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Comparative Studies on Some Characteristics of Three Races of *Drosophila auraria*

With 7 Text-figures

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It is generally believed that a race can often be an incipient species, and that if the speciation process ever happens to be revealed, it would be by investigation of races in genetically well-analysed groups such as the *Drosophila* species. *Drosophila auraria*, viewed in this light, is believed to occupy the most interesting place among the various species of this genus. This species was originally described by Peng (1937) from China (Nanchang, Sanhu, Ningpo), and was also reported from Japan (Honshu, Shikoku, Kyushu) by Kikkawa and Peng (1938)[1].

In 1951 Okada of this Department discovered two types (A, B) within the species *auraria* (Moriwaki, Okada and Kurokawa, 1952), and with the discovery of another type (C), he made a comparative morphological study of the three[2]. Subsequent studies (Kurokawa, 1952, 1954, 1955, 1956) have made it clear that the three types can be ranked as distinct races, and the data for these are presented in this paper.

These races cannot be identified by their chromosomal configuration on the metaphasic plate, since karyotypes of the three races are identical, having two pairs of V's, one pair of dots, and one pair of rods, the latter of which are sex chromosomes, as previously described by Kikkawa and Peng (1938).

Males of these races can be readily distinguished by their external morphology alone, especially, by the phallic and periphallic organs (Okada, 1954), and by the number of the sixth sternite bristles (see below).

The females can be discriminated conveniently by the different characteristics of the egg-guides (Fig. 1). Besides the morphological differences reviewed above, there are some characteristics which should be important for race formation, e.g., geographic distribution, egg productivity, hatchability, sexual isolation, etc.

The present paper deals with such ecological patterns (except sexual isolation) of these races to present further evidence for the validity of treating them as races.

1) This form seems to be of the type A of Okada's classification.
2) Okada, T. 1954 "Konchu" **22**: 36–46.

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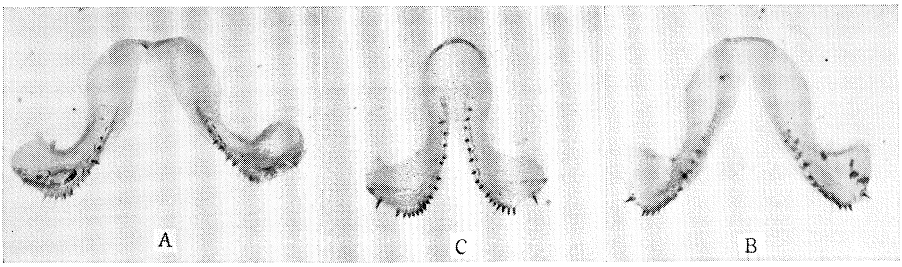

Fig. 1. Egg-guides of race A (A), race C (C) and race B (B).

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RACIAL DIFFERENCES IN SIXTH STERNITE OF MALE

Race A has many bristles (14.2±2.6) on the 6th sternite while race C has fewer (11.7±2.2), and race B has none (Fig. 2). Although numerical differences

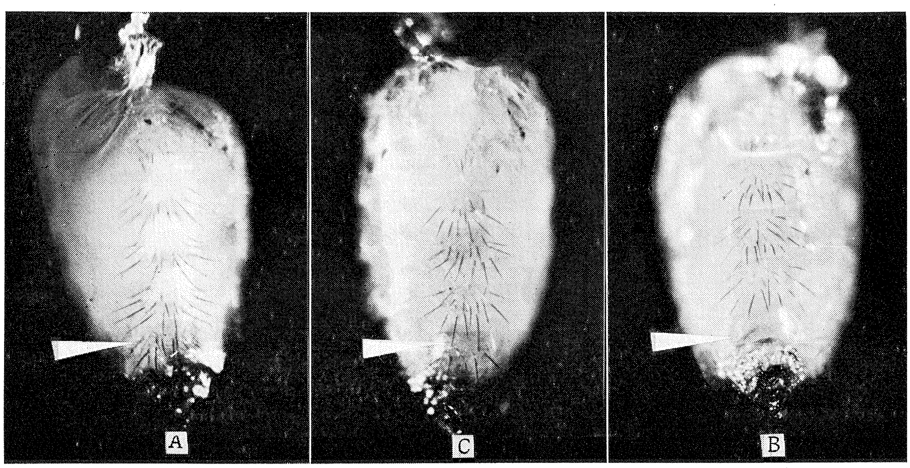

Fig. 2. Sixth sternites of the males of race A (A), race C (C) and race B (B); C being intermediate of the other two.

of the bristles on the 6th sternite between races A and C are statistically significant, judging from the values of D/S.E., 77.0, the identification of individual flies is hardly possible by considering the number of bristles alone, as the distribution of the bristle count of the two races overlap broadly (Fig. 3).

Geographic Distribution

In the laboratory, the three races of *auraria* can be intercrossed regardless of the localities of capture, though it is not so easy as in intraracial crossings. The F_1 hybrids of the interracial crosses, are fertile in both sexes, and are intermediate between parental races in characteristics.

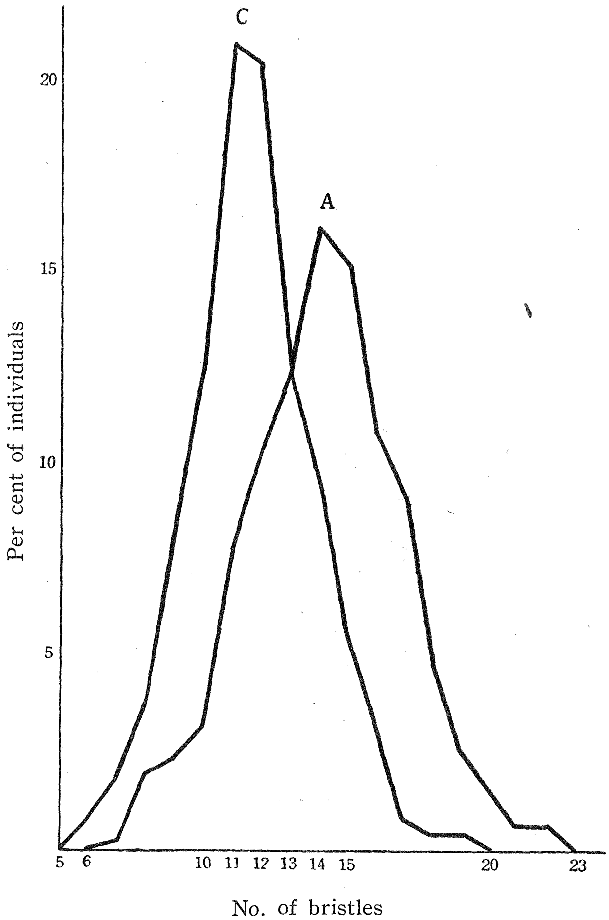

Fig. 3. Bristle counts on male 6th sternites of races A and C. Abscissae: number of bristles per sternite; ordinates: percentage frequency. Race A, a sample from Takao (500 specimens); race C, a sample from Todoroki (362 specimens).

In nature, habitats of the three races are generally separate but two or three races sympatrically occur on the borders of adjacent habitats. However, judging from the fact that no natural hybrids have ever been found among numerous samples from the border areas, gene transfer in nature seems to be prevented mainly by sexual isolation. Therefore, it is inferred that the gene pool in each race is kept discrete.

These three races are distributed widely in Japan (Fig. 4), though each has a habitat of its own. Race A commonly occurs in all areas from Hokkaido to Kyushu. It is likely that this race, by and large, is the most domestic type as the flies of race A have been collected mostly near human habitation at comparatively low altitude. On the other hand, race B inhabits regions, rather cool in summer, deciduous, bushy, and groves intermingled with forests distant from human dwellings. Accordingly, for the most part, race B has been caught in higher and wilder areas than race A. In Hokkaido, however, race B has been captured in places of low altitude a situation different from that found in more southern regions. Lastly, race C has been found at localities somewhat intermediate but rather close to that of race B, but further investigations are necessary before conclusions can be drawn.

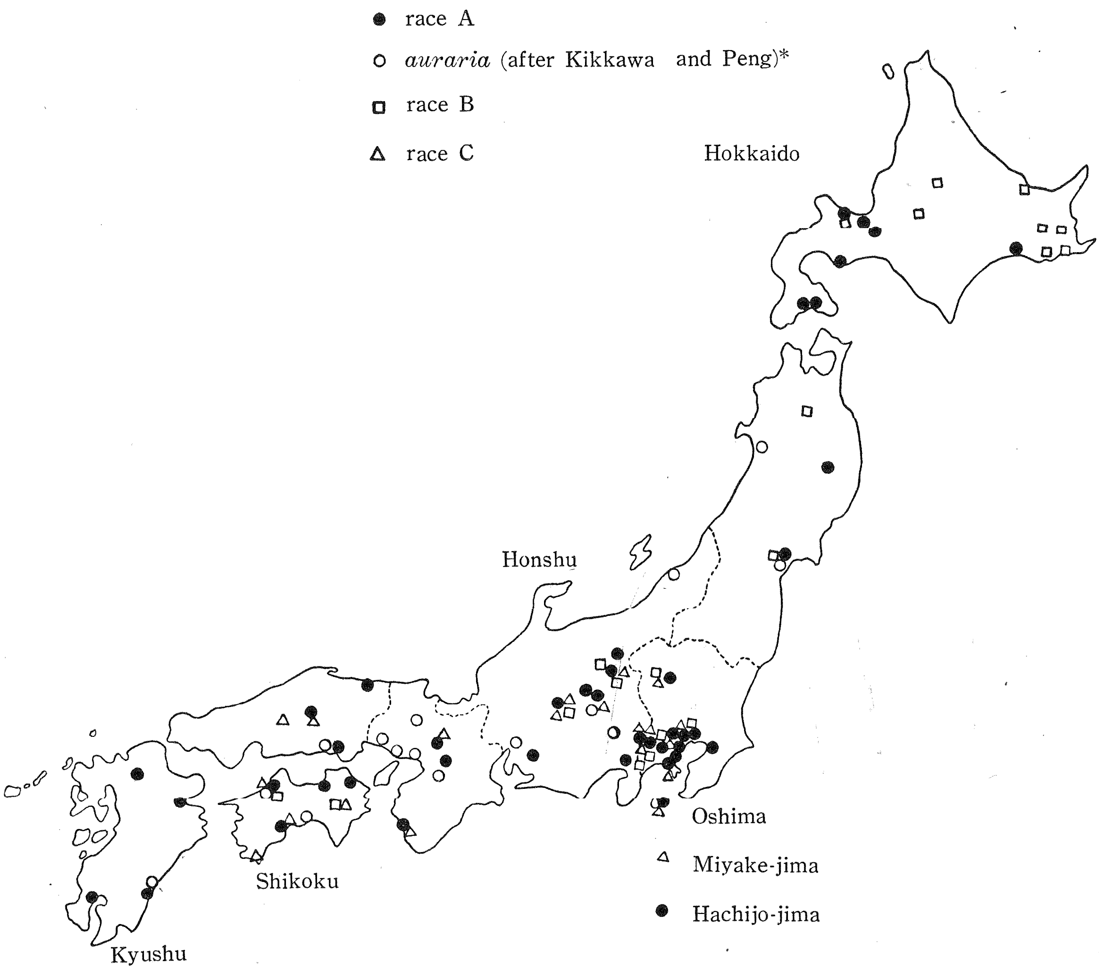

Fig. 4. The geographic distribution of *Drosophila auraria*: races A, B and C. * This is conformable to race A.

Racial Differences in Fecundity

Besides external characteristics and ecological environment, the present paper furnishes information concerning fecundity including egg productivity and hatchability of the three races at different temperatures.

(1) *Method*

Seven wild-type strains collected at distantly separated localities were chosen for the experiments. These strains were: race A 1) Takao (Tokyo), 2) Hakodate (southern-most of Hokkaido), 3) Anjo (Aichi Pref., Central Japan), race B; Sukayu (Tohoku Prov.), 2) Barasan (in eastern part of Hokkaido), 3) Kogesawa (Tokyo), race C; Todoroki (Tokyo). Each strain was derived from a small sample caught in nature, and kept in the laboratory for from several to many generations before being used.

On raising the flies, whose fecundity was to be studied, the following precautions were taken to make the condition uniform, since oviposition is known to be very sensitive to various external and internal factors of an organism. For each strain, about ten pairs of newly emerged flies were placed in a culture vial with a standard amount of cornmeal-molasses-agar food at 25°C. After they were kept for 24 hours to allow them to lay eggs, they were transferred to fresh food. The vial in which eggs were deposited during the intervals of 24 hours were then placed in incubators at 25°C and 19°C. Over-crowded vials were discarded. Care was taken to ensure sufficient yeast at the aging period. When flies emerged at

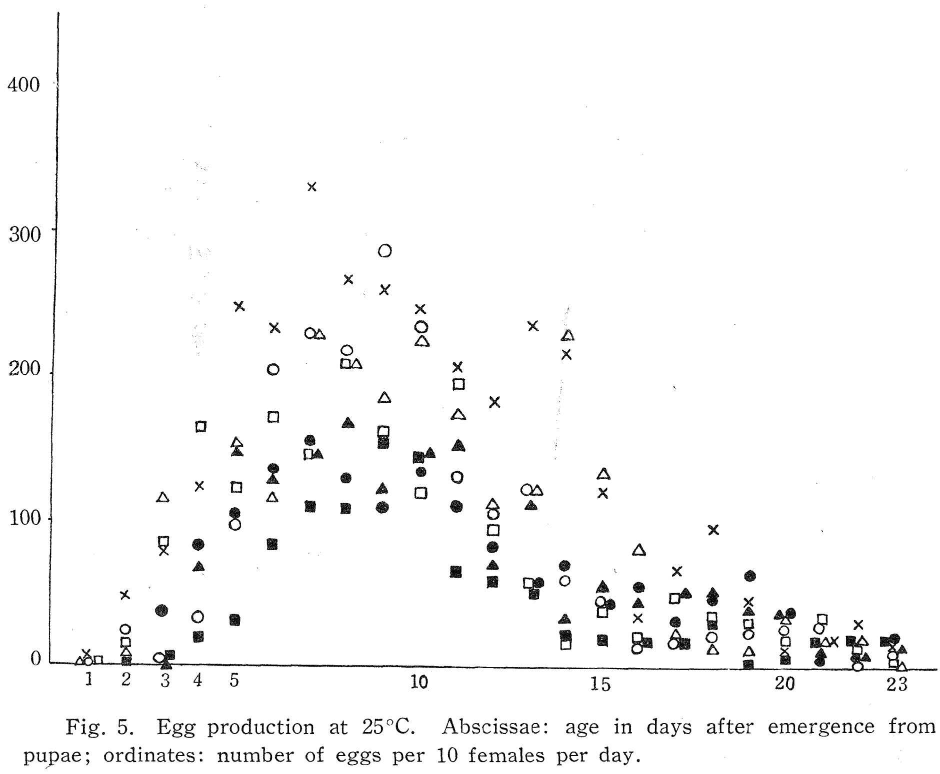

Fig. 5. Egg production at 25°C. Abscissae: age in days after emergence from pupae; ordinates: number of eggs per 10 females per day.
race A: white circles, Takao; white squares, Hakodate; white triangles, Anjo. race B: black circles, Sukayu; black squares, Barasan; black triangles, Kogesawa. race C: cruciform, Todoroki. Total egg production per 10 females during experiment. race A, Takao=1934; Hakodate=1820; Anjo=2240, race B, Sukayu=1521; Barasan=1115; Kogesawa=1621, race C, Todoroki=3100.

25°C or 19°C, ten pairs were placed in a 3×11 cm. culture vial containing the molasses-agar food (without cornmeal), where living yeast had been left to grow since the preceding day at 25°–27°C. The food was renewed every day. Eggs deposited were washed out in tepid water and eggs were counted in each vial. The relative humidity was 75–85 per cent in the incubator at 25°C, and 55–60 per cent at 19°C, though within the vials, it was probably higher than outside. The vials were kept away in the incubators from light.

The initial population size per vial was, as stated above, ten females and ten males. Checking their number every day, decrease by death or accident was made up with flies which had been reserved under similar conditions, to keep the population density constant. The experiment was started with four vials of each strain for each temperature. Therefore, the data seen in Figures 5, 6 and 7 are the mean values of the four vials. The experiment was discontinued when the fecundity of the females dropped with age though the fertility of the males did not appreciably decline with age.

(2) *Egg-laying Rate*

25°C The results obtained at 25°C are presented in Figure 5. In some strains belonging to races A and C, females began to lay eggs at the end of the second day after emergence, while with race B it was usually delayed about one day. This tendency held true at 19°C too (see below). As seen in Figure 5, the number of eggs produced per day in races A and C were higher throughout a life span than in race B. In each race the daily productivity increased rapidly

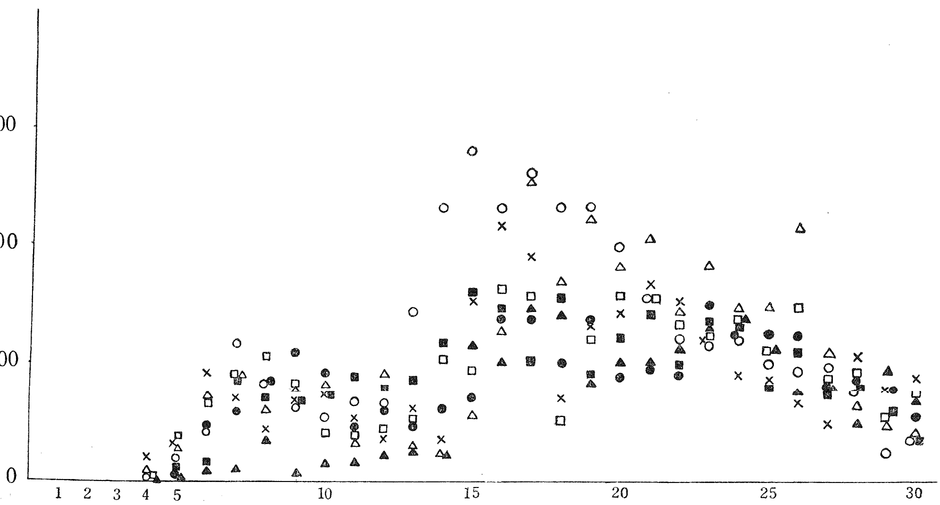

Fig. 6. Egg production at 19°C. Symbols are the same as to Figure 5. Total egg production per 10 females during experiment. race A, Takao=3278; Hakodate=2544; Anjo=2929, race B, Sukayu=2294; Barasan=2430; Kogesawa=1810, race C, Todoroki =2553.

at first, reached a maximum at about the end of the first week and declined slowly thereafter.

19°C As the entire duration of the egg-laying at 19°C is too long to be figured, the major part of the result is represented in Figure 6.

The daily production of eggs is considerably to be erratic. The first oviposition was delayed from three to four days as compared with at 25°C. In all rases (A, B, C), the productivity curves rose more gradually at 19°C than at 25°C, reaching their peaks at about the end of two weeks of life, and declining slowly with some irregularities. Race A again showed a higher productivity than B throughout all the periods as at 25°C. In short, the egg production curves of the three races at 19°C followed essentially the same course as at 25°C, except that at 19°C, there was greater fluctuation.

(3) *Egg Hatchability (at 25°C)*

The differences in egg hatchability between race A and race B were examined (Fig. 7). Out of materials used in the previous experiments, one strain in each race was chosen, i.e., Takao (A) and Barasan (B). Hatchability was examined two days after the egg-laying, through the period of maximal egg production at 25°C. The hatchability of race A was found to be significantly superior to that of race B.

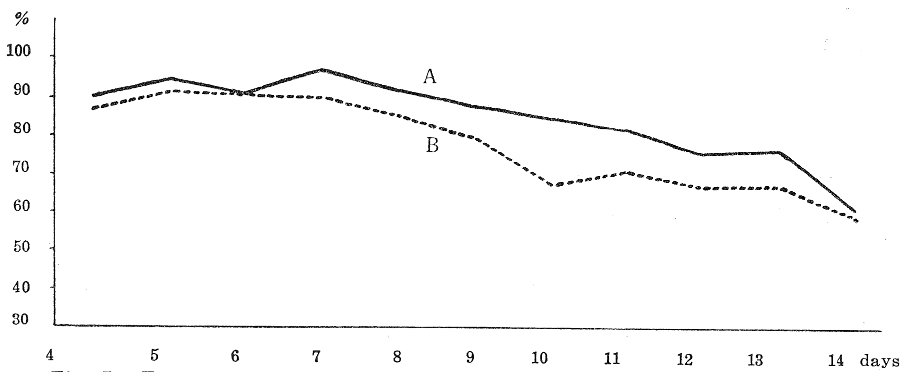

Fig. 7. Egg hatchability at 25°C. Abscissae: adult age in days after emergence from pupae; ordinates: percentage of all hatched eggs. Black line, race A; broken line, race B (race C, not examined).

Conclusions

The distribution areas of the three races seem to differ in size in the order, race A>race C>race B, although these races are sympatric.

As to the altitudinal distribution, Takada (1954) reported that the A type was abundantly found at low altitudes and tended to decrease in number with elevation while an inverse relation was found in the B type. Although the present author has observed a similar situation in some localities, the relationship with regard to altitude in the two races is not always clear-cut. However, the tendency is clear that race A becomes gradually less frequent as the distance from human habitation increases, and it is finally replaced by race C, and the latter is eventually replaced by race B toward the mountainous areas. The borderline on which one form is replaced by another does not correlate with any obvious geographic barrier.

As for the physiological traits, several facts have been brought to light: 1) productivity of race A and race C is higher than that of race B both at 25°C or at 19°C, though race B might be expected to be superior to A at the lower temperature, 2) at 25°C, productivity of race C is the highest, 3) race A is superior to race B in egg hatchability at 25°C, 4) the productivity of the three races is irregular at 19°C as compared with that at 25°C, 5) the mode of daily egg-laying of *Drosophila auraria* at 25°C follows the same curve as does that of *Drosophila melanogaster* (Hanson and Ferris, 1929; Alpatov, 1932), *Drosophila pseudoobscura* (Dobzhansky, 1935) and *Drosophila bifasciata* (Moriwaki, unpubl.). Thus, so far as the author has observed, it is likely that all of the three races are less viable at 19°C than at 25°C. In other words, race B in spite of its habitat being in cooler areas, is more viable at 25°C.

In nature, however, since a more efficient form will crowd out and supplant a less efficient one (Dobzhansky *et al.*, 1950), it can be imagined that race B which is inferior to the race A cannot help inhabiting areas away from race A.

In small populations in which the different races occur together, an analysis is not yet possible. The author hopes that it will be eventually cleared when the collection of race C is extended over the whole country.

Summary

1. The three races, A, B and C belonging to species *Drosophila auraria*, have been discussed with regard to geographic distribution and fecundity. Race A is abundantly found around areas of human habitation, while race B occurs in mountainous regions. The distribution area of race C is intermediate between A and B.

2. Races A and C were found to be superior to race B in the following characteristics.

a) short latency between pupal emergence and egg laying (25°C and 19°C).

b) early attainment of maximal productivity (25°C and 19°C).

c) egg production (25°C and 19°C).

d) egg hatchability (25°C; race C, not investigated).

3. At 19°C egg production of all three races is irregular throughout the life span.

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