KOREAN JOURNAL OF ZOOLOGY
Vol. 24, No. 1, 1 — 7, (1981)

Chromosomal Inversions in a Natural Population of *Drosophila melanogaster*

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초파리集團의 染色體 多型現象

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(Received September 8, 1980)

摘 要

초파리 自然集團의 逆位多型現象을 硏究하기 爲하여 全州近郊의 포도원에서 年間隔으로 三回 採集한 總 969 마리의 암컷을 分析한 結果 19個型의 異型接合 逆位를 觀察했다. 19逆位中 全世界分布型 6個를 除外하고 나머지는 모두 地域型이었으며, 本集團의 平均逆位頻度는 38.9%였다.

INTRODUCTION

It is a well known fact that *D. melanogaster*, cosmopolitan species, is domestic and regularly associated with human habitations. Up to a decade ago, in this species the karyotypic polymorphisms in wild populations were considered less variable than other species such as *D. pseudoobscura* of this genus. In order to clarify the problems of the evolutionary process and the adapted procedure of organisms in fluctuating environmental conditions, many geneticists performed studies on chromosomal variabilities quantitatively; one of the most important subjects in population genetics. Dubinin *et al.* (1937) carried out the pioneer work on the inversion polymorphisms in this species. Further data of evidence on ecogeographical differences in both polymorphisms and their frequencies were published from different continental populations (Warters, 1944; Ives, 1947; Mourad and Mallah, 1960; Oshima, Watanabe and Watanabe, 1964; Yang and Kojima, 1972; Zacharopoulou, 1974; Stalker, 1976). The object of this experiment has been to obtain a data concerning inversion polymorphisms from a Korean wild population of *Drosophila melanogaster*, and to discuss and compare it with other populations.

MATERIALS AND METHODS

Flies used in this work were all collected in yearly intervals in September 1977, 1978 and 1979, respectively from a vineyard near Jeonju Korea.

Samples captured were transiently put in vials placed Spieth medium (1966) and transported to the laboratory, then the wild inseminated females were transfered for breeding. Every fly was isolated in a vial containing standard cornmeal medium with a few drops of wheat germ syrup (3%) added to promote the growth of larvae. As a fungicide 5% diluted solution of propionic acid was used.

In order to good examples of the salivary gland chromosomes, a F_1 third instar larva per vial was dissected in saline solution. The salivary glands were fixed in 45% acetic acid and macerated in 1 N HCl, which was stained in lacto-acetoorcein before being washed twice in a lactic-acetic-acid mixed solution for well spreaded chromosomes. Squashes with the thumb was placed on the siliconized slide glass and the coverglass was mounted with nail polish.

RESULTS

Identification of *inversions.*

In this work, a total of 969 flies were tested and found to have nineteen different inversions from the present wild populations collected three times in a year interval in the area shown in Table 1. Beside the six common paracentric types of cosmopolitan inversions, 13 inversions which are considered most endemic were found. Among this latter group, one inversion was rarely X-chromosomal, 4 were on second chromosome and 8 on third chromosome. Except for two overlapping inversions all of others were identified in singularly. The approximate breakage points were estimated according to the standard gene arrangement described by Bridges (1935) which is now included in the monograph of *Drosophila melanogaster* by Lindsley and Grell (1967). Inversions observed in this study are listed below.

X-chromosome.

In(X)JX 4D-12F New one

Chromosome 2, Left arm.

In(2L)t 22D-34A Cosmopolitan, Bridges & Brehme (1944)

In(2L)JA 22B-26A Rim (1977), Paik (1979), Watanabe *et al.*, (1965)

In(2L)JB 26F-34E Rim (1977), Paik (1979), Watanabe (1967), Stalker (1976)

In(2L)JC 36F-38F Rim (1977)

In(2L)JD 37B-40A Paik (1967), Rim (1977)

Chromosome 2, Right arm.

In(2R)NS 52A-56F Cosmopolitan, Bridges & Brehme (1944)

Chromosome 3, Left arm.

IN(3L)P 63C-72F Cosmopolitan, Bridges & Brehme (1944)
In(3L)JA 62D-66A Rim (1977)
In(3L)JB 66A-67A New one
In(3L)JC 66D-72D New one
In(3L)JD 70B-76E New one

Chromosome 3, Right arm.

In(3R)C 92D-100F Cosmopolitan, Bridges & Brehme (1944)
In(3R)MO 93D-98F Cosmopolitan,
In(3R)P 89D-96A Cosmopolitan,
In(3R)JA 87F-94A New one
In(3R)JB 88D-94A Rim (1977)
In(3R)JC 91F-93B Rim (1977)
In(3R)JD 92D-96B Rim (1977)

Overlapping inversions

In(3R)MO/In(3R)P Rim (1977), Paik (1979)
In(3R)P/In(3R)JA New one

Inversion frequencies.

The results presented in Table 1 show the frequencies of the various kinds of heterozygous inversions. In this data the mean frequency of inversion was 38.9% on an average of every three samples. The facts, therefore, shown in the table indicate that the frequencies of inversions between each sample are not singnificantly different.

As presented in Table 1, of the frequencies of cosmopolitan inversions, Inversion (2L)t, In(2R)NS and In(3R)MO were the most frequent types among all collection; and In(3L)P, In(3R)P in spite of world-wide spreading, also cosmopolitan, were distributed narrowly at a level of endemic inversion.

The latter cosmopolitan group had frequencies too low to compare variations between the three year-interval populations. Except for In(3R)MO that showed a tendency to decrease in frequency, In(2L)t and In(2R)NS did not clearly fluctuate from year to year frequency-wise. Moreover, the differences in the relative frequencies of inversions per chromosome between the three samples were statistically significant in contingency tests ($x^2=8.91$, $P<0.05$).

Table 2. shows, in more detail, the distribution of autosomal inversions. The appearance of inversions nonrandomly occurred in second and third chromosomes. The frequency of inversion on the chromosome 2 were approximately 70% higher as a whole than that of chromosome 3. The distribution of the inversion frequencies on the two autosomal chromosomes shows that the former always double against the latter in all populations. Among

Table 1. The relative frequencies (%) of inversion heterozygotes from Jeonju populations of *Drosophila melanogaster*

	Inversions	Collection No. tested	'77 202	'78 205	'79 562
1st	In(X)JX		—	—	1 (0.2)
2L	In(2L)t		27(13.4)	13 (6.3)	91(16.2)
	In(2L)JA		1 (0.5)	4 (1.9)	3 (0.5)
	In(2L)JB		1 (0.5)	—	3 (0.5)
	In(2L)JC		2 (1.0)	—	3 (0.5)
	In(2L)JD		—	—	1 (0.2)
2R	In(2R)NS		28(13.9)	22(10.7)	54 (9.6)
3L	In(3L)P		—	—	19 (3.4)
	In(3L)JA		1 (0.5)	—	—
	In(3L)JB		—	1 (0.5)	—
	In(3L)JC		—	1 (0.5)	—
	In(3L)JD		—	—	1 (0.2)
3R	In(3R)P		1 (0.5)	—	1 (0.2)
	In(3R)C		—	1 (0.5)	30 (5.3)
	In(3R)MO		19 (9.4)	11 (5.4)	13 (2.3)
	In(3R)JA		—	—	1 (0.2)
	In(3R)JB		4 (2.0)	—	7 (1.2)
	In(3R)JC		3 (1.5)	—	—
	In(3R)JD		3 (1.5)	6 (2.9)	7 (1.2)

Table 2. Distribution of inversion frequencies on the left and right arms between two autosomal chromosomes.

Chromosome arms	Collection No. tested	'77 202	'78 205	'79 562
2L		30(14.9)	17 (8.3)	100(17.8)
2R		27(13.4)	22(10.7)	52 (9.2)
3L		1 (0.5)	2 (1.0)	20 (3.6)
3R		29(14.4)	18(8.8)	59(10.5)

Table 3. Frequencies of tested females carrying single or multiple inversions.

Inversions	Collection No. tested	'77 202	78' 205	'79 562
Single		59(29.2)	53(25.9)	147(26.2)
Double		10 (4.9)	2 (1.0)	39 (6.9)
Triple		3 (1.5)	—	2 (0.4)
Overlapping		1 (0.5)	—	1 (0.2)

the chromosome arms the most concentrated one in inversion frequencies was observed in the left arms of the second chromosome, while on the left arm of third chromosome the frequency was too low to assume whether random or nonrandom distribution of inversions took place, depending on the length of the chromosomes. On the other hand, the wild female flies carrying two or more inversions in heterozygous condition were preserved at nearly the same level in the three samples and their frequencies are given in Table 3.

DISCUSSION

On the inversion polymorphisms from a wild Korean population of *D. melanogaster*, the available data obtained in this experiment are given in the tables above. A total of 969 flies were examined to analyze the quantity and quality of inversion polymorphisms. Except for the fourth chromosomal, various inversions appeared on second and third chromosomes including a X-chromosomal one. The mean frequency of 38.9% for all inversions in the present work is more similar to those of the Jeonju parts of Paik's (1979) preferably than the 24% which I got in 1977 from the same area. The inversion polymorphisms in each three samples given in Table 2 shows that the Inversion (2R)NS appears most frequently, followed by In(2L)t and In(3R)MO in both samples taken in '77 and '78, while in the '79 samples the order of the most frequently occurred inversions was In(2L)t, In (2R)NS and the last was IN(3R)C which was the lowest or absent in the freuencqies in any samples given up to the '79 collections. On the contrary, In(3R)MO which had been observed in up to 30% of the total number of inversion uncovered in my other previously published work (1977) appeared almost at the same level as that of the Chungju population (Choi, 1977). However, the relative frequencies among inversions were not always uniformly consistent. One could hypothesize that predominant inversions in different countries are always a part of cosmopolitan inversions (cf. Dubinin *et al.*, 1937; Warters, 1944; Mourad and Mallah, 1960). A comparison of the frequency of inversion between the two major autosomal chromosomes shows that the proportions in the distribution of inversions were too much when to chromosome 2, as high as 7 : 3 approximately due to the lowest frequencies of (3L) inversions were especially uncomparable to other chromosome arms. Of the endemic inversions known, In(2L)JA and In(2L)JB are of interesting inversions. In(2L)JB which has an approximate breakage point of 26A-34E based on the standard chromosomal map by Bridges (1935) but would be so-called "quasi-cosmopolitan" as initially described by Paik (1979) although it has not till now had reasonable frequencies to become cosmopolitan in any geographic populations. This (2L)JB inversion has already been reported in my earlier experiment in 1977, and Paik has also discussed it by the name of In(2L)K in his publication. Probably the same inversion has already been discovered in the natural populations of Japan (Watanabe and Oshima, 1966), as well as in American populations by Stalker (1976) and in Greece by Zachropoulou (1974). On

the other hand, In(2L)JA with an approximate breakage point of 22B-26D on Bridges map may be interpreted as common endemic in the Asian Zone, at least that involving Korea and Japan. The two above-mentioned inversions would be selectively advantageous in any view point for comparison with other geographically limited endemic inversions that may either occur temporarily or be lost, in accordance with some environmental conditions.

Of the nineteen polymorphic inversions, seven of which were new and generally endemic, the remaining six endemics were published by other workers within and out of Korea. Until today, the total inversion polymorphisms reported from various wild populations of *D. melanogaster* in Korea amount to eighty different types; these are given up the same type inversions among that 27 by the author (1977, present result), 58 by Paik (1967, 1979) and 13 from the Chungju population of Choi (1977). Accordingly, the ranges of the inversion frequencies in all the Korean populations showed a variance of 20 to 60% in accordance with differences in seasonal and geographic conditions.

Conclusively, the problems such as the variety of chromosomal polymorphisms and their increasing trend day by day, the changes of polymorphisms and their frequencies according to the ecogeographical conditions and the dispersion mechanisms through various routs should closely be approached to their answer as pile up elaborate analytical data from other miscellaneous populations around the world. As well as the origin of both inversions, cosmopolitan and endemic, is so far uncertain even if several workers (Ives, 1950; Mampell, 1946; Yamaguchi and Mukai, 1974) have already suggested with respect to its inducing factors. These problems as mentioned above are the subjects for further investigation.

SUMMARY

1. A total of 969 flies were tested and 19 different inversions were found from the present samples collected three times at yearly intervals in an area.

2. Of the 19 polymorphisms, except for the six common paracentric types of cosmopolitan inversions, 13 were endemic. Among this latter group, one was X-chromosomal, 4 were on second chromosome and 8 on third chromosome.

3. Beside two overlapping inversions all the others were identified as single ones. And the inversion frequency on an average in every three samples tested was 38.9%.

4. The high distribution of the inversions appeared to the second chromosome suggests that a differential adaptive force may be present between the second and third chromosome.

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