THE DEVELOPMENT OF WINGED FORMS IN THE CABBAGE APHID, *BREVICORYNE BRASSICAE* LINNAEUS

II. The Period of Determination of Wing Development*

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There are three distinct types in aphids in regard to the period when the appearance of winged forms is determined. Namely, (1) Kilzmiller (1950) demonstrated in his studies of the chrysanthemum aphid, ***Macrosiphoniella sanborni*** Gillette, that the determination of appearance of winged forms occurred before birth; (2) Paschke (19○9) concluded from his experiments with the spotted alfalla aphid, ***Therioaphis maculata*** Buckton, that whether an individual will be winged or not is determined after birth; and (3) Noda (1961) stated in his studies on English grain aphid, ***Macrosiphum granarium*** Kirby, that the appearance of winged forms was determined either before or after birth according to the conditions of rearing. From the results of the writer's previous experiment (1963), it was presumed that the development of wing was determined after birth. It was not possible, however, to decide the exact time when the appearance of winged forms was determined after birth. Therefore, the present experiment was conducted in order to know the critical period of the determination of wing development in the cabbage aphid.

MATERIALS AND METHODS

The materials used in these experiments were the descendants produced by parthenogenesis from the apterous viviparous female, and the food plant used was the kale, ***Brassica oleracea*** L. var. ***acephala.***

The rearing method was essentially the same as that used in the writer's previous experiment (1963). To obtain winged form, we used density effect. Namely, forty young larvae were reared in a cage under the condition of overcrowding. Japanese pharmacopoeia No. 0 capsule was used as the cage. The larvae were reared up to fourth instar, and were examined for their wing buds, which could be easily recognized by the naked eyes at that stage. In the control series, to avoid the effect of population density, a single larva was put into a petri-dish (4.5cm in diameter × 2.0cm in hight) with a fresh piece of kale leaf (2.0 × 2.0cm) for food. The rearing temperature was regulated at 25°C within a variation of ±0.5°C. A fluorescent electric lamp (Toshiba FL-20W), operated by a time switch, gave the daily photoperiod of 16 hours; and the light intensity on the surface of each plant was 800-1000 lux. The details of methods in the experiments will be described below in each section.

* This is the English edition of the article published in Nogaku Kenkyu 49 (3): 131-136, 1962.

RESULTS

1. *The effect of rearing condition of mother aphid upon the appearance of winged forms in the next generation.*

To obtain four kinds of mother aphid, larvae, produced by parthenogenesis from the wingless adult, were grouped into four lots within 2 hours after birth. Lot 1. Forty larvae were reared in a cage under crowded condition for 144 hours, after birth and then, were transferred individually to each rearing cage. Lot 2. The same as in the lot 1, but for 72 hours in crowded condition after birth. Lot 3. Larvae were at first reared separately, one in each cage for 72 honrs, then forty of them were reared together in a cage for 72 hours, and again separated. Lot 4. This is the control lot. Larvae were reared always separately, one individual per leaf (Fig 1). All the offsprings produced from the wingless mothers thus obtained were

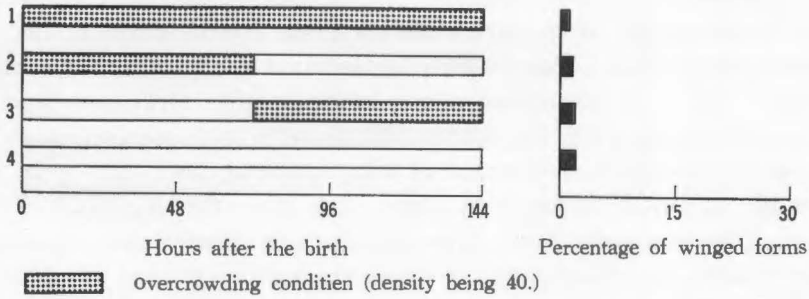

Fig 1. The effect of rearing condition of mother aphid upon the appearance of winged forms in next generation

reared individually on a leaf until all attained the fourth instar. Then, their thoracic structure was examined for their wing buds. Table 1 shows the result.

Table 1.
The influence of overcrowding of mother aphids upon the wing development of next generation in *Brevicoryne brassicae* L.

Lot No.	Number of individuals	Number of unwinged	Number of winged	Percent of winged	Number of larvae dead
1	164	162	2	1.22	0
2	132	128	2	1.54	2
3	157	153	3	1.92	1
4	100	98	2	2.00	0

As is shown in Table 1, there was only a slight difference in percentage of winged forms among different lots. Chi square tests show that there is no significant difference in the percentage not only between any two lots, but also between the control and the three treatment lots. It is evident that a high population density of mothers had not any effect on the wing development in next generation.

2. *The influence of rearing condition during various periods after birth upon the wing development.*

The offsprings produced by apterous females which had been reared without any effect of overcrowding were reared under the condition of overcrowding for various durations at different stages of developmental life, and their thoracic structure was examined at the fourth instar. Within 2 hours after birth, larvae produced by parthenogenetic wingless females were divided into six following lots: 1. Forty larvae were put into one cage immediately after birth and reared up to 144 hours after birth; 2. The same as in the lot 1, but larvae were reared up to 48 hours after birth; 3. Forty larvae were exposed twice to the overcrowding condition for 24 hours immediately after and 48 hours after birth; 4. Forty larvae were exposed to the overcrowding condition for 48 hours following 24 hours after birth; 5. The larvae were treated similarly as in the lot 4, but for 96 hours following 48 hours after birth; 6. The larvae were reared singly until fullgrowth without any effect of overcrowding. Excepting the periods specified above, all the larvae were reared singly as in the lot 6 (Fig 2). The result is shown in Table 2. From the

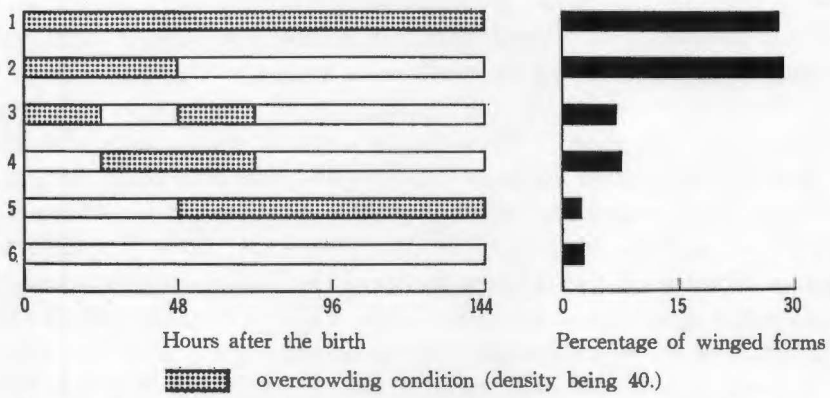

Fig 2. The influence of rearing condition during various periods after birth upon the appearance of winged forms

Table 2

The influence of overcrowding in different periods after birth upon the wing development of *Brevicoryne brassicae* L.

Lot No.	Number of individuals	Number of unwinged	Numder of winged	Percent of winged	Number of larvae dead
1	240	167	65	28.02	8
2	240	162	64	28.32	14
3	240	202	15	6.91	23
4	240	210	17	7.49	13
5	280	255	7	2.67	18
6	214	206	6	2.83	2

results shown in Table 2, it is clear that the percentages of winged forms can be classified into three groups, that is Lot 1 and 2, 3 ant 4, and lot 5 and 6, According to the chi square tests, it is evident that the differences in rate of appearance of winged forms are statistically significant at a level of 1 per cent among the three groups, but not between the treatments in one group. From the results of these experiments, it will be noted that the influence of the high population density is effective only within 48 hours after birth and not after that period.

DISCUSSION

Experiment 1 was so designed as to examine the effect of overcrowding of mother aphids at various life stages upon the wing development of the next generation. According to the result shown in Table 1 and Fig 1, it seems that the undernourishment of parents caused by overcrowding has no effect on the wing development in the next generation, since there is very little difference in percentage of winged form emergence between different lots. The object of experiment 2 was to examine the period of overcrowding of the present generation which affects the production of winged form. It is shown in Table 2 and Fig. 2, that the young larvae reared under the condition of overcrowding for 48 hours immediately after birth transform into the winged forms in a high percentage, regardless of density in the later stage. When the larvae were reared singly for 24 hours after birth and for another 24 hours following 48 hours after birth, winged forms appeared in a low percentage. When they were reared singly for 48 hours immediately following birth, the winged forms appeared very little. The difference in percentage of winged forms between the control lot and the last mentioned lot are not statistically significant at 1 per cent level. Thus, it may be concluded that the critical period of the determination of wing development is within 48 hours after birth. If newly born larvae were reared without any influence of overcrowding for the first 24 hours after birth, or for the second 24 hours, the percentage of winged forms decreased to about one-fourth of the first group (lots 1 and 2). When they were free from the effect of crowding for 48 hours after birth, the appearance of winged forms was very low, being only 2.83 per cent even in the highest case.

There are a number of studies about the " time of determination " of wing development in aphids. The time doubtless seems to vary from one species to another. Kilzmiller (1950) states in his studies of *Macrosiphoniella sanborni*, that the determination of development of winged form occurs approximately three and three-quarter days before birth. Noda (1958) found that in the aphid, *Rhopalosiphum prunifoliae*, future development of wings is determined within 5 to 35 hours after birth. The same author, however, later (1961) stated that the development of wings in *Macrosiphum granarium* occurred either before or after birth and was dependent upon the conditions prevailing both before and after birth. Takahashi (1923) printed out that, in *Astegopteryx quercicola*, there is a mor-

phological difference between the first instar larvae which are to grow up to the winged form and those to the unwinged. Thus it is interesting to examine what type of wing development is most prevalent in aphids. Whether a certain theory regarding the appearance of winged form is valid possibly varies according to species and would need experimental investigation.

SUMMARY

The critical period of determination of wing development in the cabbage aphid, ***Brevicoryne brassicae*** was studied experimentally at a constant temperature of 25°C. by varying the density of population in rearing.

1) The determination whether an individual will be winged or not occurs after birth.

2) The critical period of determination of wing development is within 48 hours after birth.

3) The conditions on both the first and second days after birth have influence on the wing development.

Acknowledgemets. This study was carried out under the kind guidance of Dr. Yasunobu Yasue, to whom the author wishes to express his sincere thanks. Many thanks are also due to Dr. Chukichi Harukawa, Professor Emeritus of Okayama University, for his kindness in reading through the manuscript.

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