GEOGRAPHICAL CLINE OF ALLELE FREQUENCY OF GROUP-SPECIFIC COMPONENT (GC) IN THE JAPANESE POPULATIONS: AN ANALYSIS OF DATA OBTAINED BY IMMUNOELECTROPHORESIS

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Summary An analysis of data on GC allele frequency obtained by immunoelectrophoresis adduced an evidence for the existence of geographical cline in the Japanese populations. The GC^*2 frequencies proved to be increasing gradually from north to south in Japan: the cline will be explicable by gene flow but not by natural selection.

INTRODUCTION

Hirschfeld (1959) identified the genetic polymorphism of GC: three phenotypes of GC 1, 2-1 and 2 determinable by two codominant alleles of GC^*1 and GC^*2 are observed together with several variant phenotypes (Johnson *et al.*, 1975) with the aid of immunoelectrophoresis and immunofixation electrophoresis. Data on the racial and geographical variations of GC allele frequencies have been accumulated and analyzed (Walter and Steegmüller, 1969; Mourant *et al.*, 1975, 1976).

In Japan, geographical clines of the allele frequencies have so far been clarified as to only ABO and GPT (Nei and Imaizumi, 1966; Fujita *et al.*, 1978; Ishimoto and Kuwata, 1974). According to Omoto (1978), Aoki's attempt to demonstrate a cline of GC failed. The used data, compiled by Omoto (1975a), must have lacked those from the Western Japan.

In this study the existence of the geographical cline of GC allele frequencies in Japan is demonstrated with recently published data supplemented, and furthermore the factors of occurrence of cline are discussed.

MATERIALS AND METHODS

The data on the GC allele frequency in the Japanese and the neighboring popu-

Received April 22, 1983

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lations obtained by immunoelectrophoresis were collected from the widely scattered literature.

The existence of geographical cline was demonstrated as was carried out by Nei and Imaizumi (1966) and Fujita *et al.* (1978) for ABO blood group system. The relationship was examined between the GC allele frequency and distance from Aomori, northernmost part of Honshu Island, to each prefectural capital of populations.

RESULTS AND DISCUSSION

Table 1 summarizes the distribution of GC^*2 frequency in the Japanese and the neighboring populations. Figure 1 shows the places where samples have been obtained for the examination of GC polymorphism.

The GC^*2 frequencies among the Japanese living in main islands of Japan (so-called Wajin) vary from 0.225 in Miyagi to 0.288 in Miyazaki with an average of 0.258. A test is made for homogeneity of the gene frequencies among 12 popu-

Fig. 1. Map of Japan and the neighboring countries. The numbers correspond to those in Table 1.

Table 1. GC*2 frequencies in the Japanese and neighboring populations.

Populations	Distance ^a	Number examined	GC*2 frequencies	References
Japanese				
1 Ainu		467	.250	Omoto and Harada (1972)
2 Aomori	0.00	632	.252	Kita and Murakami (1973)
3 Miyagi	0.39	570	.225	Kudo (1973)
4a Tokyo	0.74	500	.227	Omoto <i>et al.</i> (1964)
4b Tokyo	0.74	376	.225	Ishimoto <i>et al.</i> (1967)
4c Tokyo	0.74	204	.260	Ohyuki and Ikemoto (1967)
4d Tokyo	0.74	316	.255	Suzuki <i>et al.</i> (1968)
4e Tokyo	0.74	566	.261	Ikemoto <i>et al.</i> (1970)
4f Tokyo	0.74	1,962	.244	combined
5 Chiba	0.78	1,577	.248	Ishimoto <i>et al.</i> (1967)
6 Toyama	0.71	112	.259	Ohyuki and Ikemoto (1967)
7 Hokuriku	0.77	504	.246	Hayashi <i>et al.</i> (1978)
8 Gifu	1.14	1,021	.262	Suyama and Uchida (1969)
9 Mie	1.17	217	.263	Yada <i>et al.</i> (1966)
10 Tokushima	1.58	598	.268	Yada <i>et al.</i> (1974)
11 Ehime	1.70	160	.266	Shinomiya <i>et al.</i> (1978)
12 Kochi	1.66	1,089	.284	Ishizu <i>et al.</i> (1983)
13 Miyazaki	2.19	341	.288	Sugita and Takahama (1978)
14 Amami Ohshima		234	.301	Omoto and Harada (1967)
15a Okinawa		527	.288	Nakajima and Ohkura (1971)
15b Naha		204	.306	Omoto <i>et al.</i> (1973)
16a Miyako-jima		351	.249	Nakajima and Ohkura (1971)
16b Miyako-jima		163	.310	Waki (1972)
17 Yaeyama shoto		84	.369	Waki (1972)
Korean				
18a Seoul		116	.241	Omoto <i>et al.</i> (1964)
18b Seoul		122	.303	Kitchin and Bearn (1964)
19 Kyungsan		115	.278	Ohkura <i>et al.</i> (1979)
20 Kannung		114	.263	Miyashita <i>et al.</i> (1980)
Chinese				
21 North China		88	.312	Nakajima and Ohkura (1971)
22 South China		100	.275	Nakajima and Ohkura (1971)
Taiwanese				
23 Taiwan		100	.215	Nakajima and Ohkura (1971)

^a From Aomori (1,000 km).

lations with 5 data from Tokyo combined. The results show that there is a statistically significant heterogeneity ($\chi^2=24.4994$, $df=11$, $0.02 > p > 0.01$). It is also observed that the frequencies are lower in Eastern Japan than in Western Japan. The relationships between the GC^*2 frequency in each population and the distance from Aomori are plotted in Fig. 2. The correlation coefficient between the frequency and the distance is 0.83068 ($t=4.7182$, $df=10$, $p<0.001$), and the regression equation of the frequency (y) on the distance (x) is $y=0.0232x+0.2339$. These results show that the geographical clines of GC allele frequencies exist in the Japanese populations, namely the GC^*2 frequencies increase gradually towards southern localities.

The GC^*2 frequencies among the Japanese living in Ryukyu Islands (so-called Ryukuan) range in between 0.249 and 0.369, and are apparently higher than those among Wajin (Omoto *et al.*, 1973). It appears that the above-mentioned clines extend to Ryukuan populations. The neighboring populations including the Koreans and the Chinese show rather higher GC^*2 frequencies on the whole. The cline found in the Wajin may also reach the Korean and the Chinese populations along other routes.

On the other hand, GC is known to be a carrier protein of vitamin D (Daiger *et al.*, 1975). Walter and Steegmüller (1969) have reported that GC^*2 frequencies tend to decrease from north to south in the Old World. Mourant *et al.* (1976) have shown that GC^*2 frequencies are low in sunny climates and high in dull climates, and have suggested that the occurrence of such a difference is due to natural selection related to efficiency in fixing vitamin D. A geographical decrease in the GC^*2

Fig. 2. Gradient of GC^*2 allele frequency.

frequency from north to south in the Chinese populations (Nakajima and Ohkura, 1971) is well-explicable by the above hypothesis. Another explanation may be given that such a cline was formed by gene flow in past spreads of populations acquiring high GC*2 frequency in dull climates.

The findings that in Japan the GC*2 frequencies increase gradually towards sunny climates are not explicable by the natural selection. It should be thought that the occurrence of the cline directly proportioned to the mean intensity of solar radiation is due to the gene flow. Japan Islands are a branch of such migrations. This notion may be supported by the high GC*2 frequencies in the neighboring populations and by the slightly low frequency in the Ainu population, which remains relatively unaffected by the genetic component of the "later" Mongoloid populations due to their geographically peripheral position (Omoto, 1975b). Eskimos, acquiring high adaptability to cold, have high GC*2 frequencies (Mourant *et al.*, 1975).

Recently Constans and Viau (1977) succeeded in subtyping the common GC*1 allele into two subtype alleles of GC*1F and GC*1S with the aid of polyacrylamide gel isoelectric focusing followed by immunofixation with anti-GC serum. This technique provides us with further informations of the Japanese and the neighboring populations. An analysis of these data is in progress (Yuasa *et al.*, 1983).

Acknowledgment We are grateful to Ms. T. Yamaoka for her clerical assistance.

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