On the Pear-Bark Miner, *Acrocercops astaurota* Meyrick. II.

By

Chukichi Harukawa and Saburō Kumashiro.

[January 26, 1932.]

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I. Field Observation.

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Table I.

Results of Field Observations.

Second Generation in 1929 which overwintered.

Collection No.	Date of Collection.	Total Number of Insects collected.	Number of Individuals in Different Phases of Life Cycle.
i	June 4, 1930	120	Larvae still feeding............33 Larvae in Cocoon...............87
ii	June 17, 1930	85	Larvae still feeding............ 0 Larvae in Cocoon...............44 Pupae in Cocoon...............38 Dead Larvae (parasitized) ... 3
iii	June 25, 1930	95	Pupae in Cocoon...............56 Adults emerged*...............27 Dead Larvae.....................12

* The number of the adult insects which had already emerged was determined from the number of the pupal skins that were attached to the cocoons.

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First Generation in 1930.

Collection No.	Date of Collection.	Total Number of Insects collected.	Number of Individuals in Different Phases of Life Cycle.
iv	August 11, 1930	115	Larvae still feeding............107 Larvae in Cocoon.............. 6 Pupae in Cocoon.............. 2
v	August 23, 1930	83	Larvae still feeding........... 41 Larvae in Cocoon.............. 24 Pupae in Cocoon.............. 18
vi	September 2, 1930	67	Larvae still feeding........... 9 Larvae in Cocoon.............. 5 Pupae in Cocoon.............. 47 Adults emerged .... 1 Dead Larvae.................... 5
vii	September 5, 1930	84	Larvae still feeding........... 1 Larvae in Cocoon.............. 4 Pupae in Cocoon.............. 58 Adults emerged .... 11 Dead Larvae.................... 10

From the results of the observations which are recorded in Table I the following summary may be made: In 1930, the larvae of the second generation in the preceding year which had overwintered, began to make cocoons about May 20th and the majority finished cocooning several days before June 17th. The pupation seems to have begun about the beginning of June and the adult began to emerge several days before June 25th. The larvae of the first generation began to attain the fullgrowth about the beginning of August. The majority seems to have been fullgrown before the end of August. The pupation seems to have begun about August 10th, and ended before September 10th. The adult began to appear in the beginning of September. The larvae of the second generation overwintered in the early larval stage as in the preceding year.

These results are generally in agreement with those recorded in the first report. However, there is a slight difference in some respects. For instance, the end of cocooning period in 1930 was slightly later than in 1929. The beginning of the pupation of the first generation larvae in 1930 was slightly earlier than in 1929. Such differences between these two years are probably due to the different weather conditions in these two years.

II. Development of the Pear-Bark Miner in Relation to Temperature.

In order to learn the range of temperature in which the pear-bark miner grows, the observations on the development of the egg, larva and pupa under various constant temperatures were made.

Since the larva of this insect can not be induced to feed on the cut shoots after it is once taken out of the mine, the larva can not be reared in the incubator till it reaches the maturity. Owing to this circumstance, the reliable data could not be obtained in regard to the growth of the larva under different temperatures.

i) *Egg*.

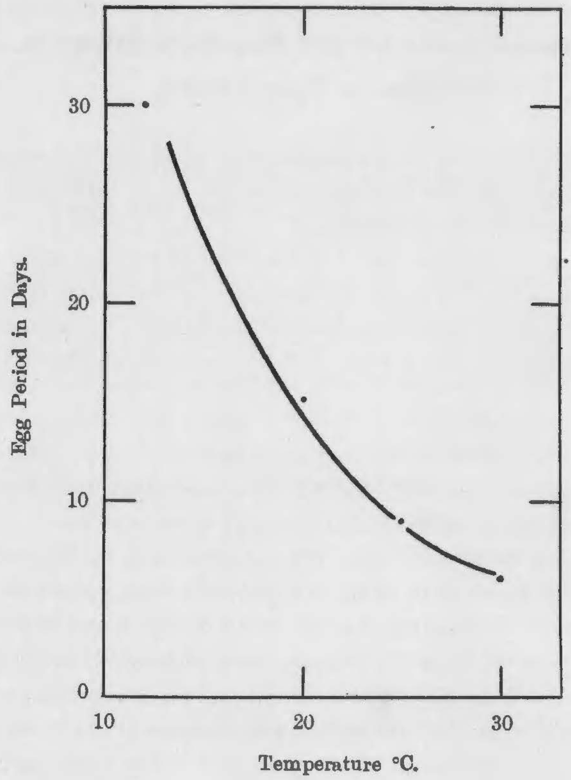
The eggs of the pear-bark miner developed and hatched in 6 days at 12°C., if they were first incubated at 20°C. for 12 days and then transferred to 12°C. Under this condition, the development of the eggs already so much progressed as they would soon hatch out if they were kept at 20°C. a little longer. Assuming that the eggs would develop at 12°C., the probable egg period was calculated from the result of the experiment just mentioned. It was found that the probable period would be about 30 days if the eggs were incubated under 12°C. during the entire egg period. In reality, however, only a small percentage of the eggs developed when they were first incubated for 10 days at 12°C. and afterwards transferred to 20°C., and the larvae which developed in the eggs were not able to hatch out of the egg-shell and died. The majority of the eggs which were incubated at 12°C., died before embryos were formed in them. These results indicate that a constant temperature of 12°C. is almost at the lower limit of the effective temperature for the development of the egg.

At 20°C., the development was completed in 15 days and the larvae hatched out. However, the larvae which developed in the eggs could not hatch out and died if the eggs were first incubated for 10 days at 12°C. and afterwards transferred to 20°C. This result seems to indicate that the incubation at 12°C. had greatly diminished the vigor of the embryo in the egg.

At a constant temperature of 25°C., the egg period was greatly shortened and it was about 9 days. At 30°C., it was 6 days. When the egg was incubated at 33°C., the egg developed in a rather short period, but the larva in the egg was not able to hatch out and died. This result indicates that a constant temperature of 33°C. is beyond the higher limit of the effective temperature for the development of the egg of this insect.

Under the out-of-door conditions in Kurashiki a temperature as high as 33 or 34°C. occurs for only a few hours on very hot days in summer, so that probably it does not affect much the egg of the pear-bark miner.

The results of the experiments described above were plotted to show the relation of temperature to the development of the egg and the curve was obtained as shown in the following figure :



Egg Period under Various Constant Temperatures.

ii) *Pupa.*

Some larvae pupated at 12°C. when the fullgrown larvae in cocoon were kept under that temperature for a few days before pupation took place, but the pupae which thus appeared did not transform to the adult insects. They remained in the pupal state for a period of about 60 days and after that the majority of the pupae died. This result indicates that a constant temperature of 12°C. is probably below the minimum temperature for the development of the pupa of this insect.

The pupal period at 20°C. was 25 days and the pupal period at 25°C., 14 days.

At a constant temperature of 35°C., the pupation did not occur indicating that 35°C. is beyond the range of the effective temperature for the development of the pupa.

The writers were not able to determine the actual *pupal period* when the first report was prepared. Last year, the writers succeeded in determing the time of pupation under the variable temperature in the insectary. The period from the cocooning to the pupation was about 3 days at a mean temperature of 25 to 25.5°C. The *pupal period* was about 16 days at a mean temperature of about 25°C. The *cocoon period* is about 19 days at a mean temperature of about 25°C. These results seem to indicate that the development of the pupa under the variable temperature is slightly slower than under the constant temperature when the mean of the variable temperature is about 25°C.

iii) *Larva.*

The larva which developed in the egg could not come out of the egg-shell when the egg was incubated under 12°C., as has been stated in a previous paragraph.

The field observation made on the overwintering young larvae revealed that the larvae ceased to feed usually from the middle of January to the end of February. Sometimes, they stopped to feed from the beginning of January to the middle of March. During this period, the maximum temperature for the day is lower than 12°C. except on a few, very warm days. The mean temperature for the day is almost always below 10°C.

These facts seem to indicate that the growth of the larva does not occur when the air temperature is below 12°C.

At a constant temperature of 35°C., some of the larvae lived for several days and the growth seemed to have occurred, but it was not possible to rear the larvae further since the food plant rapidly deteriorated under this temperature and the larvae died in a rather short period. It seems probable that a constant temperature of 35°C. is no longer suitable to the activity of the pear-bark miner, judging from the results of the observations and experiments made on the egg and pupa.

III. Choice of Food Plants.

In the first report, the writers enumerated 6 species of the family Rosaceae as the food plants of the pear-bark miner. It was stated preliminarily that the Japanese pear-tree was most commonly attacked and that the apple-tree followed it in its susceptibility to the miner.

However, in certain parts of Japan, the apple-tree seems to be attacked severely. In the vicinity of Kurashiki, the apple-trees are rather scarce, so that the writers' statement based on the observations made on these few apple-trees may not have been well founded. Therefore, the experiments on the egg laying habit of the moth were carried out in order to study the choice of the food plant made by the adult insect.

Two kinds of experiments were carried out. In the one kind of the experiments, 2 or 3 species of small fruit-trees which were known to be attacked by the miner were planted in a large net-house and a good many pairs of the adult insects were released in it. The number of the eggs deposited on each tree was determined afterwards.

In the other case, the experiment was carried out in the rearing-room using the breeding cages. The shoots of various fruit-trees of about the same length and thickness were cut and placed in the breeding cage into which many pairs of the moth were introduced. The number of the eggs laid on each shoot was determined afterwards.

As a result of these experiments, the number of the species of the plants on which the adult of the pear-bark miner laid eggs was found to be 11, but whether the larva really feeds and grows on all of these species or not was not yet determined. The list of these plants is as follows :

"*Nashi*", Japanese pear, *Pyrus pyrifolia* NAK.
"*Seiyō-nashi*", Pear, *Pyrus communis* L.
"*Ringo*", Apple, *Malus sylvestris* MILL.
"*Momo*", Peach, *Prunus persicae* S. et Z.
"*Seiyō-sumomo*", Plum, *Prunus domestica* L.
"*Anzu*", Apricot, *Prunus ansu* KOMAR.
"*Umé*", *Prunus mume* S. et Z.
"*Mizakura*", Cherry, *Prunus avium* L.
"*Sakura*", Japanese flowering cherry, *Prunus yedoensis* MATS.
"*Boké*", *Chaenomeles lagenaria* KOIDZ.
"*Zumi*", *Malus zumi* KOIDZ.

The results of the oviposition experiments made on these plants are shown in Table II.

Table II.

Oviposition Experiment.

Experiment.	No.	Method.	*Nashi*	Pear	Apple	Peach	Cherry	*Sakura*	Plum	Apricot	*Umé*	*Zumi*	*Boké*
1930,	I	R. R.	—	26	31	—	—	—	8	—	—	—	—
〃	II	N. H.	19	—	10	—	—	—	0	—	—	—	—
〃	III	R. R.	—	27	36	—	1	—	1	—	—	—	—
〃	IV	〃	—	—	28	—	9	—	23	—	—	—	2
〃	V	〃	—	0	67	19	8	11	7	7	3	8	—
1931,	I	〃	—	33	20	—	—	—	—	—	—	—	—
〃	II	〃	—	27	10	—	—	—	—	—	—	—	—
〃	III	N. H.	26	—	26	—	0	—	—	—	—	—	—
〃	IV	R. R.	—	31	49	—	—	—	—	—	—	—	—
〃	V	〃	—	6	82	—	—	—	—	—	—	—	—
〃	VI	〃	—	41	50	—	—	—	—	—	—	—	—

R. R.......Experiment which was carried out in the breeding Cage.

N. H.......Experiment which was conducted in the net-house.

Dashes in the column denote that the plant in the respective column was not used for the experiment.

The figures represent the number of eggs laid.

The egg laying habit of the adult of the pear-bark miner seems to be influenced by certain factors which have not yet been clearly understood. It is beyond doubt that the moth prefers, for oviposition, the pear-tree (including the Japanese pear) and the apple-tree to the other plants used for the experiments. However, it sometimes happened that no egg was laid on the pear shoots when they were used together with many other plants. In such cases, the habit of the moth has probably been modified by certain unknown factors. As is well-known, the young shoots of the apple or the pear-trees are covered with fine short hairs towards the terminal portion. This pilosity seemed to be at least a factor which modifies the habit of the moth, because the moth of the pear-bark miner usually prefers the more smooth, basal part of a shoot or a branch to its hairy portion. If the hairy portion of shoot of the pear-tree is used for the experiment, the moth will lay few eggs on it in spite of its preference for the smooth pear shoot.

The pear and the apple-trees were carefully compared in regard to the choice made by the moth than in the case of the other food plants. There were 10 experiments in which the apple and the pear-tree were used side by side. In 6 cases out of these 10 experiments, the moth laid more eggs on the apple-tree than on the pear, and only in one case the number of the eggs laid on each of them was equal. The total number of the eggs laid on the apple in these 10 experiments was 381 ; and that on the pear was 236. This result indicates that the moth of the pear-bark miner prefers the apple-tree to the pear for the oviposition. It may be expected, therefore, that the injury by the pear-bark miner will be more severe on the apple-tree than on the pear in the localities where apple-trees are more abundantly grown.

IV. Method of Control.

Several series of the control experiments were conducted with the egg, larva and pupa, in order to determine the most susceptible stage to various insecticides in the life history of this insect. The results will be briefly described below.

i) *Experiment on Egg.*

The following insecticides were tested as to their effectiveness as ovicides :

Black Leaf 40. 56 grams of soap was used per 18 litres of the diluted solution.

Neoton. This is a commercial insecticide prepared from *Derris*. To dilute this insecticide for use, 180 litres of water and 450 grams soap were used for 225 grams of Neoton. This is the standard strength as recommended by the manufacturer.

Emulsion of pyrethrum extracted with a mixture of kerosene and gasoline. The stock solution of the emulsion was prepared according to the following formula:

Pyrethrum powder...		...75 grams.
Mixture of	kerosene	... 0.9 litre.
	gasoline	... 0.9 „
Soap ...		...56 grams.
Water ...		... 0.9 litre.

Uenotron. A commercial insecticide prepared from pyrethrum.

The result obtained with these insecticides was as follows:

	Dilution in Volume.	Per Cent. of Eggs killed.
Black Leaf 40	1000	100
„	3000	100
„	5000	100
„	10000	91.6
Neoton	Standard strength.	10
Uenotron	500	22.2
Pyrethrum Emulsion	10	17.0

The result shows a striking ovicidal action of Black Leaf 40. The other insecticides tested were found to have only a weak toxic action towards the egg.

ii) *Experiment on Larva.*

(a) *Laboratory Experiment.*

When the larvae were still very small and mining, several insecticides were applied on the cuticle of the shoot which was covering the mine. The result obtained was a discouraging one as it is shown below.

	Dilution in Volume.	Per Cent. killed.
Pyrethrum Emulsion	10	0
Black Leaf 40	100	0
Kerosene	not diluted	0
Gasoline	„	37.5
Machine Oil	„	33.0

(b) *Field Experiment in Small Scale.*

The cuticle covering of the mine dries up and partly peels off from the bark of the branch at the margin of the mine when the larva attains the last stage of feeding, as has been described in the first report.

It was considered that it might be possible to kill the larva in this last stage of feeding by applying on the mine some insecticides which spread well. Accordingly the branches with the mines in their last blotch stages were selected and each mine was sprayed thoroughly with a hand sprayer. Two series of the experiment were conducted and the results obtained were as follows:

Experiment		Dilution	Per Cent. killed.
(i)	Pyrethrum Emulsion	20	90
	Black Leaf 40	800	70
(ii)	Pyrethrum Emulsion	20	89.0
	Black Leaf 40	500	85.3

(c) *Practical Field Experiment.*

The method just described above seemed to be rather promising. Therefore, another series of experiments was carried out in a more practical scale than in the former series of the experiment. The Japanese pear-trees which were infested with the pear-bark miners, of which the mines were in their last stage, were sprayed with pyrethrum emulsion and Black Leaf 40. In this experiment the whole tree was sprayed with a hand sprayer, the method of spraying being different from the former series in which each mine was sprayed thoroughly. The result obtained was as follows:

	Dilution.	Percentage of Dead Larvae.
Pyrethrum Emulsion	30	73.9
Black Leaf 40	800	69.4
Control		15.0

The experiment was not an exhaustive one so that the result may not be very reliable, but it seems to indicate that this method is fairly effective in killing the larva in mine.

In another series of the experiment, the pupae in mine were sprayed with the same insecticides as used in the experiment just described. The result showed that the pupae in cocoon were very resistant to the sprays and that only a small percentage were killed.

Suggestions for the Method of Control. It seems to be possible to give the following suggestions for the method of the control, judging from the results of the experiments with the insecticides as well as from those of the life history studies on this insect.

The most promising method seems to be to spray the pear-tree thoroughly with a mixture* of one part of Black Leaf 40 with 1000 parts of water when the eggs are being laid in July. The emergence period may be slightly different according to the different climatic conditions so that the time of the spraying must be modified in different localities.

In the vicinity of Kurashiki, the first spray should be given about July 1st, and two more sprayings should be done at an interval of a week. Since the period in which oviposition occurs is rather long, it can not be expected that all the eggs are destroyed by the spraying prescribed above. Therefore, if it is observed that a conciderable number of the miners are still feeding, a spray-fluid

* For 18 litres of the diluted solution 56 grams of soap should be added.

consisting of one part of the emulsion of the pyrethrum extract and 19 parts of water should be sprayed when the larvae of the first generation are in the last stage of mining and before they spin cocoons. This spraying should be done two to three times at an interval of about 10 days, the first spraying being given on August 1st.

The time of the appearance of the pear-bark miner may vary slightly from year to year even in the same place according to the weather conditions. Therefore, the observation as described in chapter I should be made in oder to determine the proper time for spraying.

V. Summary.

1. The result of the experiment on the development of the pear-bark miner under the constant temperature was as follows: the lower limit of the effective temperature for the egg of the pear-bark miner is about 12°C. and the higher limit is slightly below 33°C. The minimum temperature for the growth of the larva is also about 12°C. It was not possible to determine the maximum temperature for the growth. The minimum temperature for the development of the pupa is slightly above 12°C. The maximum temperature was not definitely determined, but it is beyond doubt that it is lower than 35°C.

2. The adult insect of the pear-bark miner was found to lay eggs on the following 11 species of the plants of the family Rosaceae: Japanese pear, pear, apple, peach, plum, apricot, *umé*, cherry, Japanese flowering cherry, *boké* and *zumi*. Of these 11 species, the apple-tree is the most preferred plant and the pear follows it.

3. As the method of control of the pear-bark miner, spraying with nicotine sulphate at the time when the oviposition is going on is recommended. If it is found that this spraying alone is not effective enough for controlling the miner, another spraying with the emulsion of the kerosene extract of pyrethrum should be done when the larvae are in their last stage of mining and before they spin their cocoons.

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