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Experimental Study on the Phenomenon of so-called "Pre-adaptation" in *Drosophila melanogaster*[*]

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I. Introduction

Although the fact that the greater part of animals living in caves or in underground waters are blind is widely recognized, origin and evolutionary process of this phenomenon has never been confirmed. With respect to this, we can find two contrasting theories. One is a Lamarckian concept, according to which the animals happened to be in caves have gradually been fitted to darkness there losing their photosensibilities due to absence of light. The other is the concept supported by the experimental geneticists, who deny the possibility of inheritance of acquired characters. According to this theory the blind animals in caves are believed to have derived from the mutants which had existed mingled with normal wild animals before they entered the caves, and were selected there as survivors. Loeb (1916) called the phenomenon of this kind the "pre-adaptation". Once L'Héritier, Neefs and Teissier (1937) reported that the individuals of mutant *vestigial* of *Drosophila melanogaster* were overwhelmed by the normal wild individuals in a population cage placed in the laboratory room, whereas when placed in blowing wind the result was conversed and the number of normal individuals decreased more and more as days elapsed. This seems to be a good example of the pre-adaptation phenomena, though the information is now prevailing that the Mendelian mutants are generally weaker in competition than the wild (Reed and Reed, 1950 ; Oshima, 1952 ; etc.).

Of late years, studies on population dynamics using various types of population cages have been carried out by many investigators, among them T. Dobzhansky and his colleagues form one of the most prominent groups. Although the Dobzhanskies, using population cages in the laboratory for the analysis of population problems in nature, seem to be attempting to gain

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ecological or evolutionary informations, every case used by them is always designed as having uniform environment for flies. Namely, no freedom is allowed for flies to choose their suitable niches in the cage. The experiment of L'Héritier and others is in this point, based on the same principle, i. e., they only changed the environment for flies by transferring the cage itself from a place to another. Then, what may happen when flies are placed in a cage having different environments in it is a theme that remains untouched and is of great importance from the viewpoint of general biology.

Under these circumstances we attempted the present experiment. We devised a cage which has both light and dark portions in it, put a certain number of wild type (red-eyed) individuals and white-eyed mutants or *Drosophila melanogaster* into each portion, and pursued the successive changes in population composition. The research is still in progress, of which this report is the first announcement.

Taking this opportunity, we would express our hearty thanks for the kind suggestions and criticisms constantly given us by Dr. Denzaburo Miyadi, Dr. Mitosi Tokuda, Mr. Kisaburo Ono, Dr. Kenji Nakamura, Mr. Tadasi Imaizumi (all belong to Kyoto University) and Dr. Chozo Oshima (Osaka University).

II. Method

The wooden population cage, 60 × 18 × 10cm, the upper and front sides of which were glazed, was used (Fig. 1). A glass partition (Fig.2, Pc), having a narrow pathway (2 cm wide) in the center is made at the middle of the cage. Flies are able to go anywhere they will in the cage through this pathway. This central partition is a barrier and furthermore two glass barriers (Pl and Pr) are made at both sides of the central pathway. Every one of these three barriers is made of a pair of glass plates.

Covering over the upper and front glass plates of the right half of the cage with black paper and inserting pieces of black paper between two glass plates of the central and right barriers (Pc and Pr), the right half of the cage was darkened, and the left half was left uncovered so that it may be illuminated by daylight. This half light and half dark cage prepared (the LD cage) is the experimental one and besides this we used always the total light (LL) and the total dark (DD) cages as the controls.

At the start of experiment, six small glass bottles (3.7 cm in daimeter by 8 cm high), each containing 15 cc of Pearl's medium, were introduced into the cage through the bottom holes of the cage (Fig. 2, Nos. 1, 3, 5), and then the equal number of pairs of the wild (red) and the *white* individuals was put into each portion of the cage from the side-hole. After two weeks, another set of six food bottles was introduced into the cage through the holes

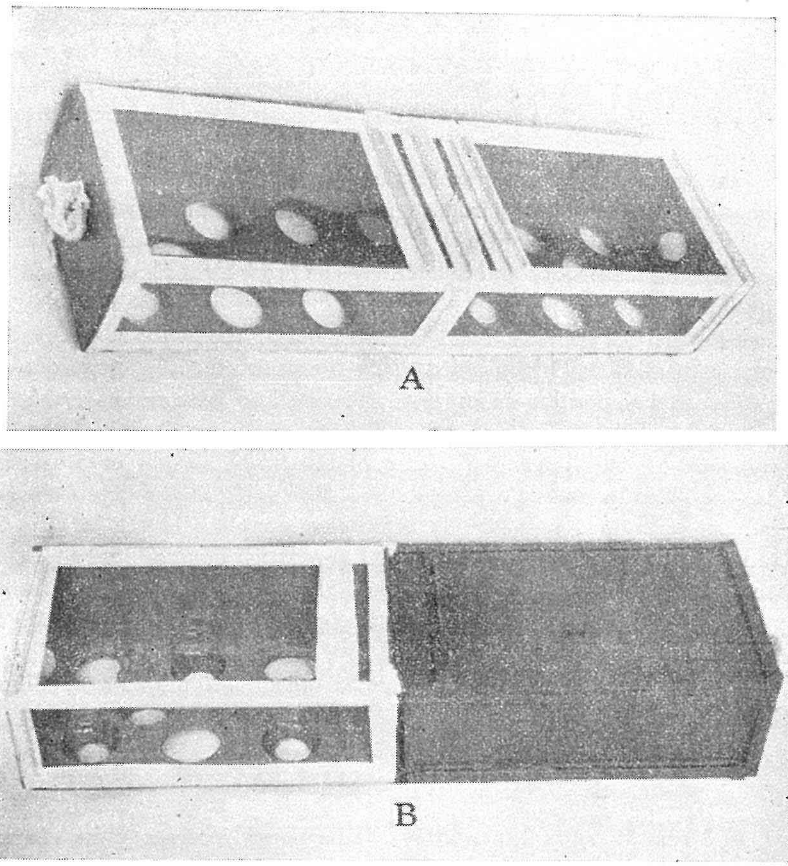

Fig. 1. Photographs of the cages. A : LL cage or total light cage. B : LD cage, having both light (left) and dark (right) portions in it.

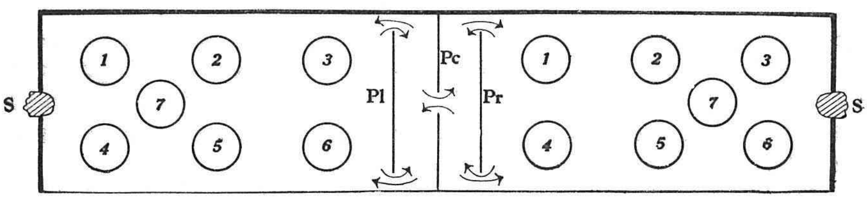

Fig. 2. Upper view of the cage. Pc : central glass barrier. Pl and Pr : left and right glass barriers. The holes 1–6 are used for introducing food bottles and the holes 7 for introducing sampling bottles. S : side holes.

(Nos. 2, 4, 6,), and at the same time two sampling bottles, through the No. 7 holes. The sampling bottles were taken out after three days and the number of emerged flies in each bottle was counted. Two weeks after the second six food bottles were introduced, the old (first) six food bottles, now shriveled, were replaced by new ones, and at the same time the sampling was repeated. Two weeks may be taken as the duration of one generation in this species at 25°C, and the sampling was justifiably made of each of successive generations.

In the first series of experiment, three cages (LD, LL and DD) were used, and the initial total population in one cage was 10 pairs of the wild and 10 pairs of the *white* (40 individuals in all). This experiment was discontinued after 9 generations on account of an accident. The procedures of the second series of experiment were the same as those of the first one, except that the initial population was 16 pairs of the wild and 16 pairs of the *white* respectively (64 individuals in all). We continued this experiment till 28 generations, when the population composition in every cage seemed to have attained the equilibrium state. The third series of experiment, in which the initial population was 20 pairs of the wild and 20 pairs of the *white*, is now in progress.

In the second series of experiment, all flies living in the cage were anaesthetized and examined immediately after the sampling bottles of the 28th generation were taken out, and the actual population compositions of the total flies in the cage were compared stochastically with those inferred from the sample counts. The result was that the agreement between them was very satisfying in every cage.

The whole experiment was conducted under thermostatic condition at 25°C.

III. Results obtained

Figs. 3 and 4 show the results. The curve represents the change in percentage of total number of *white* individuals to total emerging flies from two sampling bottles of each cage. Number of countings (abscissae of the figures) which was made at intervals of two weeks can be taken as indicating number of generations. In the LD cage of the first series of experiment, the number of the *white* exceeds the total by 50% at the 4th generation and later on it always maintains this dominancy to that of the wild, while in the LL and DD cages the wild overcome the *white*, the latter decreasing gradually.

Fig. 4 shows the result of the second series of experiment. Although the percentages of *white* flies in the LD cage are smaller in this case than in the first series[3], it may be said that general tendency is identical in both

3) The discord seen between the results in the first series of experiment and in the second may be due to the difference of stock lines adopted. Different states of population equilibrium resulting from using different lines are reported, for examples, by L'Héritier (1934) and Moore (1952).

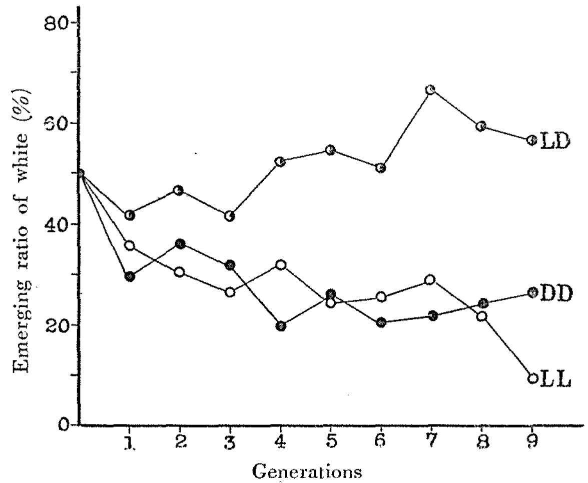

Fig. 3. Change of emerging ratio of the *white* (%) in the first series of experiment. LL; total light cage. DD: total dark cage. LD: half light and half dark cage.

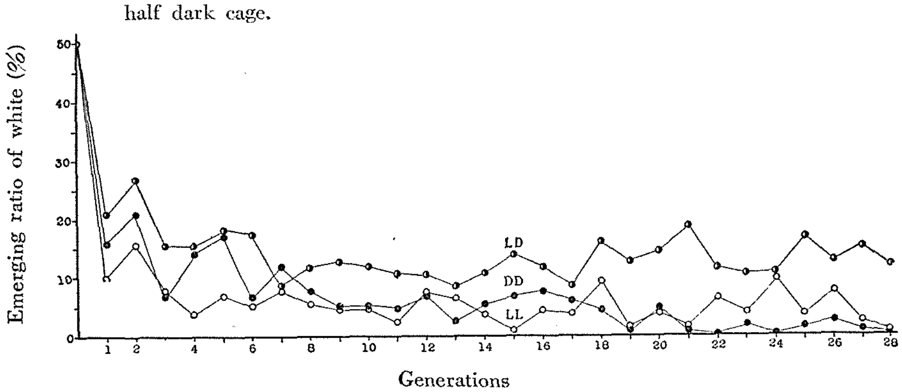

Fig. 4. Change of emerging ratio of the *white* (%) in the second series of experiment. Abbreviations see Fig. 3.

Table 1. Results of the stochastical examination concerning the differences among three cages. α denotes the level of significance.

	Number of generation in which significant difference was	
	seen ($\alpha \leq 0.05$)	not seen ($\alpha > 0.05$)
Betw. LD and LL	18	10
Betw. LD and DD	21	7
Betw. LL and DD	8	20

series. Namely, in a cage of which environment is heterogeneous concerning light, the population equilibrium is attained at a higher level of proportion of the *white* than in a cage of homogeneous (total light or dark) environment.

To make sure the difference between the LD cage and the LL or the DD cage, stochastical examination was performed. Table 1 shows the results obtained from the second series.

IV. Considerations

1. We planned this experiment with a view to ascertain whether the phenomenon of Loeb's so called "pre-adaptation" can be demonstrated in the population cage or not, so it was found necessary for this purpose to put animals having different characters into a heterogeneous environment consisting of different niches. We made a heterogeneous enviroment concerning light condition, and used red-eyed and white-eyed *Drosophila melanogaster* as animals having different characters. It is widely known that the photic reaction is clearly differentiated between wild and *white* flies, the phototaxis of the former showing more positive tendency than that of the latter (McEwen, 1917; Kikkawa, 1943). We also confirmed this fact, although the detailed description of the experiment is not to be given here.

We had assumed before the experiment that, when these two types of *Drosophila* were put into a cage having different niches concerning light, the wild type which is more sensitive to light would thrive more in the light part of the cage than in the dark part, while the white type which is less sensitive to light would show the opposite tendency. In other words we assumed the occurrence of habitat segregation in the cage. If this were true, the percentage of the *white* individuals to total flies would be expected to be greater in the LD cage than in the LL or the DD cage.

The results of the experiment reveal that the assumption is generally true. At some point, however, the assumption is in discord with the fact. Accordingly if this assumption were perfectly correct, the percentages of the *white* in the light part and in the dark part of the LD cage would be different. In the first series of experiment this assumption turned out to be true and the percentage of the *white* after 7 generations is greater in the dark part than in the light part, the difference being stochastically significant. But in the second series of experiment we can scarcely find any significant difference between the percentages of the *white* in the light part and in the dark part of the LD cage.

In conclusion, the results obtained are in general such as we expected, except that, in the LD cage of the second series of experiment, no significant difference is found in the percentages of the *white* between the light part and the dark part.

2. It is often asserted that generally the Mendelian mutants are deformed and inferior to the wild type in competition. But we think that whether some organism is malformed or not, must be determined relatively by the situation it occupies under various conditions of environment. It is indicated by our experiment that, if a suitable environment is offered for a Mendelian mutant, it can thrive overwhelming the wild type.

3. Extensive works performed by Dobzhansky and his colleagues using population cages seem to have an aim to analyse the population dynamics prevailing in nature. But we wonder whether this aim can be attained so long as the experiment is restricted within the adoption of the cage merely having homogeneous environment in it. Reed and Reed (1950) have established a theoretical formula considering such a factor as selective mating ratio in the study of population cage, but their study seems to be, at most, the first step for grasping the dynaimic aspects of natural population. Natural habitats are considerably complicated, and the phenomena occurring in organisms are multifarious. In order to contribute to the evolutiodary knowledges, we believe, this sort of research must be directed along such a line as shown by the early works of L'Héritier and others or by our present work.

V. Summary

1. Wooden population cage ($60 \times 18 \times 10$ cm), upper and front sides glassed, was used. The cage was separted into two parts by a glass partition constructed at the middle, having a pathway of 2 cm width, through which the fly could go from a part to the other the cage. In the experimental cage (the LD cage), a half part was darkened by covering the glass surfaces with black paper and the other half was left uncovered so that it was light under illumination of daylight. Besides, two control cages having homogeneous environments concerning light were used, the one being dark in both parts (the DD cage) and the other being light in both parts (the LL cage).

2. Equal numbers (10 pairs in the first series of experiment and 16 pairs in the second respectively) of the wild and the *white* mutants of *Drosophila melanogaster* were put into each cage, and the transition of population composition was observed. The percentage of the *white* to the total emerged adults decreased as generations pass on in both the LL and the DD cages, down to 5 % or even below after 9 generations in the second series. In the LD cage, however, it was maintained at higher levels, between 10 and 20 % (in the second series), or even surpassed that of the wild (in the first series).

3. We consider that the cause of the appearance of this phenomenon is in the difference of the photosensibility between the wild and the *white*.

4. It is generally recognized that, in the population cage, the wild overcome the mutant and that the latter gradually disappear. But when a cage has a heterogeneous environment in it, the matters will differ as our experiment shows. In some cases, the mutant even surpass the wild, which may be taken as an example of the phenomena of "pre-adaptation".

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