in this case the young larvae usually die, not being able successfully to pass the winter[3),4)].

There has been no definite record of experiments as to whether there are any larvae of the second generation, which overwinter in the earlier larval stage, in other warmer parts in Japan. May it not be possible for the second generation larvae to overwinter in the young larval stage under such warm climate as in Kurashiki ? If there are any such young rice-borers, and if they are able to pass the winter successfully, the time when they are full-grown in the following spring, and appear as adult insects, would naturally depend upon whether or not they are able to freely take food in the spring. If this supposition is not mistaken, the stage of development to which the larvae have attained before the hibernation period would be the chief factor which determines the time of pupation in the following spring. Such consideration has led the writers to study whether food and the degree of growth have any relation to the time of pupation and emergence. The results of these studies are reported in the present paper.

Method of Experiment.

Experiments were started at various time in autumn or in winter. The larvae to be used for the experiments were classified into three according to their size: *large*, *medium* and *small*. In 1932 and the following years, they were classified into only two: *large* and *small*. This procedure was followed because the writers assumed that the size of the body approximately indicates the degree or stage of development which the hibernating larvae have attained.

The test insects were divided into two groups and one-half was kept in incubators of various constant temperatures while the other was kept in the rearing room which was not heated during the winter. Each group was again subdivided into two parts and while the one part was supplied with food, no food was supplied to the other part which served as *check*.

Time of pupation and of emergence, duration of pupal period, percentages of the larvae that pupated and also of the larvae that transformed to adult insects were determined. Incidentally, the number of Hymenopterous parasites which appeared from the hibernating rice-borers was also determined.

The materials which were used as food were fresh culms of the rice-plant or wheat or sometimes sugar-cane. Although the rice-borers readily bored into such food material, it was not easy to determine whether they really utilized such material as food or simply bored into them. As a matter of fact, it was not tried to determine this point in any experiment.

In cases where sugar-cane was used as food, a considerable percentage of the rice-borers were dead before pupation for unknown causes. This might have affected the results of experiments to a certain extent.

Results of Experiments.

The results of experiments are shown in Tables I and II. In Table I, the data of the time of emergence, the percentage of emergence and also the number of Hymenopterous parasites which appeared per 100 rice-borers are shown, and in Table II are given the data of the time of pupation, the percentage of larvae pupated and the pupal period.

(Tables I and II are given on page 259—263.)

Table I.

Time of Flight and Size of Hibernating Larvae and Feeding.

A. Variable Temperature in Rearing Room.

Experiment No.	Food	Size of Larvae	Number of Days elapsed before Emergence of the first Adult	Number of Days elapsed before Emergence of the last Adult	Mean Number of Days elapsed before Emergence	Number of ♀♀ emerged	Number of ♂♂ emerged	Per Cent emerged	Number of Parasites appeared per 100 Hosts	Number of Rice-Borers used	Remarks
(1)	Not supplied	Large	73	104	83.0	31	29	30.0	0	200	April 2, 1929
		Medium	75	”	87.5	23	60	41.5	0.5	”	
		Small	65	103	84.1	13	60	36.5	0.5	”	
	Supplied	Large	69	96	81.0	48	26	37.0	0	”	
		Medium	”	101	87.2	41	82	61.5	0	”	
		Small	72	97	79.8	18	37	27.5	7.0	”	
(2)	Not supplied	Large	59	86	73.2	32	13	44	0	100	April 7, 1930
		Medium	58	84	71.7	17	20	37	0	”	
		Small	59	86	72.9	5	11	14	5	”	
	Supplied	Large	66	79	72.1	14	8	21	0	”	
		Medium	59	82	71.7	9	22	30	0	”	
		Small	66	84	72.9	10	15	22	7	”	
(3)*	Not supplied	Large	102	149	122.7	68	19	43.5	0	200	Nov. 7, 1930
		Medium	108	136	122.6	28	15	21.5	0	”	
		Small	106	136	122.5	4	15	9.5	7	”	
	Supplied	Large	106	142	117.2	65	26	45.5	0	”	
		Medium	105	145	116.2	40	56	48.0	1	”	
		Small	110	142	119.5	3	8	5.5	8.5	”	
(4)	Not supplied	Large	76	97	88.5	37	26	31.5	0	”	April 4, 1931
		Medium	77	106	87.5	28	33	30.5	0	”	
		Small	74	107	84.2	15	43	29.0	1.5	”	
	Supplied	Large	72	96	83.0	36	19	27.5	0.5	”	
		Medium	75	101	85.1	16	35	25.5	0	”	
		Small	77	103	89.2	4	16	10.0	8.5	”	
(7)*	Not supplied	Large	105	142	119.4	47	30	77	1	100	Dec. 1, 1931
		Medium	”	146	119.8	17	29	47	16	”	
		Small	—	—	—	0	0	0	28	”	
	Supplied	Large	106	149	124.4	27	15	44	0	”	
		Medium	105	146	124.6	4	11	17	15	”	
		Small	—	—	—	0	0	0	32	”	

Table I. (Continued.)

Experiment No.	Food	Size of Larvae	Number of Days elapsed before Emergence of the first Adult	Number of Days elapsed before Emergence of the last Adult	Mean Number of Days elapsed before Emergence	Number of ♀♀ emerged	Number of ♂♂ emerged	Per Cent emerged	Number of Parasites appeared per 100 Hosts	Number of Rice-Borers used	Remarks
(9)	Not supplied	Large	70	95	88.8	53	25	78	0	100	April 7, 1932
		Medium	64	97	80.8	23	33	56	11	"	
		Small	66	87	76.4	3	2	5	47	"	
	Supplied	Large	75	102	86.0	26	23	51	1	"	
		Medium	67	94	83.2	15	25	43	0	"	
		Small	78	—	—	0	1	1	32	"	
(14)	Not supplied	Large	68	86	77.1	40	19	59	0	100	April 7, 1933
		Medium	64	"	77.9	11	27	38	1	"	
		Small	47	81	72.9	4	17	21	10	"	
	Supplied	Large	63	86	74.9	27	15	42	0	"	
		Medium	68	"	74.0	11	9	20	1	"	
		Small	67	77	72.3	6	14	20	8	"	
(15)	Not supplied	Large	62	83	74.6	40	27	67	0	100	April 7, 1933
		Medium	61	82	73.7	17	32	49	1	"	
		Small	62	87	75.3	7	37	44	24	"	

* When calculating the number of days elapsed before the emergence of the adult insects in these experiments, it was assumed that the experiments were begun on March 1st.

B. Constant Temperature[1)].

Experiment No.	Food	Size of Larvae	Number of Days elapsed before Emergence of the first Adult	Number of Days elapsed before Emergence of the last Adult	Mean Number of Days elapsed before Emergence	Number of ♀♀ emerged	Number of ♂♂ emerged	Per Cent emerged	Number of Parasites appeared per 100 Hosts	Temperature under which Experiments were conducted	Remarks
(5)	Not supplied	Large	32	78	46.8	13	23	37	2	27→30	Dec. 2, 1931
		Medium	22	53	37.1	3	14	17	40	"	
		Small	68	—	—	1	0	1	53	"	

Table I. (Continued.)

Experiment No.	Food	Size of Larvae	Number of Days elapsed before Emergence of the first Adult	Number of Days elapsed before Emergence of the last Adult	Mean Number of Days elapsed before Emergence	Number of ♀♀ emerged	Number of ♂♂ emerged	Per Cent emerged	Number of Parasites appeared per 100 Hosts	Temperature under which Experiments were conducted	Remarks
(6)	Not supplied	Large	47	74	57.8	9	13	22	1	25	Dec. 3, 1931
		Medium	42	90	62.9	2	10	12	13	”	
		Small	37	64	45.5	0	2	2	28	”	
	Supplied	Large	41	84	58.0	7	6	13	0	”	
		Medium	46	91	52.1	2	15	17	13	”	
		Small	—	—	—	0	0	0	20	”	
(8)	Not supplied	Large	25	71	52.8	42	20	62	1	25	Jan. 16, 1932
		Medium	27	61	48.0	23	26	49	4	”	
		Small	37	64	50.0	1	1	2	41	”	
(10)	Not supplied	Large	32	89	59.0	17	17	34	0	30	Dec. 21, 1932
		Small	35	75	47.0	2	12	13	8	”	
(11)	Not supplied	Large	40	111	69.9	44	19	63	0	25	Dec. 21, 1932
		Small	45	119	69.8	5	20	25	19	”	
(12)[2]	Not supplied	Large	80	113	100.8	20	10	30	0	20	Feb. 10, 1933
		Small	81	115	98.8	3	9	12	13	”	
	Supplied	Large	81	120	105.7	13	8	21	0	”	
		Small	84	87	85.5	0	2	2	4	”	
(13), a.	Not supplied	Large	30	63	43.1	42	32	74	1	25	Mar. 10, 1933
		Small	32	67	46.2	16	35	51	25	”	
(13), b.	Not supplied	Large	30	55	38.1	33	29	62	0	25	Mar. 10, 1933
		Small	26	53	41.3	17	46	63	27	”	

1) Number of rice-borers used for each experiment was 100.

2) The rice-borers in this experiment were at first kept under a constant temperature of 20°C. and they were transferred to the rearing room in the later part of the experimental period.

Table II.

Time of Pupation and Size of Hibernating Larvae and Feeding.

Experiment No.	Food	Size of Larvae	Number of Days elapsed before Appearance of the first Pupa	Number of Days elapsed before Appearance of the last Pupa	Mean Number of Days elapsed before Pupation	Per Cent pupated	Mean Pupal Period	Temperature under which Experiments were conducted	Number of Larvae used for Experiment	Experiments started on
(3)*	Not supplied	Large	89	140	113.1	54.0	10.5	Rear. room temp.	200	Nov. 7, 1930
		Medium	94	135	113.6	30.0	10.8	"	"	"
		Small	93	130	113.1	10.5	10.6	"	"	"
	Supplied	Large	94	124	107.9	50.0	11.4	"	"	"
		Medium	93	127	106.3	57.0	"	"	"	"
		Small	98	120	109.6	7.5	11.0	"	"	"
(4)	Not supplied	Large	64	89	79.3	40.5	10.6	"	"	April 4, 1931
		Medium	65	97	77.2	38.5	10.8	"	"	"
		Small	63	96	74.7	34.0	11.2	"	"	"
	Supplied	Large	60	87	73.1	34.0	11.8	"	"	"
		Medium	63	91	74.9	34.5	11.2	"	"	"
		Small	65	94	78.8	11.5	11.5	"	"	"
(5)	Not supplied	Large	25	73	47.5	43.0	7.2	27→30	100	Dec. 2, 1931
		Medium	15	49	33.9	25.0	7.6	"	"	"
		Small	25	61	43.5	2	7.8	"	"	"
(6)	Not supplied	Large	37	73	50.3	25	9.8	25	"	"
		Medium	33	78	52.9	12	10.0	"	"	"
		Small	27	55	41.8	3	10.8	"	"	"
	Supplied	Large	—	—	—	19	10.2	"	"	"
		Medium	—	—	—	19	10.0	"	"	"
		Small	—	—	—	0	—	"	"	"
(8)	Not supplied	Large	25	61	43.0	71	11.1	25	"	Jan. 16, 1932
		Medium	16	51	37.1	54	11.4	"	"	"
		Small	28	53	43.5	3	—	"	"	"

Table II. (Continued.)

Experiment No.	Food	Size of Larvae	Number of Days elapsed before Appearance of the first Pupa	Number of Days elapsed before Appearance of the last Pupa	Mean Number of Days elapsed before Pupation	Per Cent pupated	Mean Pupal Period	Temperature under which Experiments were conducted	Number of Larvae used for Experiment	Experiments started on
(10)	Not supplied	Large	—	—	—	48	—	30	100	Dec. 2, 1932
		Small	—	—	—	24	—	"	"	"
(11)	Not supplied	Large	—	—	—	68	—	25	"	"
		Small	—	—	—	31	—	"	"	"
(14)	Not supplied	Large	—	—	—	64	—	Rear. room temp.	"	Apr. 7, 1933
		Medium	—	—	—	58	—	"	"	"
		Small	—	—	—	27	—	"	"	"
	Supplied	Large	—	—	—	51	—	"	"	"
		Medium	—	—	—	30	—	"	"	"
		Small	—	—	—	27	—	"	"	"

* Number of days from the beginning of experiment to pupation was computed assuming that the experiment were begun on March 1st.

Discussion of the Results of Experiments.

Examination of the data in Table I reveals that the percentage of the larvae that transformed to adult insects was markedly lower in the larvae of *small* size than in those of *medium* and *large* size. Since, in the case of the Hymenopterous parasites here considered, only one parasite emerges from each parasitized larva, the number of parasites indicates at the same time the number of hibernating larvae which were killed by them. Now, the number of Hymenopterous parasites that emerged was markedly larger in the rice-borers of *small size* and the hibernating rice-borers of *large* size were either completely free from parasites or the percentage of parasitism was very low. These results seem to indicate that the rice-borers which were parasitized in the earlier larval stage could not attain their normal size even when they were mature. Similar observations were made on certain other insects[5,6,7].

Besides, it is evident, from what has been stated above, that the size of hibernating rice-borers is not necessarily correlated to their degree of growth and also that parasitized larvae are less resistant to adverse enviromental conditions than the healthy larvae. There is still another thing which demands our attention. It is the difference in the sex ratio when the rice-borers are classified into three groups according to their size. While markedly more females appeared from the rice-borers of the larger size, more males emerged from the borers of the medium or smaller size. This must be taken into consideration when the time of emergence of moth is discussed, since it is believed that the males generally appear earlier than the females.

i. Time of Emergence of Moths.

a) *Results obtained in the rearing room under variable temperatures.*

According to the data in Table I, the number of days from the beginning of experiments to the appearance of the first adult insect and also the number of days to the last adult insect were sometimes larger in cases where food was supplied while in the other cases just the reverse results were obtained. Similarly, it was larger in some cases in the rice-borers of the large size, while in the other cases the reverse tendency was observed.

Experiments in which at least 10 per cent of the borers emerged as adult insects were selected and the average of the mean numbers of days from the beginning of experiment to the emergence of adults was calculated. Since the time when experiments were started was not always the same, it was assumed that all experiments were begun on March 31st and the number of days from this assumed date of beginning to emergence was used for calculating the average number of days which elapsed before emergence. The results obtained by this calculation are shown in Table III.

The data in Table III will be examined to learn whether supplying of food had any effect on the time of emergence.

The mean number of days from March 31st to the time of emergence varied slightly in different experiments, but it was approximately from 80 to 90 days. In certain cases it was slightly larger when food was supplied while, in the other, the contrary tendency was observed. The average value of these mean numbers of days elapsed before emergence was calculated separately for each group of the rice-borers classified according to the size and also as to whether food was supplied or not. In large larvae, the average value calculated in the manner mentioned above was 85.8 days when food was supplied and 87.8 days when food was not supplied. The difference between the two was approximately 2 days. In the larvae of the medium size, it was 86.3 days when food was supplied and 87.1 days when no food was supplied, the difference being only 0.8 days. Thus, it seems that the time of emergence was slightly earlier in cases where food was supplied during the hibernation period, but the difference is rather small and it would be safe to conclude that the difference might have been due to contact

Table III.

Mean Number of Days from March 31st to the Emergence of Adult Insects.

(Experiments conducted under Variable Temperatures in Rearing Room.)

Size of Larvae	Experiment No.	Not fed	Fed
Large[1)]	(1)	84	82
	(2)	79.2	78.1
	(3)	92.7	87.2
	(4)	91.5	86.0
	(7)	89.4	94.4
	(9)	94.8	92.0
	(14)	83.1	80.9
Average Number of Days		87.8	85.8
Medium[1)]	(1)	88.5	88.5
	(2)	77.7	77.7
	(3)	92.6	86.2
	(4)	90.5	88.1
	(7)	89.8	94.6
	(9)	86.8	89.2
	(14)	83.9	80.0
Average Number of Days		87.1	86.3
Small[1), 2)]	(1)	85.1	80.8
	(2)	78.9	78.9
	(4)	87.2	92.2
	(14)	78.9	78.3
Average Number of Days		82.5	82.5

1) Number of days elapsed before emergence was calculated assuming that all experiments were begun on March 31st.

2) Experiments, in which the percentage of emergence was less than 10 per cent, were excluded.

moisture accompanying the food rather than the nutritive effect of the food. In the larvae of the small size, the average of mean numbers of days elapsed before emergence was 82.5 days in two cases, i.e., both where food was supplied and where it was not. This result is important, for it may be expected that the effect of supplying food should be more striking in the rice-borers of the smaller size, if supplying food during the hibernation period has accelerating effect on their development. As a matter of fact, the result of the experiment showed that food had no effect on the time of emergence of these larvae of the smaller size. Therefore, the fact that the rice-borers were small when they were used for experiment does not necessarily indicate that they were not fully grown at the beginning of the experiment.

Body size and time of emergence. When food was supplied in the hibernation period, the average number of days elapsed before emergence was about 0.5 days longer for the larvae of the medium size than for the large larvae. On the contrary, it was 0.7 days shorter in the larvae of the medium size when food was not given. The average number of days elapsed before emergence was 82.5 days for the small larvae and this value is shorter by approximately 3 to 5 days than those for the larvae of the large or the medium size. The fact that the average number of days before emergence was smaller in the smaller larvae than in the larger does not seem to be due to the size of the larvae, but to the fact that the males were predominant among the larvae of the smaller size and that the males usually appear slightly earlier than the females. The data shown in Table IV, which has been compiled from the records in Table I, are strong evidence in support of the above conclusion.

Table IV.

Size of Hibernating Rice-Borers and the Sex of the Moths that appeared.

Food	Supplied						No Food Supplied					
Size	Large		Medium		Small		Large		Medium		Small	
Sex	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
Number	243	136	136	240	38	82	308	211	147	217	37	131
Ratio	1	0.56	1	1.76	1	2.15	1	0.68	1	1.47	1	3.54

According to the data in Table IV the females are predominant among the large larvae while the males are from 2 to 3 times more numerous than the females among the larvae of small size.

b') *Results obtained under constant temperatures.*

Effect of food supply. The results of the experiments conducted under constant temperatures are shown in Table I, part B. There are only a few experiments available for the purpose of studying the effect of supplying food. In

Experiment (6) the mean number of days elapsed before the emergence of adults was 58.0 days for the large larvae when food was supplied and 57.8 days when food was not supplied. In the case of the larvae of the medium size, the mean value was 52.1 days when food was supplied and 62.9 days when food was not supplied. In Experiment (12), the mean value for the large larvae was 105.7 days when food was supplied and 100.8 days when food was not supplied. Though the results cannot be considered conclusive, it seems that no consistent tendency can be found between the time of emergence and feeding.

Body size and time of emergence. As has been stated elsewhere, the percentage of larvae which emerged as adults was markedly lower when larvae of the smaller size were used than when the larger larvae were used. It cannot be expected therefore that we shall arrive at a definite conclusion by comparing the results obtained for the larvae of the smaller size with those for the larvae of the larger size. However, if the results of the experiments with the smaller larvae, in which the percentage of emergence was 10 per cent or more, are compared with those obtained with the larger larvae, it would be possible to find an approximately correct tendency. Such experiments were selected and the results are given in Table V.

Table V.

Mean Number of Days elapsed before the Emergence of Moths.

(Experiments under Constant Temperatures.)

Experiment No.	Size of the Rice-Borer		Temperature under which Experiments were conducted	Remarks
	Large	Small		
(10)	59.0	47.0	30	Larvae not fed
(11)	69.9	69.8	25	"
(12)	51.8	49.8	20→Room Temp	"
(13), (a)	43.1	46.2	25	"
(13), (b)	38.1	41.3	"	"
Average	52.3	50.8		

Number of adult insects which appeared in the experiments cited above was as follows:

From "large larvae" {♀ 156, ♂ 107} ; from "small larvae" {♀ 43, ♂ 122}

When the data shown in Table V are averaged, disregarding the difference of temperatures under which the experiments were conducted, the average values shown in the last line in Table V are obtained. According to these average number of days elapsed before emergence, the period from the beginning of experiment to the emergence of adults was 1.5 days smaller in the case of the smaller larvae. When the ratio of the male to the female was computed from the number of the borers used in these experiments, the following results were obtained:

Larvae of	
Larger size	Smaller size
♂ : ♀	♂ : ♀
1 : 1.45	1 : 0.35

Thus, females were markedly more numerous in the larvae of the larger size, while just the reverse was found in the case of the smaller larvae. From these results it seems to be possible to conclude that the finding that the average number of days before emergence was shorter in the smaller larvae was probably due to the fact that the males were more numerous among the smaller larvae, and that it does not indicate that the stage or degree of development which the hibernating larvae attained is related to the time of emergence.

ii. Time of Pupation of Hibernating Larvae.

a) *Effect of feeding on the time of pupation.*

There are only two experiments which are available for studying the effect of feeding on the time of pupation. They are Experiments (3) and (4). The average number of days elapsed before pupation, which were calculated from the results of these two experiments is shown in Table VI.

Table VI.

Average Number of Days from the Beginning of Experiments to Pupation.

Size of Larvae	No Food Supplied	Food Supplied	Difference
Large	83.2	77.5	5.7
Medium	82.4	77.6	4.8

Results of experiments in the rearing room.

The results shown in Table VI seem to indicate a definite tendency. Namely, that the number of days elapsed before pupation is always smaller by approximately 5 days in the experiments in which food was supplied without regard to the size of the larvae used for the experiments. This finding agrees with what the writers found from the study of the time of emergence of moth.

The data in Table VI do not seem to indicate that there is a certain relation between the time of pupation and the size of the larvae. However, no definite conclusion can yet be drawn since the number of experiments is only two and since the data of the small larvae are wanting.

b) *Percentage of the larvae that pupated.*

As is evident from Table II, the percentage of pupation differred markedly according to the size of the rice-borers used for experiments. For instance, the highest percentage of the larvae pupated, when the larvae of the small size were used, was 34 per cent which was obtained in Experiment (4) in the case where no food was supplied. In the other experiments in which small larvae were used, the percentage of pupation was markedly lower than that cited above. In cases where larvae of the larger size were used, the percentage was usually much higher. Thus, in the case where no food was supplied, in Experiment (8), 71 per cent pupated and this was the highest percentage which was obtained. Usually, more than 25 to 30 per cent pupated when the hibernating larvae of the larger or medium size were used for experiments. Such a tendency as is described in this paragraph may probably be attributed to the effect of the parasitic Hymenoptera as has already been mentioned elsewhere.

c) *Pupal period and the size of larvae and food supply.*

We shall first examine whether feeding diminishes the pupal period or not. The experiments which are suitable for this purpose are Experiments (3) and (4). The results of these experiments are given in Table VII.

Table VII.

Pupal Period and Feeding.

Size of Larvae	Food Supplied	No Food Supplied	Difference
Large	11.6	10.5	1.1
Medium	11.3	10.8	0.5

According to the data in Table VII, the pupal period seems to be slightly longer when food was supplied to the hibernating larvae than when food was not supplied, but the difference is rather small.

So far as we can judge from the results shown in Table VII, there seems to be almost no difference in the duration of pupal period, which is due to the difference in the size of the hibernating larvae. When the results of other experiments conducted under constant temperatures are examined, it is found that the mean pupal period in Experiments (5), (6) and (8) seems to be slightly shorter in the larvae of the larger size. These experiments were carried out under different constant temperatures. When their results are averaged disregarding difference in the temperatures under which the experiments were conducted, the average duration of the pupal period was found to be 9.3 days for the larger larvae and 9.6 days for the larvae of medium size. Thus, the duration seems to be slightly longer for the smaller larvae. However, the difference between the two kinds of larvae is very small and the data in Table VII do not show a similar tendency. Therefore, we may not be justified in concluding that there is a definite relation between the duration of pupal period and the size of the hibernating rice-borers.

Summary and Conclusion.

In the northern part of Japan such as Hokkaido or Aomori Prefecture, the majority of the larvae of the first generation of the rice-borer overwinter. When another generation is produced in these localities, the larvae, which are not able to become full-grown before the cold winter season comes, die in the hibernation period. What will be the fate of the hibernating rice-borers, which are not full-grown, under a milder climate, such as prevails in the southern part of Okayama Prefecture ? There seem to be no results of experimental studies relating to this point.

The writers supposed that, even under the climatic conditions of Kurashiki, there may be some larvae of the second generation, which are not fully grown even though the last moulting has been completed, and also that the time of emergence in the following spring of such immature larvae may differ according as whether they can find food freely in the spring or not. Assuming that the stage or the degree of development which hibernating rice-borers attained can be distinguished by the body size, the writers carried out experiments in order to learn whether there is difference in the time of emergence in the following spring, according to the size of the larvae, and whether feeding in the period of hibernation affects the time of flight.

According to the results obtained from these experiments, there seems to be no connection between the size of the larvae and the stage or degree of development which the larvae attained. The majority of the hibernating larvae of the larger size were the females and conversely, the majority of the smaller larvae were the males. The percentage of parasitized larvae was lower among the larger larvae while it was markedly higher among the smaller larvae. The average time of flight was slightly earlier for the smaller larvae than for the larger larvae. This does not indicate that there is a relation between the time of flight and the size of the larvae, but it simply indicate that most of the smaller larvae are the males which appear slightly earlier than the females.

As a natural corollary to the conclusion just mentioned above, it might be expected that feeding the larvae in the hibernation period would not affect the time of flight of the moth in the following spring. As a matter of fact, the time offlight was slightly earlier when food was supplied to the hibernating larvae. This slight acceleration in the time of flight does not seem to be due to the nutritive effect of the food, but to the action of water which accompanies the fresh food which is given to the hibernating larvae.

Literature.

1) HARUKAWA, C., TAKATO, R. and KUMASHIRO, S., Berichte d. Ōhara Inst. f. landw. Forsch., Bd. V : 177 — 207, 1931.
2) Ditto., Berichte d. Ōhara Inst. f. landw. Forsch., Bd. VII : 239 — 256, 1936.
3) MURATA, T. (村田藤七), 米麥作の害蟲と豫防驅除, 77 — 78 頁, 昭和2年, (1927).
4) Hokkaido Agricultural Experimental Station. 北海道農事試驗場彙報, 第47號, 昭和3年, (1928).
5) Cox, J. A. and DANIEL, D. M., Jour. Econ. Ent., Vol. 28 : 113 — 120, 1935.
6) CUSHMAN, R. A., Jour. Agric. Res., Vol. 6 : 847 — 855, 1916.
7) HARUKAWA, C. and KUMASHIRO, S., Results of observation, which have not yet been published.