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

I. The Influence of Population Density, Photoperiod and Temperature

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It has been suggested by many previous investigators that the wing development in aphids is related with such enviromental factors as temperature, photoperiod, population density, and the moisture as well as the chemical composition or constituent of their host plants. Noda (1954) found that the population density is one of the powerful factors for the wing development in the apple grain aphid, *Rhopalosiphum prunifoliae* Fitch. Temperature is another factor which has been investigatated by a number of workers. But the results published do not agree. The present experiment was conducted in order to study the effects of population density, photoperiod and temperature on the wing development in the cabbage aphid, *Brevicoryne brassicae* Linnaeus.

MATERIALS AND METHODS

All materials used in these experiments were the descendants originated by parthenogenesis from one unwinged viviparous female of *Brevicoryne brassicae* Linnaeus; and the host plant adopted was kale leaves, *Brassica oleracea* L. var. *acephala* DC. The first instar larvae born within two hours before the test were used. A definite number of young larvae were placed in a cage on the kale leaf; and their density in the cage varied as shown in Fig. 1 and 2, (viz., 20, 40, and 60 individuals per 0.36 cm^2). Japanese pharmacopoeia No. 0 capsule was used as the cage. The larvae were reared up to fourth instar; then, their thoracic structure was examined for their wing buds, which could be easily recognized by the naked eyes at that stage. The experiments were carried out in double-walled glass cabinets, in which both temperature and photoperiod were controlled. The temperature was regulated at 20° and 25°C, within a variation of

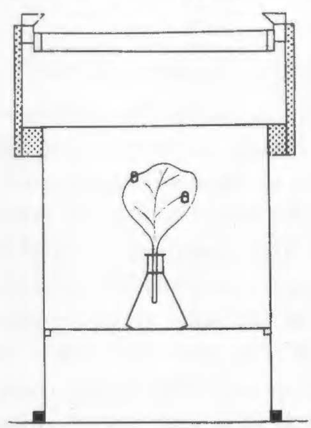
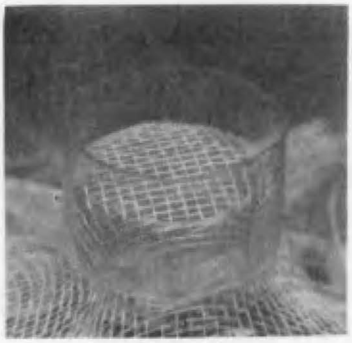
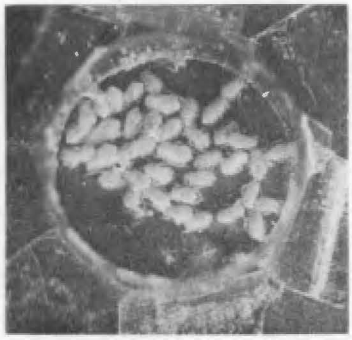


Fig. 1. Diagrammatic profile of the cabinet for rearing aphid.



a



b

c

Fig. 2. Rearing cage and aphid larvae on the surface of the kale leaf.

a. Rearing cage coverd with fine-mesh nylon cloth. (×4)
b. Larvae, just after treatment. (×4)
c. Larvae, four days after treatment. (×4)

±0.5°C. A fluorescent lamp (*Toshiba* FL-20W), operated by time switches, gave the daily photoperiod of 8 and 16 hours; and the light intensity on the surface of host plants was 800–1000 Lux. The water in the vial was supplied every day, the leaves having been cut from the stem in water to avoid their wilting.

RESULTS

Effect of Population Density

The results of the rearing experiments are shown in Tables 1 and 2. As shown clearly in these tables, most of 20 individuals on the given area (0.36 cm^2) grew up to the unwinged forms at the constant temperatures of 20° and 25°C, and under both "long" (16 hours) and "short" (8 hours) photoperiods. In this lot, the percentage of winged forms was the highest being 2.97%, when the temperature was at 25°C, and the photoperiod was 8 hours. In the 40 individuals placed in the same area, the percentage varied from the highest 10.76% to the lowest 8.37%, and was 9.48% on the average; and in the 60 individuals, the percentage was still larger, namely, 22.74% on the average.

As it has been stated already, the higher the density is, the higher the percentage of winged form is in every combination of temperatures and photoperiods. To show this relationship more clearly, the writer prepared Table 3 and Fig. 3. In this table it is clearly seen that the difference between

TABLE 1
Influence of population density on the production of winged form in *long* (16 hours) and *short* (8 hours) photoperiods at 25°C

Photoperiod	Density	Total	Number of winged	Percent of winged	Death
16 hr.	20	240	5	2.14	6
	40	240	19	8.37	13
	60	240	54	23.79	13
8 hr.	20	240	7	2.97	4
	40	240	24	10.76	17
	60	240	45	21.84	34

TABLE 2
Influence of population density on the production of winged form in *long* (16 hours) and *short* (8 hours) photoperiods at 20°C

Photoperiod	Density	Total	Number of winged	Percent of winged	Death
16 hr.	20	240	4	1.74	10
	40	240	20	8.93	16
	60	240	46	22.12	32
8 hr.	20	240	6	2.59	8
	40	240	21	9.86	27
	60	240	48	23.19	33

TABLE 3
The difference of percentage of winged forms among three lots of different densities

Temperature	Photoperiod	When density increased from 20 to 40	from 40 to 60
25°C	16hr.	6.23	15.42
	8hr.	7.97	11.08
20°C	16hr.	7.19	13.19
	8hr.	7.27	13.33

the percentage of winged forms of 20 individual-lot and that of 40 individual-lot was about as half much as the difference between the 40 individual-lot and 60 individual-lot; viz., the former was 7.12% and the latter 13.26% on the average. The rate of increase of the percentage of winged forms was comparatively lower in 40-lot and higher in 60-lot. Therefore, the curve which

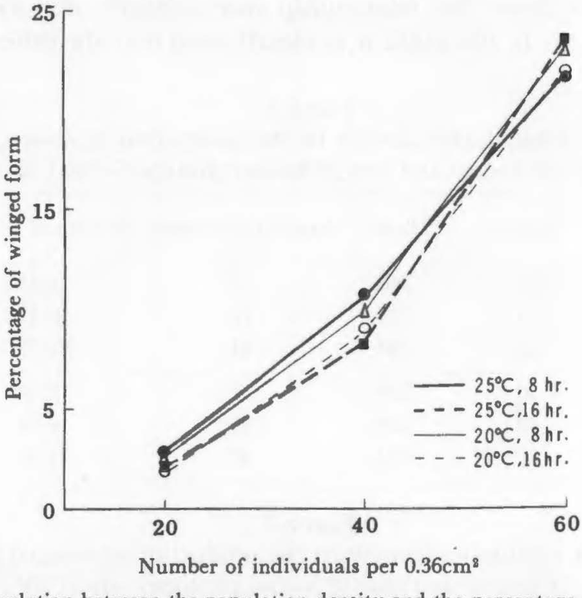


Fig. 3. The relation between the population density and the percentage of winged forms.

indicates the percentage of winged forms produced becomes concave upwards.

It is apparent that significant difference at 5 percent level exists in the wing development among three lots of different densities.

Effect of Photoperiod

The Table 4 was prepared to examine the influence of photoperiod under

TABLE 4
The difference of percentage of winged forms between *long* (16 hours) and *short* (8 hours) photoperiods

Temperature	Density	Difference between 16hr.−8hr.
25°C	20	−0.83
	40	−2.39
	60	1.95
20°C	20	−0.85
	40	−0.93
	60	−1.07

the same temperature. This table indicates that, when temperature was 25°C the percentage of wing formation in long photoperiod was less than that in short photoperiod, excepting the result at the density of 60 individual-lot, while at the temperature of 20°C the percentage of winged forms in long photoperiod was always less than that in short photoperiod. According to the result of

x^2-test there is no significant difference in the wing formation between short and long photoperiods.

Effect of Temperature

The effect of temperature on wing formation may now be considered in detail. Table 5 was constructed from Tables 1 and 2. The difference is always

TABLE 5
The difference of percentage of winged forms between 20° and 25°C

Photoperiod	Density	Difference between 25°−20°C
	20	0.40
16hr.	40	−0.56
	60	1.67
	20	0.38
8hr.	40	0.90
	60	−1.35

very little, but the percentage of winged forms at 25°C is somewhat larger than that at 20°C excepting two cases observed at 20°C. The result of x^2-test does not show that the differences of percentage of winged forms between 20° and 25°C is significant.

DISCUSSION

In various investigations, it has been noted that the number of winged forms tends to increase with the increase of population density on the host plant. Bonnemaison (1951), studying on the cabbage aphid, *Brevicoryne brassicae* Linnaeus, concluded that "crowding" (i. e., high density) caused the number of winged forms to increase. The result of the present study indicated that population density was more important factor than either temperature or photoperiod, for the production of winged or unwinged form. Bonnemaison, indeed, suggested in his work that density acted directly, not through the plant, on the insect. But judging from his experimental design, it is doubtful that there was no change at all in the physiological condition of the plant in the course of his experiment. Therefore, the conclusion that the influence of density alone acted on the aphid directly seems to be somewhat hasty according to the writers opinion. From the nature of the present experiment, it is impossible to determine which caused the increased number of winged forms, the density or the physiological change in the host plant resulting from a high population. To solve this problem, I believe that more detailed studies must be carried out.

Photoperiod is another factor which has been investigated by a number of workers, such as Marcovitch (1924), Shull (1929), and others. It has been shown that for some aphids the alternation of photoperiod might have caused proportional increase or decrease of winged forms. The results of the present experiment, however, indicated that photoperiods of 16 hours and 8 hours had nothing to do with the production of winged forms, under the temperature range of 20°–25°C.

Temperature has been investigated by many workers as a causatic factor, whether positive or negative, which caused the development of winged forms. Ewing (1916) correlated the maximum wing production in *Aphis avenae* Fabricius with the temperature of 18.3°C. The results of Call (1918), investigating wing-inducing factors in *Aphis maidis* Fitch, indicated that the maximum number of winged forms was obtained when temperature was in the range of 15.5°–21.1°C. More recently, White (1946) found in her work with *Macrosiphoniella sanborni* Gillette that 12°C and continuous light produced more winged forms than under other temperature and light condition. Kenten (1955), studying *Acythosiphon pisum* Harris, showed that wing formation in this aphid was brought about by low temperature of from 7° to 11°C combined with 16 hours photoperiod. Reinhard (1927) and Rivnay (1937) found that there was no effect of temperature on the winged forms production in *Aphis gossypii* Glover and *Toxoptera aurantii* Fonscolombe. According to the writers' present investigation, the difference in wing development was not discernible, between 20° and 25°C; so it is clear that temperature played little or no part in the production of winged forms. the writer, however, did not avail of low temperature of 15°C in the present experiment; so the writer is not, as yet, able to show whether low temperature had any effect on the wing formation.

SUMMARY

The effects of population density on the development of wings in the larvae of cabbage aphid, *Brevicoryne brassicae* Linnaeus, were examined experimentally at the constant temperature of 20° and 25°C, both in long (16 hours) and short (8 hours) photoperiods; and the following results were obtained.

1) The rate of occurrence of winged forms tended to increase with increase in the population density.
2) The maximum rate of occurrence of winged forms amounted to 23.79% under the condition of 25°C, 16 hours photoperiod, and population density of 60 individuals per 0.36 cm^2.
3) The wing development does not seem to be correlated with the length of photoperiod under the constant temperature of 20° and 25°C, as far as the photoperiod is between 16 and 8 hours.
4) The increase in the rate of winged forms was not observed at the constant temperatures of 20° and 25°C, unless accompanied by high population

density.

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