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Genetic Studies on Human Populations in the Goto-Islands

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INTRODUCTION

Isolated populations are one of the most suitable materials to study the genetic structure of human populations. However, there are so many difficulties to carry out the investigation. One of the points encountered in such studies is the ascertainments of ancestral family records. Fortunately, the Japanese have an official family registration system called "*Koseki*" (YANASE, 1965), and based on this system we could identify easily and correctly ancestral information retrospectively for more than one hundred years. Usually, many isolated populations studied so far are the populations isolated by geographical or socio-economical factors and composed of a relatively homogeneous structure. But in Nagasaki Prefecture, there are some isolated populations restricted by a geographical environment, and differences of socia-economical conditions divide the population into sub-populations and those differences may form characteristic structural changes among them.

To obtain some fundamental informations on the genetic structure of a Japanese isolated population, about five thousand people dwelling in two adjacent areas in the Goto-Islands, Nagasaki Prefecture, were investigated. In each area there lived three different religious groups and we could observe clear isolation concerning the material events between the groups though they showed no obvious residential separation.

ASPECTS OF THE INVESTIGATED AREA

The Goto-Islands are located in the westernmost end of Kyushu, Japan, and composed of about one-hundred islands, of which about a quarter are inhabited (Figure 1). Anciently, they had an important role as the intermediate ports between the mainlands of Japan and China, but after the 16th Century, they lost their role. They now belong administratively to Nagasaki Prefecture. Object areas of the present study are Hisaka Island (abbreviated H after this) and the Okuura area of Fukue Island (abbreviated O after this). As shown in Table 1, both areas have only about 10 percent of cultivated

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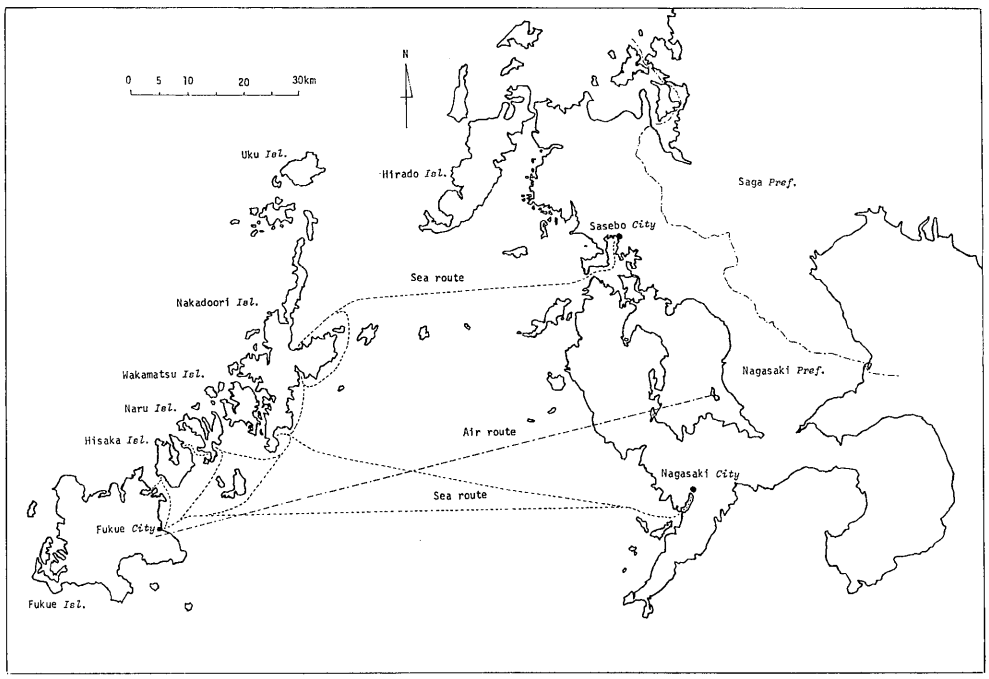

Fig. 1 North-West Part of Kyushu Showing Location of Goto-Lslands.

Table 1. The Geographical Aspect of Hisaka -jima and Fukue-jima-Okuura Areas.

Zone	Hisaka-jima	Fukue-jima-Okuura
Total	3749h	2278h
Cultivated land	365 (9.74%)	269 (11.81%)
Forest	3289 (87.73%)	1738 (76.29%)
Residential zone	95 (2.53%)	271 (11.90%)

land, and the other parts are about 80 to 90 percent waste mountains and woods infeasible to cultivate. H island has a horseshoe shape, 9.0 Km for north and south, 7.8Km for east and west directions. It has four administrative units (*cho*) and every unit is composed of two to five villages for a total of 16 villages (*buraku*). Main traffic means are small motor boats or fishing boats and they connect villages in and out of the islands.
O area is located in the northeastern part of Fukue-jima Island, the largest one in the Goto-Islands. O area has a complicated coastline and the southern part has a road which leads to Fukue-city, but in the western part they cannot go directly to adjacent villages by road but must go by means of a motor boat. Otherwise, they have to take a round-about way via Fukue-city. As in the H area, small motor boats have an important role in this area. O area has three administrative units and a total of 17 villages (Figure 2).

One of the important factors influencing a choice of spouse is the difference of

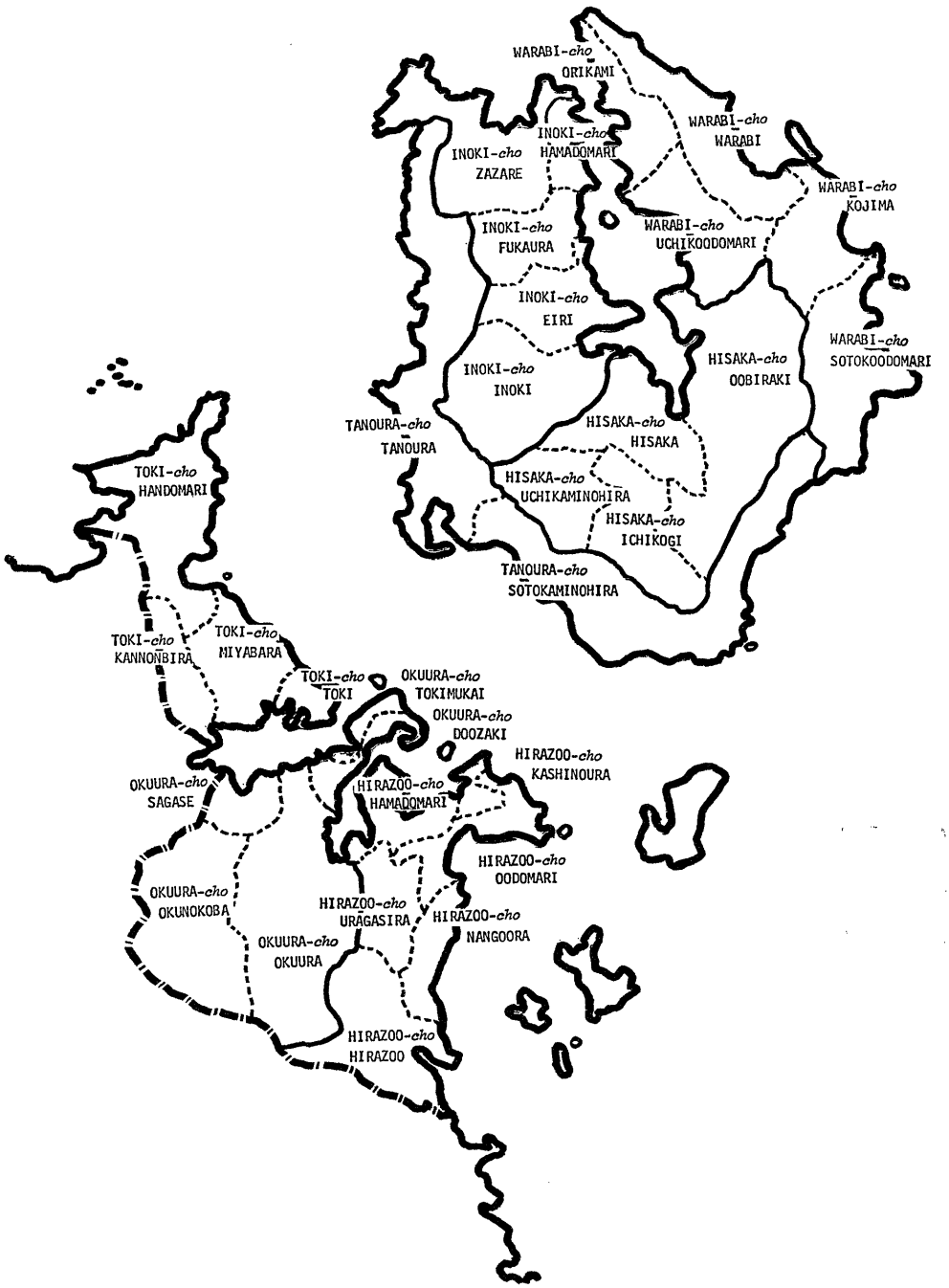

Fig. 2 Hisaka-jima and Fukue-jima-Okuura Areas Showing the Administrative Boundary. (Toki in Toki-*cho*, Okuura area, is divided into three *Buraku*, Tokisaki, Tokihana and Tokiura.)

religion they believe in. In the areas investigated there lived three religious groups, namely, Buddhist, Shintoist, and Roman Catholic and they are isolated from each other from the aspect of marriage. Buddhists have lived there for several hundred years. Christianity was introduced to Japan in 1549 and propagated mainly in northwestern Kyushu. However, in 1614 the Tokugawa shogunate prohibited and suppressed the belief of Christianity. At that time, many people moved from Kyushu to the Goto-Islands to avoid persecutions from the authorities. After that, residents of the Goto-Islands were divided roughly into two religious groups: the Buddhists who lived there originally, and the Catholics removed from the mainland of northwestern Kyushu including the people in the Goto-Islands converted from Buddhism to Catholicism. "Shintoist" has a history as follows: In about 1870, the Meiji new government guaranteed the freedom of religious belief and the people who had remained faithful to Christianity secretly to avoid suppression rebuilt the Catholic churches and came back to their church. However, some people did not go back to the church and separately continued their secret worships as before. Their external worship forms were very similar to the Shintoism for the purpose of skillfully camouflaging their beliefs to avoid severe persecution and ever since then they have been called by the name of Shintoist. Therefore, they are not the original Shintoist but the so-called "Hidden Catholics".

Consequently, three sociological sub-populations, Buddhist, Shintoist, and Catholic are found in both areas at present. Such phenomena as different religious sub-populations living in the same area but isolated from each other are observed in the Goto-Islands and in some areas of Nagasaki Prefecture, but is not the general case in Japan (KATAOKA, 1967).

Buraku (village) as the smallest unit of an area is not always occupied by any one of these religious groups but mostly is composed of two or three groups and it is not so clear for residential sectionalism (Table 2).

There is no difference between both areas in the economic state. Both have only

Table 2. Constitution of Religious Communities in *Buraku*.

Constitution	Hisaka-jima	Fukue-jima-Okuura
Buddhist community only	Fukaura, Inoki, Ichikogi, Tanoura	Tokihana, Tokiura, Tokisaki, Tokimukai, Okuura, Kashinoura
Shintoist community only		Kannonbira
Catholic community only	Sotokoodomari, Kojima, Hamadomari, Uchikaminohira	Doozaki
Buddhist and Catholic communities	Warabi*, Uchikoodomari*, Oobiraki*, Sotokaminohira***	Okunokoba*, Hirazoo*
Shintoist and Catholic communities	Orikami**	Hamadomari***, Oodomari***
Buddhist, Shintoist and Catholic communities	Zazare***, Hisaka*, Eiri**	Miyabara**, Nangoora**, Handomari***, Sagase***, Uragashira***

* Buddhists are predominant. ** Shintoists are predominant.
*** Catholics are predominant.

10 percent cultivated land and being surrounded by sea many people engage in small-scale fishery. About 63 percent of all households belong to half-fishery and half-farming.

COMPOSITION OF THE POPULATION EXAMINED

Based on the resident cards of Fukue-city offices as of August 1, 1969, the population of H area is 2,128 (1,034 males and 1,094 females) and it has 472 households, 4.5 mean family members, and 0.57 per hectare population density. O area has 2,951 population as of November 1, 1969 (1,486 males and 1,465 females), 653 households, 4.5 mean family members, the same as H area family size, but the population density is 1.30 per hectare and this is more than twice that of the H area (Table 3).

Mean ages of the residents are 31.4 years old in males and 35.1 years in females of the H area and 30.2 years in males and 33.8 years in females of the O area. Age distribution patterns are almost the same in both areas as shown in Figure 3. The part of age bracket 21 to 30 years old is reduced markedly than the overall Japanese value of about 9.5 percent. This selective reduction means the flow out of young laborers to the central city districts of Japan with a rapid economical growth on a nation-wide scale after the last war.

The H area has two primary-, one middle-, and one jointed primary- and middle-schools. One primary school has its branch. The O area has two primary schools, in which, one has its branch, and one middle-school. The number of pupils in each school is shown in Table 4.

METHOD OF PEDIGREE INVESTIGATION

There are two methods to investigate a pedigree for the genetic study. One is based on hearings from propositi, their families, or their acquaintances, directly or indirectly by a questionnaire. Another method is based on the official records such as residential registration systems or personal records. In Japan, we have an official family registration system called "*Koseki*" dating from 1871. We can now use the *Koseki* system established in 1886 and after that there were some minor changes in the system. In 1948 a new *Koseki* system was established, in which a married couple is a unit of registration. Contrary to this, the old system adopted a system including the whole family as a unit. When we attempt to identify our ancestors by *Koseki*, it is impossible to recognize the parents of anyone who died before 1886 except in special cases having archaic records. In addition, there are some cases in which *Koseki* records were destroyed by fire during the World War II or the Kanto earthquake. Thus, there are limitations to get information from *Koseki*, but usually concerning the youngest generation one can identify the ancestors over four or five generations.

Compared to the first method based on one's remembrance, it can be said that the second method using the *Koseki* system may be very reliable and the most valuable

Table 3. Numbers of Households and Persons in Hisaka-jima and Fukue-jima-Okuura Areas Classified into Administrative Units and Religious Groups.

Area Administrative unit (*cho*) *Buraku*	Buddhist		Shintoist		Catholic		Total		
	H	P	H	P	H	P	H	P	
Hisaka-jima	358	1498	32	168	79	436	472	2128	(26)
Warabi-*cho*	87	331	4	17	21	94	112	451	(9)
Orikami	0	0	4	17	1	2	5	19	
Warabi	84	318	0	0	2	6	86	333	(9)
Sotokoodomari	0	0	0	0	12	49	12	49	
Uchikoodomari	3	13	0	0	2	10	5	23	
Kojima	0	0	0	0	4	27	4	27	
Inoki-*cho*	72	329	27	145	16	81	115	557	(2)
Zazare	8	32	7	35	7	39	22	106	
Hamadomari	0	0	0	0	5	25	5	25	
Fukaura	19	74	0	0	0	0	19	74	
Eiri	1	4	20	110	4	17	25	133	(2)
Inoki	44	219	0	0	0	0	44	219	
Hisaka-*cho*	152	668	1	6	20	126	175	813	(13)
Hisaka	80	329	1	6	1	9	84	353	(9)
Oobiraki	34	164	0	0	5	27	39	194	(3)
Ichikogi	38	175	0	0	0	0	38	175	
Uchikaminohira	0	0	0	0	14	90	14	91	(1)
Tanoura-*cho*	47	170	0	0	22	135	70	307	(2)
Tanoura	45	162	0	0	0	0	46	164	(2)
Sotokaminohira	2	8	0	0	22	135	24	143	
Fukue-jima-Okuura	319	1300	126	574	204	1068	653	2951	(9)
Toki-*cho*	115	448	62	267	30	169	210	891	(7)
Handomari	2	6	5	24	12	67	19	97	
Kannonbira	0	0	15	49	0	0	15	49	
Miyabara	3	13	42	194	18	102	66	316	(7)
Tokihana	41	164	0	0	0	0	41	164	
Tokiura	31	113	0	0	0	0	31	113	
Tokisaki	38	152	0	0	0	0	38	152	
Okuura-*cho*	83	338	1	1	30	153	114	492	
Tokimukai	23	108	0	0	0	0	23	108	
Doozaki	0	0	0	0	17	85	17	85	
Sagase	1	2	1	1	12	65	14	68	
Okunokoba	3	13	0	0	1	3	4	16	
Okuura	56	215	0	0	0	0	56	215	
Hirazoo-*cho*	121	514	63	306	144	746	329	1568	(2)
Hamadomari	0	0	4	16	20	101	25	119	(2)
Oodomari	0	0	13	75	35	168	48	243	
Kashinoura	77	333	0	0	0	0	77	333	
Uragashira	3	12	5	26	80	439	88	477	
Nangoora	1	3	41	189	5	24	47	216	
Hirazoo	40	166	0	0	4	14	44	180	
Total	677	2798	158	742	283	1504	1125	5079	(35)

H: Number of household. P: Number of person.
( ): Number of person whose religious category was uncertain.

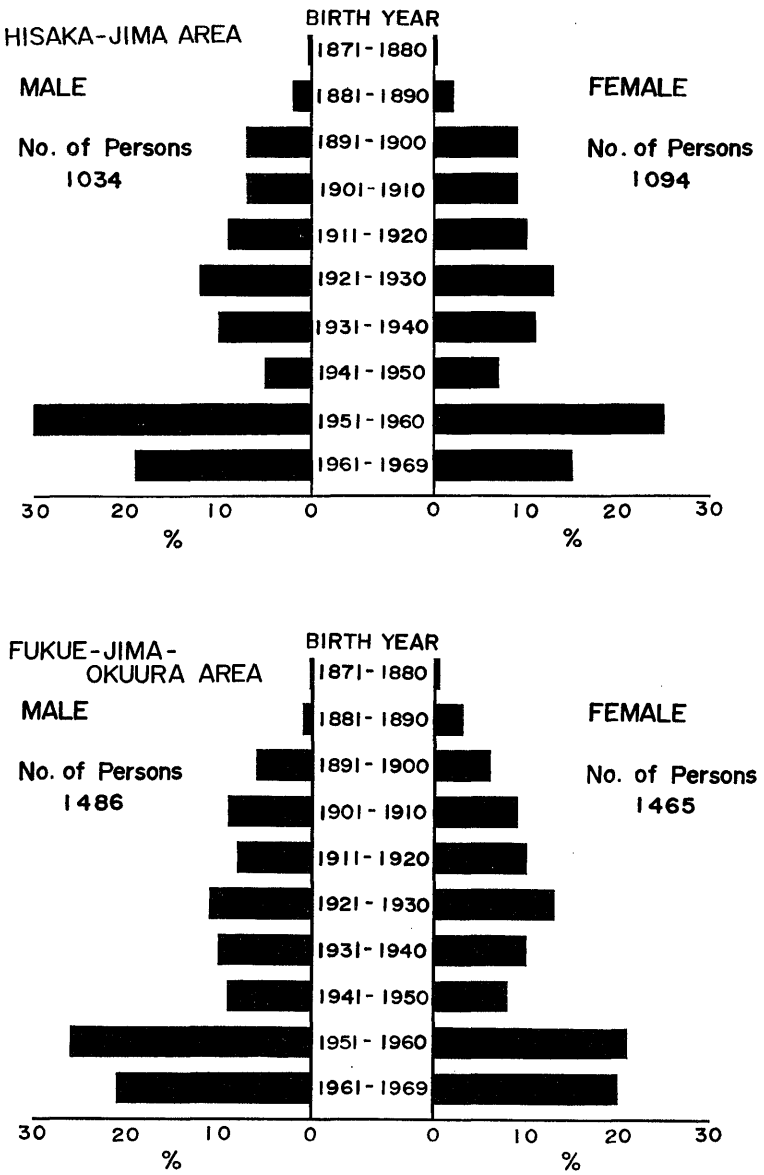

Fig. 3. Distributions of Birth Year among Residents in Hisaka-jima and Fukue-jima-Okuura Areas.

Table 4. Number of Pupils in Hisaka-jima and Fukue-jima-Okuura Areas.

Name of school	No. of pupils
Hisaka-jima area	530
Tanoura Primary School	47
Hisaka Primary School	205
Hisaka Primary School, Zazare Branch	14
Hisaka Middle School	158
Warabi Primary and Middle School	106
Fukue-jima-Okuura area	721
Toki Primary School	94
Toki Primary School, Handomari Branch	19
Okuura Primary School	357
Okuura Middle School	251
Total	1251

one (**YANASE**, 1962, 1965). As described before, the present *Koseki* system is formed with a married couple and their child(ren) as a unit. But in the *Koseki* system formed before 1948, many couples over many generations were recorded in one unit. *Koseki* has registered each member's data from birth to death in relation to the other members. In the present study we used the *Koseki* formed after 1887. First of all, based on the resident registration records and the *Koseki* records, it has been established that the number of married persons are 2,449 (male 1,087; female 1,362). It includes a spouse who has a common-low relationship. From those people we confirmed 1,951 couples and detailed distribution numbers classified by the administrative units and by the religious groups as shown in Table 5. Distributions of couple's number are in proportion to the population of each religious group. Accordingly, there are great differences in the distribution between both areas. In the H area, Buddhist couples take up three quarters and the rest are at the rate of two and one for the Catholic and the Shintoist. In the O area, half of the couples are Buddhist and the other half are at the rate of three and two for the Catholic and Shintoist. For a pedigree, the following items are inquired into the *Koseki*: (1) proband couple; name, sex, birthplace and birthdate, present and permanent addresses, marriage date, end date of marriage for those who are not married now, and the reason for its end, by divorce or death of the spouse, (2) brothers and sisters of the couple; name, sex, birth order, birthdate, date of death if deceased, married or unmarried, permanent address, birthplace, and (3) children of the couple; name, sex, birth order, birthdate, date of death if deceased, permanent address, birthplace. Date on ancestors of a couple are collected so far as we could follow up retrospectively.

A system to record the birthplace in *Koseki* was enacted in 1914. So, we could not know from *Koseki* records the birthplace of those bornbefore that time.

In Japan, people are generally inclined to establish their permanent address within their resident area, especially those in non-urban or isolated populations. Table 6 shows the location of permanent addresses for both area residents. More than 90 percent of residents have their permanent dress in their resident area.

Table 5-1. Number of Married Persons and Couples.

Area Administrative unit (*cho*)	Men	Women	Couples
Hisaka-jima	468	577	662
Warabi	99	128	143
Inoki	126	147	176
Hisaka	180	226	254
Tanoura	63	76	89
Fukue-jima-Okuura	619	785	929
Toki	203	262	297
Okuura	112	129	162
Hirazoo	304	394	470
Total	1087	1362	1591

Table 5-2. Distribution of Couples Classified by Religious Groups.

Religious group	Hisaka-jima area		Fukue-jima-Okuura area		Total	
	No. of couples	%	No. of couples	%	No. of couples	%
Buddhist	501	*75.68*	456	*49.09*	957	*60.15*
Shintoist	56	*8.46*	178	*19.16*	234	*14.71*
Catholic	104	*15.71*	291	*31.32*	395	*24.83*
Unknown	1	*0.15*	4	*0.43*	5	*0.31*

$x^2 = 114.48$ d.f. $= 3$ $P < 0.005$

Table 6. Distribution of Permanent Address.

Location of permanent address	Residents of Hisaka-jima area		Residents of Fukue-jima-Okuura area		Pooled	
	No. of persons	%	No. of persons	%	No. of persons	%
Within Residential Area	1935	*90.93*	2833	*96.00*	4768	*93.88*
Within Goto-Islands (Excluding Residential Area)	128	*6.02*	59	*2.00*	187	*3.68*
Within Nagasaki-Prefecture (Excluding Goto-Islands)	41	*1.93*	21	*0.71*	62	*1.*
Within Kyushu-District (Excluding Nagasaki-Prefecture)	12	*0.56*	27	*0.91*	39	*0.77*
Others	12	*0.56*	11	*0.37*	23	*0.45*
Total	2128		2951		5079	

RESULTS OF PEDIGREE INVESTIGATION

Extent of retrospective ancestral survey: When we do a pedigree investigation based on the *Koseki* data, there are some problems concerning the extent of the retrospective ancestral survey. First of all, it is impossible to ascertain from the *Koseki* the parents of any ancestors who died before 1886. Consequently, when we survey a population which has a heterogeneous age bracket, a limit of ancestral ascertainment is very variable from person to person. Younger people have a high retrospective data record and the older have a lower degree. Secondly, the problem is a case of no description concerning the parents. Most cases concern an illegitimate child whose father's name is unknown, and we cannot follow up the paternal ancestors anymore. Of 5,079 residents in both areas 66 persons (1.30 percent) are unknown for their fathers, and one for both parents. The third point is the case of loss of records or an unclear description of the *Koseki* account. These facts inevitably lowered the possibility to detect the common ancestors at a survey of consanguineous marriages. So without some correction, a frequency of consanguineous marriage and its degree obtained are underestimated from the real one (TANAKA, 1977; YANASE, 1966). Figure 4 shows the degree of known ancestral proportion in our survey. The older the birth year the lower the proportion of ancestors detected. These deteriorations are not so remarkable for the people who were born in the last 20 years and there were no differences observed until P–3 generations and in the latest 50 years until P–2 generations for the degree of identification, but about the

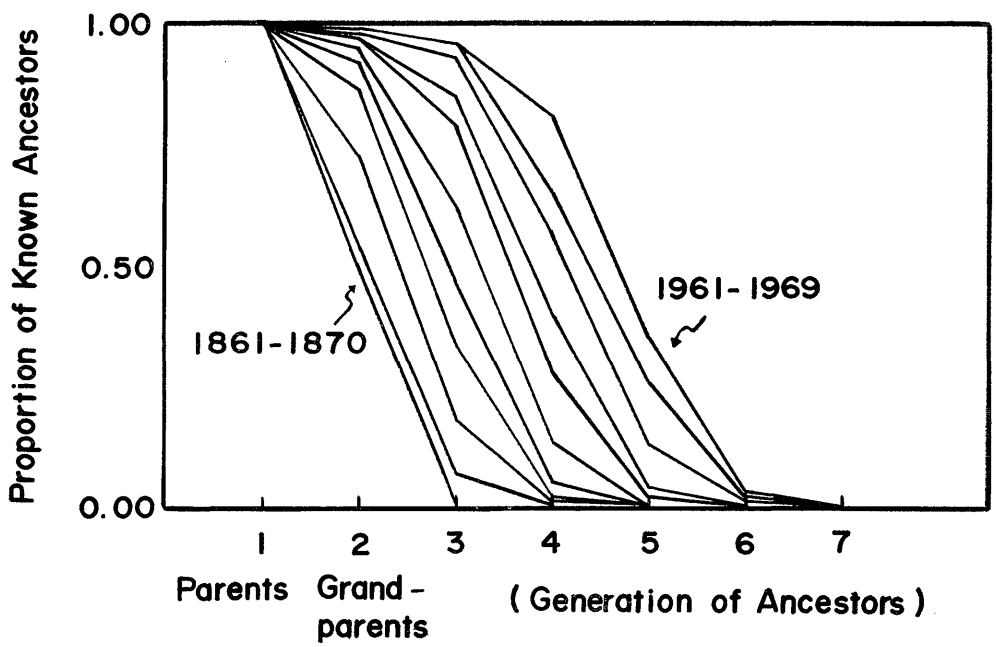

Fig. 4. Proportion of Known Ancestors. Persons Born in the Year 1861–1969.

ancestors after those generations differences of identification are rapidly enlarged. Thus we have to estimate the lost frequency and degree of consanguineous marriages due to the unidentified ancestors.

Frequency of consanguineous marriages: Starting with 1,591 couples we have carried out our pedigree investigation. It can be found that in the H area, 154 couples out of 662 (23.26 percent), and in the O area 138 couples out of 929 (14.85 percent) are consanguineous marriages. Clearly the rate is higher in the H area as compared with the O area. Table 7 shows the sorts of consanguineous marriages classified into religious

Table 7. Distribution of Consanguineous Marriages among the Religious Communities.

Consanguinity	Religious Communities									
	Buddhist		Shintoist		Catholic		Unknown		Total	
	H*	O**	H	O	H	O	H	O	H	O
UN	0	0	1	0	0	0	0	0	1	0
1C	43	24	5	12	1	2	0	0	49	38
D1C	3	2	0	0	0	0	0	0	3	2
1C+2C	9	5	0	5	0	2	0	0	9	12
1C+D2C	2	0	0	0	0	0	0	0	2	0
1C+2C+$2^1/_2$C	1	0	0	1	0	0	0	0	1	1
1C+2C+D$2^1/_2$C	1	0	0	0	0	0	0	0	1	0
1C+2C+3C	0	1	0	0	0	0	0	0	0	1
1C+$2^1/_2$C	0	0	0	1	0	0	0	0	0	1
1C+T3C	0	0	0	1	0	0	0	0	0	1
$1^1/_2$C	19	3	4	4	0	3	0	0	23	10
D$1^1/_2$C	1	1	0	0	0	0	0	0	1	1
D$1^1/_2$C+$2^1/_2$C	1	0	0	0	0	0	0	0	1	0
$1^1/_2$C+2C	0	0	0	0	0	2	0	0	0	2
$1^1/_2$C+$2^1/_2$C	1	1	0	0	0	1	0	0	1	2
$1^1/_2$C+3C	0	0	0	1	0	0	0	0	0	1
2C	18	8	4	11	7	10	0	1	29	30
D2C	4	1	0	2	0	5	0	0	4	8
2C+$2^1/_2$C	4	0	0	2	0	0	0	0	4	2
2C+3C	1	0	0	1	1	0	0	0	2	1
$2^1/_2$C	10	2	3	1	1	12	0	0	14	15
D$2^1/_2$C	1	0	1	1	0	0	0	0	2	1
T$2^1/_2$C	0	0	0	0	0	1	0	0	0	1
3C	2	2	0	2	3	4	0	0	5	8
D3C	1	0	0	0	0	0	0	0	1	0
T3C	1	0	0	0	0	0	0	0	1	0
Unrelated	378	406	38	133	91	249	1	3	508	791
Total	501	456	56	178	104	291	1	4	662	929

H*: Hisaka-jima area. O**: Fukue-jima-Okuura area. UN; Uncle-niece marriage.
1C; First cousin marriage. $1^1/_2$C; First cousin once removed marriage.
2C; Second cousin marrage. $2^1/_2$C; Second cousin once removed marriage.
3C; Third cousin marriage. D-C; Double……cousin marriage.
T-C; Triple……cousin marriage.

Table 8. Frequency of Consanguineous Marriages in Three Religious Communities.

Community	Hisaka-jima area	Fukue-jima-Okuura area	Both area
Buddhist	24.55%	10.96%	18.08%
Shintoist	32.14	25.28	26.92
Catholic	12.50	14.43	13.92

groups. Frequencies of consanguineous marriages are highest in the Shintoist group in both areas (Table 8).

TANAKA (1971, 1977) has discussed the effect of incomplete inquiry on the estimation of frequency of counsanguineous marriages and has shown a formula to calculate the frequency of first-cousin marriages:

$$c=\frac{M}{n_0+\frac{n_1}{2}+\frac{n_2}{4}}$$

where M is a number of cousin marriages ascertained from pedigrees, n_0, n_1, and n_2 are the numbers of couples inquired, n_0 is a number of couples whose four grandparents are ascertained from the *Koseki*, n_1 is a number of couples with three grandparents ascertained, n_2 is a number of couples of whom one of the husband's and one of the wife's grandparents are ascertained.

The number of single first-cousin marriages in the H area is 49 couples and in addition when another first-cousin marriage with the other consanguinity added, the number of M becomes 65 couples and the frequency is 9.88 percent of 658 couples except that it could not be ascertained as a first-cousin marriage or not. From the pedigree values of n_0, n_1, and n_2 are 623, 34, and 1, respectively. Thus the frequency of corrected first-cousin marriages in the H area becomes 10.15 percent. Single first-cousin marriages in the O area are 38 couples and adding to the other complex first-cousin marriages, all first-cousin marriages are 56 couples (6.40 percent). The numbers of n_0, n_1, and n_2 are 767, 102, and 6 in each, and the corrected frequency of first-cousin marriage become 6.83 percent. Accordingly, comparing the first-cousin marriage frequencies in both areas, the H area has shown a higher value than the O area.

Estimation of coefficient of parentage: The degree of inbreeding shown in this paper is expressed as a coefficient of parentage (Coefficient de Parenté) F introduced by MALÉCOT (1948). F is defined between two specified individuals in a population, and an average coefficient of parentage of a population is shown as $\alpha=\Sigma F/N$, where N is the total marriage number. The coefficient of parentage is equal to the inbreeding coefficient of a child from two specified individuals (WRIGHT and MCPHEE, 1925).

We have not found such a case of consaguineous marriage that the common ancestor is one party, male or female, for example the half-first-cousin marriage. Always we have found the common ancestors as a couple. And in the pedigree, when a common ancestor is male or female only, it shows that we could not find out one of the spouse. Therefore, when one side of the ancestor couple is common and the other side is not identified, we calculate the coefficient of parentage as considered the couple is the common

ancestor. In our survey, the possible limit of retrospective inquiry is as far as 1837, but the real bounds of ancestors used to calculate the coefficient of parentage are from P_1 (parents of the couple) to P_4 generations.

In a survey of consanguinity, it is necessary to extract enough samples from an objective population and that factors such as age, etc., are homogeneous. Especially to estimate the degree of consaguineous marriages, it requires to equaize the degree of retrospective inquiry to ancestors which is influenced by the age of propositi. Such equalization is possible when we study a great population such as the urban type. However, it is very difficult when we investigate a small isolated population. In the present study, we made a pedigree chart of all marriages in both areas. Consequently, retrospec tive degrees of pedigree surveys are different from the age of propositi, and the coefficient of parentage calculated from the degree of observed consanguineous marriage is necessary to correct based on the proportion of unidentified ancestors. For this purpose, we carried out a correction of coefficient of parentage referred to the method described by YANASE (1966). As shown in Figure 5, ancestral generation of husband side Pa may have certain number of ancestral couples common to the ancestral generation of wife Pa, $P_{(a+1)}$, and $P_{(a-1)}$. For example, when we consider an ancestral couple in Pa generation, there are possibilities to exist common ancestors between the ancestor couples of husband and uife in this Pa generation, between the ancestral couples of Pa and $P_{(a-1)}$ generations, and further between Pa and $P_{(a+1)}$ generations. When all ancestral couples are ascertained, the number of relationship L is expressed as shown in Table 9. If we assume the number of ascertained ancestral couples in husband and wife sides as va, ma; v_{a-1}, m_{a-1}; and v_{a+1}, m_{a+1}, the expected coefficient of parentage (F exp) in the case of complete ascertainment is given by the formula of the last row of Table 9 from the observed coefficient of parentage (F). In the table, Fa, $Fa._{(a-1)}$, $F_{(a-1)}.a$, $Fa._{(a+1)}$, and $F_{(a+1)}.a$ are observed coefficients of parentage based on the number of common ancestral

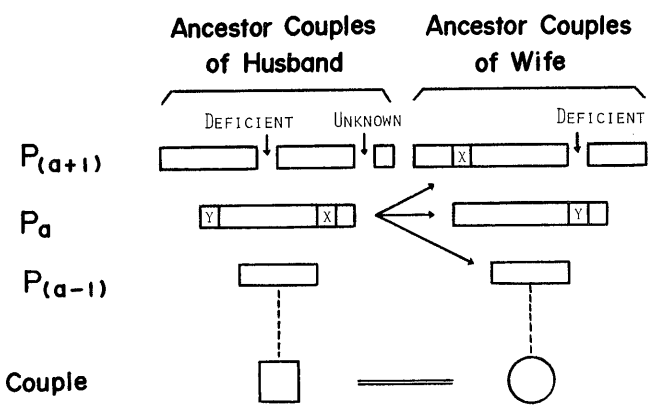

Fig. 5. A Diagrammatic Representation of the Procedure for Correcting Degree of Inbreeding. Parts Marked with X or Y Indicate Common Ancestral Couples Identified among the Known Couples in the Pa th and P (a+1) th Generation.

Table 9. Procedures for Correcting Coefficient of Parentage with the Degree of Retrospective Follow-up the Ancestral Couples (See text in details).

Combination between husband's and wife's ancestral couples		No. of relationship in full ascertainment of ancestral couples	Observed coefficient of parentage	Final coefficient of parentage after correction
Husband	Wife	(L)	(F)	(F_{exp})
Pa	Pa	$2^{2(a-1)}$	Fa	$\frac{2^{2(a-1)} \times N}{\Sigma_{va \cdot ma}} \times Fa$
Pa	P(a−1)	2^{2a-3}	$F_{a\cdot(a-1)}$	$\frac{2^{2a-3} \times N}{\Sigma_{va \cdot ma-1}} \times F_{a\cdot(a-1)}$
Pa	P(a+1)	2^{2a-1}	$F_{a\cdot(a+1)}$	$\frac{2^{2a-1} \times N}{\Sigma_{va \cdot ma+1}} \times F_{a\cdot(a+1)}$

couples found among Pa generation, between Pa and $P_{(a-1)}$ generations of husband or wife, and between Pa and $P_{(a+1)}$ generations of husband or wife, and N is a number of marriage. In Table 10 is shown the method to calculate the expected coefficient of parentage (F exp) in the surveyed area and the results obtained. The mean coefficient of parentage of the whole population obtained from the pedigrees is 0.007444, and is corrected as 0.009459 by the method described above. Thus, the mean coefficient of parentage of population lost by the unidentified ancestors becomes 0.002015, and so by the correction the observed value is increased about 27 percent.

Table 10. Procedures for Correcting Coefficient of Parentage. Pooled Data from Hisaka-jima and Fukue-jima-Okuura Areas.

Combination between husband's and wife's ancestral couples		No. of relationship in full ascertainment of the ancestral couples		No. of observed relationships between known ancestral couples	Indication of expected increment in coefficient of parentage	No. of common ancestral couples ascertained	Observed coefficient of parentage	Final coefficient of parentage after correction
Husband	Wife	L	$N \times L$ (N=1591)	Σ (v×m)	$\frac{N \times L}{\Sigma(v+m)}$		($\times 10^{-2}$)	($\times 10^{-2}$)
P_1	P_2	2	3182	3011	1.0568	1	0.007857	0.008303
P_2	P_1	2	3182	3067	1.0375	0	0.0	0.0
P_2	P_2	4	6364	5924	1.0743	126	0.494972	0.531748
P_2	P_3	8	12728	10133	1.2561	28	0.054997	0.069082
P_3	P_2	8	12728	9716	1.3100	17	0.033391	0.043742
P_3	P_3	16	25456	17366	1.4659	123	0.120797	0.177076
P_3	P_4	32	50912	16532	3.0796	35	0.017187	0.052929
P_4	P_3	32	50912	15424	3.3008	18	0.008839	0.029176
P_4	P_4	64	101824	19184	5.3078	26	0.006384	0.033885
Total							0.744424	0.945941

RESULTS OF ANALYSIS ON THE CONSANGUINEOUS MARRIAGE

In Japan the degree of consanguineous marriages is remarkably different in the populations studied. SCHULL *et al.* (1958) reported the frequencies of cousin marriage in Hiroshima, Kure, and Nagasaki as 3.38%, 3.90%, and 4.81%, respectively. KOMAI and TANAKA (1972) studied the population of Shizuoka Prefecture and obtained the frequency of cousin marriage as 4.38%. It has been reported by IMAIZUMI *et al.* (1975) that the mean frequency of all Japanese cousin marriage is 2.13%. Comparing these values with those of European populations, Japanese populations showed very high value (CAVALLI-SFORZA and BODMER, 1971). Further, some populations which have comparatively high degree of isolation showed the frequency more than ten times of the mean value of all Japan (YANASE *et al.* 1973). These facts mean that there are large regional differences in the frequency of consanguineous marriages.

As described before, the number of couples in the H area is 662 and in the O area is 929. Frequency of consanguineous marriages in the H area is 23.26% and 14.85% in the O area, and it became clear that the H area has a higher value than the O area.

Table 11. Dtstribution of Marital Numbers Classifiedby the Degree of Coefficient of Parentage and Religious Groups.
H: Hisaka-jima Area. O: Fukue-jima-Okuura Area.

Coefficient of Parentage (F)		Religious Groups: Buddhist H	Buddhist O	Shintoist H	Shintoist O	Catholic H	Catholic O	Unknown H	Unknown O	Total H	Total O
0.125	Degree corresponding to uncle-niece	3	2	1	0	0	0	0	0	4	2
0.09375		3	0	0	0	0	0	0	0	3	0
0.0859375		1	0	0	1	0	0	0	0	1	1
0.08203125		0	1	0	0	0	0	0	0	0	1
0.078125		9	5	0	5	0	2	0	0	9	12
0.07421875		0	0	0	1	0	0	0	0	0	1
0.0703125		1	0	0	1	0	0	0	0	1	1
0.0625	Degree corresponding to 1st cousin	44	25	5	12	1	2	0	0	50	39
0.046875		0	0	0	0	0	2	0	0	0	2
0.0390625		1	1	0	0	0	1	0	0	1	2
0.03515625		0	0	0	1	0	0	0	0	0	1
0.03125	Degree corresponding to 1st cousin once removed	23	4	4	6	0	8	0	0	27	18
0.0234375		4	0	0	2	0	1	0	0	4	3
0.01953125		1	0	0	1	1	0	0	0	2	1
0.015625	Degree corresponding to 2nd cousin	19	8	5	12	7	10	0	1	31	31
0.01171875		1	0	0	0	0	0	0	0	1	0
0.0078125	Degree corresponding to 2nd cousin once moved	11	2	3	1	1	12	0	0	15	15
0.00390625	Degree corresponding to 3rd cousin	2	2	0	2	3	4	0	0	5	8
0.0	No relation	378	406	38	133	91	249	1	3	508	791
Total		501	456	56	178	104	291	1	4	662	929

Table 12. Number of Single Cousin Marriages (SC) and Double Cousin Marriages (DC) in Hisaka-jima and Fukue-jima-Okuura Areas.

Religious community	Hisaka-jima		Fukue-jima-Okuura		Total	
	SC	DC	SC	DC	SC	DC
Buddhist	92	31	39	11	131	42
Shintoist	17	1	30	15	47	16
Catholic	12	1	31	11	43	12
Unknown	0	0	1	0	1	0
Total	121	33	101	37	222	70

Marital numbers classified by the degree of coefficient of parentage and by religious groups are shown in Table 11. Based on the religious groups, frequencies of consanguineous marriages are for the Buddhist, 18.08%, the Shintoist, 26.92%, and the Catholic 13.92%, thus the Shintoist shows the highest value, especially in the H area they have the value as high as 32.14% (Table 8). This suggests that the isolated degree of the Shintoist population is highest because of the population size being smaller than the other two and originating from their unusual socio-religious customs.

According to YANASE (1966) there exists a complex biological relationship in the high degree of isolated populations, and he pointed out that the rate of single cousin marriage was reduced in these populations because of the increase of double consanguineous marriages. Table 12 shows the number of single- and double-cousin marriages in both areas and religious groups. The number includes first-, second-, and third-cousin marriages, and those cousin-once-removed marriages. Proportions of double-cousin marriages to the all-cousin marriages are 21.43% in the H area, and 26.81% in the O area. Based on those values, in spite of their geographical environment, it suggests that the O area has a higher degree of isolation than the H area. On the other hand, population size of the Shintoist in the H area is very small as compared with the other religious groups, and despite its highest frequency of consanguineous marriages, 32.14%, it shows a low frequency of double-cousin marriages as 5.56%. The reason is that the population size is too small to maintain and established isolated population as in the O area's Shintoist, and in fact there are comparatively many marriages between the Shintoist groups in neighboring islands.

EFFECT OF GEOGRAPHICAL AND SOCIOLOGICAL FACTORS ON THE CONSANGUINEOUS MARRIAGE

Frequency of consanguineous marriage is influenced remarkably by various factors such as geographical and socio-economical ones. A size of population is also an affect on the frequency and the types of consanguineous marriages. It is very difficult to separate the factors respectively. Degree of isolation and population size affect each other and form a more complex state.

Another factor that effects the frequency of consanguineous marriage is the social customs. Usually in Japanese populations, they have no customs to avoid by compulsion a consanguineous marriage except for the legal prohibition of within third degree nor to encourage it as observed in some countries. However, in the Catholic population, they avoid clearly the near-related consanguineous marriages based on religious restriction. According to the survey of SCHULL *et al.* (1962), residents of Kuroshima Island in Nagasaki Prefecture are divided into two religious groups, Buddhist and Catholic, and they observed the diffirences of frequency of cousin marriages and mean coefficient of parentage between the two populations. Namely, while the rate of cousin marriage to all marriages is 10.20% in Buddhist populations, Catholic populations have shown the rate as 3.17%. And the mean coefficients of parentages are 0.01809 in the former and 0.00578 in the latter. The greater parts of this difference are due to the restriction of the near-related consanguineous marriage based on the religious standpoint in the Catholics.

When a population survey to compare a degree of consanguinity is attempted, it is necessary to group the characteristics of subpopulations within the area such as the Goto Islands, where so many Catholic people live. There exists a clear difference of proportion of subpopulations between the H and O areas. Table 13 shows the average coefficients of parentage (α) of each area and each religious group based on the data from Table 11. This average population coefficient of parentage (α) is calculated from the next formula.

$$\alpha=\frac{1}{N}\Sigma\ (n_1 \cdot F_1 + n_2 \cdot F_2 + \ldots\ldots),$$

where N is the marital number of each population, F_1, F_2, ...•. are coefficients of parentage in accordance with the various degrees of consanguinity, and n_1, n_2, ... are marital numbers having coefficient of parentage F_1, F_2, ... Expected average population coefficient of parentage (α exp) is a value corrected by the degree of retrospectivity on ancestors.

As observed in the table, the α value of the H area is higher than the O area and it suggests that there exists a geographical effect on the consanguinity. Further, the highest average coefficient of parentage is observed in the Shintoist population in the H area. In the O area also the Shintoist shows the highest value. The Buddhist population

Table 13. Average Coefficient of Parentage.

Religious group	Hisaka-jima		Fukue-jima-Okuura		Average	
	(α)	(α_{exp})	(α)	(α_{exp})	(α)	(α_{exp})
Buddhist	0.011056	0.012798	0.005697	0.007327	0.008502	0.010467
Shintoist	0.011858	0.014476	0.010468	0.013418	0.010801	0.013710
Catholic	0.002028	0.002783	0.003275	0.005327	0.002947	0.004565
Unknown			0.003906	0.005435	0.003125	0.005435
Average	0.009689	0.011342	0.005845	0.007993	0.007444	0.009459

in the H area has shown almost the same value as the Shintoist, but in the O area, the Buddhist has clearly a low value, and it could be explained by the reason that the degree of migration of the Buddhist is higher in the O area than in the H area. In the Catholic populations, values are clearly lower than the other two populations, and this may be due to the religious restriction of Catholicism on consanguinity as described before.

In the survey of consanguineous marriages carried out on Hirado Island populations, Nagasaki Prefecture, by SCHULL *et al.* (1968, 1970), the same tendency is observed. Both the frequency of consanguineous marriage and the average coefficient of parentage are highest in the Hidden Catholic, then the Buddhist, and the catholic is the lowest. A population which has a religion as the common base seems to be formed as an isolated subpopulation from the other religious groups. A report of SCHULL *et al.* (1970) has shown the result that the marriages between the different religious groups are very low as 97 among 10,379 couples, or 0.93%. As observed in Table 13, the highest average coefficient of parentage shown in the Shintoist population may be due to the reasons that they are a religious group having a special form and the size of population is very small as compared with the other groups. As described before, this may be conjectured that the Shintoist has the highest frequency of double-cousin marriage and shows very high degree of isolation.

Table 14 shows the frequency of consanguineous marriage and average coefficient of parentage in each administrative unit (*cho*). The administrative units which show the highest average coefficient of parentage are Hisaka *cho* in the H area and Okuura *cho* in the O area. When we compared the unit populations, it is easy to suppose that the difference of the average coefficients of parentage between the *cho* units is dependent on the proportion of religious groups. In the case of the H area, the frequency of marital numbers except the Catholics who avoid marriages between close relatives is 87.14% as compared with the mean area value of 84.29%. On the other hand, in Okuura *cho*, 71.94% of all marriages are non-Catholics and the whole O area value is 68.68%. However,

Table 14. Number of Consanguineous Marriage Coefficient of Parentage in Each Administrative Unit (*cho*).

Cho	Number of marriage	Number of consanguineous marriage		Observed coefficient of parentage	Coefficient of parentage after correction
Hisaka-jima					
Warabi	143	37	*25.87%*	0.009752	0.011562
Inoki	176	39	*22.16*	0.007813	0.009505
Hisaka	254	64	*25.20*	0.013057	0.014987
Tanoura	89	14	*15.73*	0.003687	0.004442
Fukue-jima-Okuura					
Toki	297	43	*14.48*	0.005235	0.007419
Okuura	162	23	*14.20*	0.008102	0.010196
Hirazoo	470	72	*15.32*	0.005452	0.007593

Table 15. Frequency of First Cousin Marriages among Administrative Units and Religious Groups Divided with Non-Catholic and Catholic populations.

Area	Non-Catholic population		Catholic population	
Administrative unit (*cho*)	No. of marriage	No. of first cousin marriage	No. of marriage	No. of first cousin marriage
Hisaka-jima	534	63 (3) *12.36%*	97	1 *1.03%*
Warabi	113	13 *11.50*	21	0
Inoki	149	11 *7.38*	20	0
Hisaka	210	37 (3) *19.05*	31	1 *3.23*
Tanoura	62	2 *3.23*	25	0
Fukue-jima-Okuura	533	51 (2) *9.94*	267	4 *1.50*
Toki	218	14 *6.42*	43	1 *2.33*
Okuura	100	15 (2) *17.00*	39	0
Hirazoo	215	22 *10.23*	185	3 *1.62*

Numbers in parentheses are double first cousin.

it seems difficult to explain the observed increases of average coefficient of parentage more than 34.76% and 38.61% in those of each area due to the difference of the religious group components. Table 15 shows the frequency of first-cousin marriages among populations in both areas and the Catholics and non-Catholic religious groups. Hisaka *cho* and Okuura *cho* have clearly a higher frequency of first-cousin marriages than the other *cho* of the same area. In Table 15, pedigree data are adopted only from the proposituous couples whose ancestors are ascertained completely to the grandparents. From these data, it proves that the average coefficient of parentage is different in the *cho*-unit within the area, and the sub-population which locates the center of area has shown the higher value than the others. These tendencies are also observed in the cases of first-cousin-once-removed marriages and the second-cousin marriages.

CHRONOLOGICAL CHANGES OF THE FREQUENCY OF CONSANGUINEOUS MARRIAGE

In Japan, developments of traffic and corresponding means and changes of economical basis after the World War Ⅱ brought the increase of population movement, mainly from the farming land to the great city circles. These changes resulted in an expansion of selective sphere of the spouse and brought the decrease of consanguineous marriage frequency in all of Japan. IMAIZUMI *et al.* (1975) extracted 9,385 marriages from 300 administrative units all over the country and studied the frequency of consangrineous marriages by the questionnaire method. The result shows the frequency of first-cousin marriages is remarkably reduced as the married years become newer. Before June 1947, the frequency of first-cousin marriages was 6.78%, but among the marriages during June 1962 to June 1972 the frequency was linearly reduced to 0.77%. Socio-

economic changes described above affect the isolated populations, and it seems to break down the isolation in every population. However, the degrees of breakdown are not uniform among all populations, and YANASE (1966) got a result that the breakdown of isolation was rapid in the recent 40 years in a population having a high degree of isolated state in the past, but it was slow in a population that a degree of isolation was not so high. FUJIKI *et al.* (1968) have investigated seven isolated populations in their marriages before 1944 and after 1945, and found in four populations a remarkable decrease in their coefficient of parentage, but in the remaining populations the decrease was little or had a tendency to slight increase.

Chronological changes of the average coefficient of parentage of couples in the present investigated areas are shown in Figure 6 as classified by the area and religious groups. Degrees of retrospective ascertainment of ancestors are naturally lowered down as a married year became older and the probability to detect the common ancestors became older and the probability to detect the common ancestors became lower. This means an

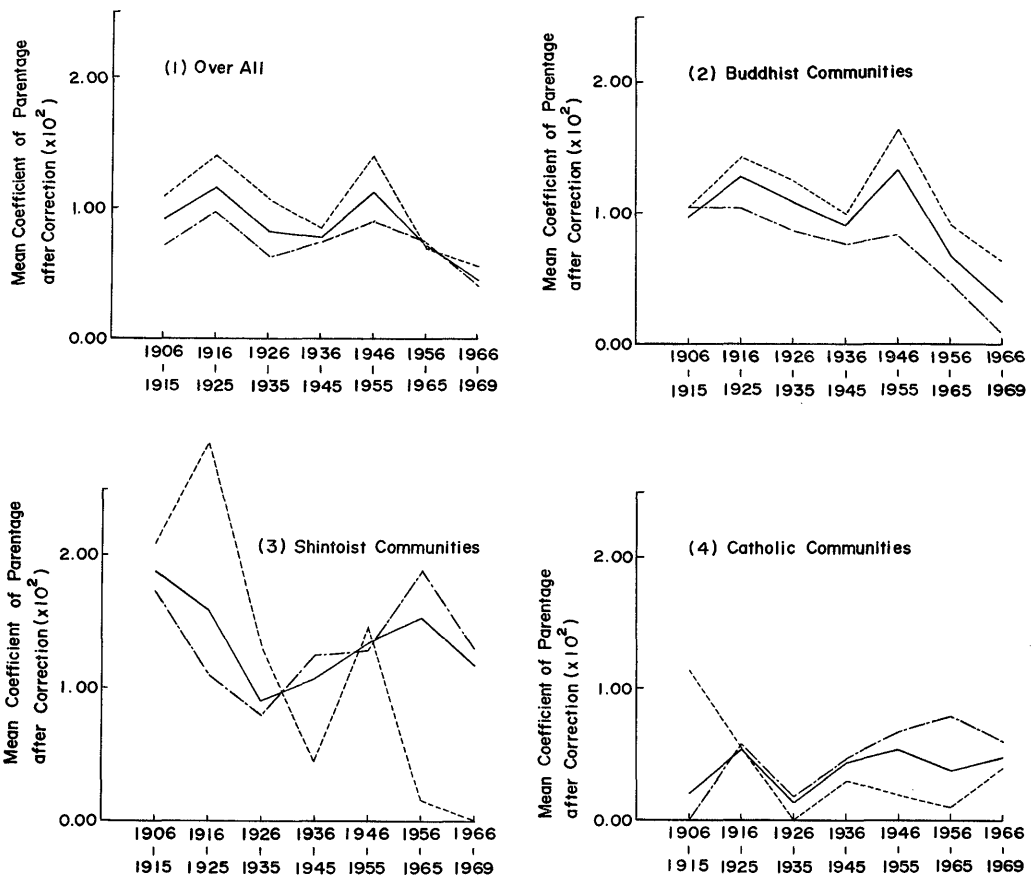

Fig. 6. Chronological Changes of Average Coefficient of Parentage.
..... Hisaka-jima Area, —•—•— Fukue-jima-Okuura Area.
——— Pooled.

underestimation of the average coefficient of parentage observed in the older marriages. Consequently, the figures are shown based on the corrected average coefficients of parentage.

In both areas, average coefficients of parentage in the couples married after the period of 1946 to 1955 are clearly decreased. This decrease is mainly due to a decrease of the coefficient in the Buddhist population as shown clearly in the figure. There are some area differences between the value in the Buddhist populations, but in both populations the value decreased remarkably in the marriages after 1946. Between the periods of 1936 to 1945 and 1946 to 1955, there was observed a particular increase of the coefficient, clearly in the H area and a little in the O area. This may be a reflection of temporary changes in population structure of the post-war period. These post-war increases of the coefficient value are not observed in the other religious groups. On the one hand, there is no fixed tendency of change in the Shintoist group of both areas, and this may be due to the too small population of the Shintoist in the H area. Further, the Shintoist as a whole has shown no decrease in the coefficient values. Similarly, in the Catholic populations, they have low values of the average coefficient of parentage due to the religious reason in general and one cannot recognize the chronological changes.,

Considered from a basis that the breakdown of isolation has brought the decrease of frequency of consanguineous marriages, it may be pointed out that the isolation is gradually broken down in the Buddhist population. On the other hand, it may be suggested that in both Shintoist and Catholic populations there remain a degree of isolation comparatively strong as yet, and these populations have characteristics of striking locality.

RELATIONSHIP OF CONSANGUINITY BETWEEN THE COUPLE AND THEIR PARENTS

At the pedigree survey on the isolated population, there are many cases having many consanguineous marriages in a family. it Is an interesting point that whether this familial gathering of consanguineous marriages is by chance or actually has some tendency to gather up.

Concerning this point, 743 pairs ascertainable whose parents can be identified untill P_3 generations are used as materials. Among the proband couples 579 pairs (77.93) are non-consanguineous and the remaining 164 pairs (22.07%) are consanguineous marriages. According to the consanguinity of their parents, the relationship of the consanguinity of proband couples is shown in Table 16. Proportion of the couples who have consanguineous relationship is lower in the case that the parents have no consanguinity than the case that the one or both parents are consanguineous marriages. This suggersts that there is positive correlation between the consanguinity of the couples and their parents. Further, the higher rate of consanguineous marriage is observed in the case of the wife's parents having consanguinity. Consanguinity rate of the couple whose one or both of parents have consanguinity is 28.68%, while in the case of both parents having non-

Table 16. The Relationship Between Couple's and Their Parent's Consanguinity.

Relationship of parents		Consanguinity of couple				Total
Husband's	Wife's	Non-consanguineous		Consanguineous		
Non-consanguineous	Non-consanguineous	487	*79.32%*	127	*20.68%*	614
Non-consanguineous	Consanguineous	44	*69.84*	19	*30.16*	63
Consanguineous	Non-consanguineous	45	*72.58*	17	*27.42*	62
Consanguineous	Consanguineous	3	*75.00*	1	*25.00*	4
Total		579	*77.93*	164	*22.07*	743

consanguinity the rate is 20.68%, and the difference is statistically significant ($X^2=3.97$, d.f.$=1$, $0.025< P< 0.05$). TANIMURA and TANAKA (1977) have analyzed whether there are correlations between three pairs, namely the couples concerned, the parents of the husband, and the parents of the wife, for their consanguinity. And they observed that the combination of all three pairs having consanguinity showed very higher values than the expected. Their estimation is that the distribution of consanguineous marriages among families is not one expected from random phenomenon but one which has a tendency to pile up in a family.

SUMMARY

To obtain fundamental information on the genetic structure of isolated human populations, all residents (about 5,000) of two adjacent areas in the Goto-Islands, Nagasaki Prefecture were investgated. Both populations, Hisaka-jima and Fukue-jima-Okuura residents are subdivided into three religious communities, Buddhist, Shintoist (not the original one but the Hidden Catholic), and Roman Catholic, and these religious groups are isolated to each other for their marriage.

Using the official family records, *Koseki*, 1,591 couples (662 in Hisaka-jima area and 929 in Fukue-jima-Okuura area) are detected and pedigree investigation was carried out for them. Frequencies of consanguineous marriage and average coefficients of parentage are 23.26% and 0.011342 in Hisaka-jima area, and 14.85%, 0.007993 in Fukue-jima-Okuura area. These coefficient values are corrected ones based on the number of ascertainable ancestral couples. Number of couples, frequency of consanguineous marriages and average coefficient of parentage in each religious groups are: 957, 18.08%, 0.010467 in the Buddhist; 234, 26.92%, 0.013710 in the Shintoist; and 395, 13.92%, 0.004565 in the Catholic.

Thus the frequency and the coefficient of parentage are different not only from each area populations but also among the religious communities, and it seem to depend on the geographical conditions as well as socioreligious ones.

According to the married year of couples, the average coefficient of parentage has a peak at the end of the World War II and decreased by about one half now, and this is a prominant feature in the Buddhist population. It means the breakdown of isolation

has progressed in the Buddhist group, but the other groups still have their isolated situations.

Comparing the consanguinity of couples with that of their parents, an accumulation of consanguineous marriages within pedigree was observed.

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