Reproductive Success Among the Sephardic Jews of Gibraltar: Evolutionary Implications.

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ABSTRACT

The completed reproductive performance of 719 Sephardic Jewish couples married in Gibraltar from 1820 to 1939 is examined in detail. An examination of 'reproductive success' revealed that only 24.7% of the children produced over the study period actually participated in the breeding structure of the Sephardic community of Gibraltar. 'Non-successful' components of reproductive performance were identified and discussed. Emigration and record-linking difficulties constituted the single most important component of non-successful reproduction observed among the Jews of Gibraltar. The evolutionary implications of the fertility differentials observed among the Jews are discussed in light of the results yielded from a modified approach to Crow's Index of Total Selection Intensity. Two of the cultural factors identified here as having potential biological import are celibacy and governmental regulations regarding permanent residency in Gibraltar.

With several notable exceptions (e.g., Spuhler and Clark, 1961; Coleman, 1977; Hiorns, et al. 1973), physical anthropologists interested in the demographic structure of human populations have traditionally concentrated on communities of small population size practising a subsistence pattern of agriculture or hunting and gathering. These settlements offer the researcher a relatively 'closed' population with spatial-temporal continuity where the ecological, demographic, social and biological boundaries coincide with one another to form an easily definable unit. Modern cities and towns, on the other hand, typically lack one or more of these properties and offer the researcher much more difficulty (Coleman, 1973).

The present demographic investigation examines the Jewish residents of the town of Gibraltar who through their religion, group cohesion, and nearly exclusive participation in commercial activities have remained a highly definable unit, clearly delimited from the other inhabitants of the Rock. Their comparatively small population size and the existence of registration systems of births, deaths and marriages permits a rather comprehensive examination in demographic terms of community development from its origin in 1704 to the present day. The Jews of Gibraltar are members of the Sephardic division of World Jewry. Sephardic Jews have

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been defined by Patai (1971) as "the descendents of Jews who lived in Spain and Portugal until their expulsion in 1492, or their voluntary emigration prior to 1492, or their subsequent escape after a period of existence as Marranos or crypto Jews". Following the Spanish Diaspora of the 15th century, the Sephardim dispersed into a variety of environments that resulted in the formation of geographically defined subpopulations in northern Europe, north Africa and the eastern Mediterranean. Until very recently, the Sephardic community at Gibraltar was one of a number of breeding units founded by the mercantile activities of the north African Jews of Tetuan and Tangier in concert with the colonial expansion efforts of the British. The virtual disappearance of these mercantile centers in Morocco in recent years brings to a close the existence of the north African subpopulation of Sephardic Jewry, and leaves the Jews of Gibraltar to become progressively more isolated from the remaining Sephardic communities of the Old World. Despite the research opportunities provided by the study of heterogenous subpopulations following the dispersion of a defined population (Neel, 1975), comparatively little research on Sephardic Jews has been conducted (see, e.g. Margolis, et al. 1960; Goldschmidt, 1963; Szeinberg, 1973; Goodman, 1976; Carmelli and Cavalli-Sforza, 1979).

The present study focuses specifically on secular trends in the reproductive performance of the Sephardic Jews of Gibraltar and the potential genetic implications of the demographic parameters reported here. Following the work of Jacquard (1971) and Gomila (1975), comprehension of human micro-evolution at the intrapopulational level requires numerical definition of the actual number of offspring who reproduce themselves in the breeding unit as well as the factors which indirectly affect familial patterns of reproductive success. With few exceptions, however, investigators have used the number of children who survive to sexual maturity (typically set at 15 years of age) as the demographic measure of reproductive success under the assumption that the majority of the survivors will marry and reproduce themselves within the local breeding unit. Unfortunately, most investigators lack the geneological depth to test the validity of this assumption. The present study reports the magnitude of familial differentials of reproductive success among the Jewish residents of Gibraltar over a 120 year period as well as the relative importance of those factors that have indirectly affected familial patterns of fertility; that is, celibacy, infertility, morality, emigration and immigration. Measured from a demographic perspective, familial differentials in reproductive success also provide evidence of the 'opportunity' or 'potential' for evolu-

tionary change occurring through the action of natural selection. The present study employs Crow's (1958) Index of Total Selection Intensity to measure the magnitude of selection possible among the marriage cohorts of 1820 to 1939. In addition to a modification introduced by Matsunaga (1966), Crow's index is further modified to incorporate additional demographic information on a major source of variation in reproductive performance observed among the Sephardic Jews of Gibraltar.

The Population and its Setting

Colonization of Gibraltar by the Sephardic Jews occurred shortly after the Rock fell from Spanish control to the British on the 24th of July 1704. A proclamation dated 1704 listing the names of individuals who paid rent to Governor H.S.H. Prince Hesses Darmstadt indicates the presence of a number of Jewish merchants in Gibraltar at this time. Since that time Gibraltar has remained a British crown colony and its prime importance initially was one of its strategic military location at the western entrance of the Mediterranean (see Fig. 1). The entire territory of Gibraltar is 4.02 kilometers in length, varying in width from 0.32 to 1.21 kilometers. At its northern end it rises perpendicularly to a height of 427 meters above sea level from the strip of flat sandy ground which connects it with the Spanish mainland. There are no natural resources of economic importance and Gibraltar is largely dependent on re-exports, the tourist trade and on the work provided by the dockyard, service departments, the government and city council. The history of the Jewish community at

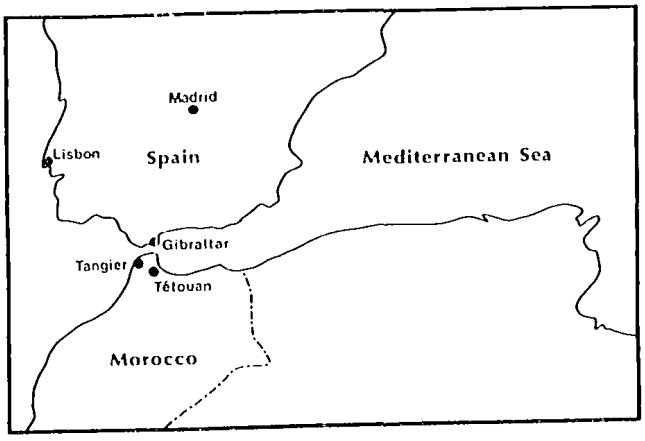

Fig. 1. Map showing location of Gibraltar.

Gibraltar under British rule can be divided into four phases. The first phase corresponds to the period of initial colonization of the Rock in 1704 by the Jews and the subsequent establishment of a viable Sephardic community at Gibraltar. During this period, the Jewish founding population comprised numerically approximately one-third of the resident civilian population. Colonization of the Rock by the Jews occurred primarily out of the need by the British to secure provisions and building materials for their garrison from Morocco and the fact that until the 20th century, a closed society of Jewish merchants controlled the majority of maritime trade in the western Mediterranean (Corcos and Cohen, 1971). The return of the Jews to the Rock after the Great Seige (1779-1783) marks the onset of the second phase of the history of the Sephardic community—the period of recolonization. In 1791, the total resident population within the fortress was 2,890 individuals, and by 1814, 24 years later, the population had increased more than three fold to 10,136 individuals. Migration to Gibraltar during this period was stimulated in part by the excellent economic opportunities available to entrepreneurs as well as by the fact that Gibraltar offered a place of refuge from religious and political oppression. It was, however, also a period in which population growth was checked by a series of epidemics. The third historical phase begins in the mid 19th century and can be described in relative terms as a period of stabilization. The decline in maritime activity and general commercial activity during this period served to limit continued demographic and economic growth of the Separdic community. It was also a period when the Government of Gibraltar introduced legislation to limit population growth within the fortress by restricting immigration through the Alien Order in Council (1885). The fourth phase begins with the close of the 19th century and is marked by political instability in international affairs which ultimately contributes to the decline of the Sephardic community in demographic, economic and biological terms.

As of the last census (1970), the Jewish community at Gibraltar numbered 552 individuals, or 2.2% of the total resident population. The population at Gibraltar is predominantly Roman Catholic (77.5%) and among the non-Christians, the Moslem religion is dominant. Despite their small numbers in recent years, the Jews have and continûe to play a vital role in civilian affairs of Gibraltar. There are four synagogues in Gibraltar, three of which were built in the 18th century. Activities of the Jewish community include the Talmud Tora, Schechita, and the Burial and General Welfare Societies. In recent years, however, there has been a growing concern regarding the viability the Sephardic community at Gibraltar

given their numerical decline and increasing frequency of religious heterogamy.

Materials and Methods

Research on the Sephardic community of Gibraltar was initiated in the summer of 1974. Demographic information was collected from a variety of sources: birth, death and marriage registers of the civilian government of Gibraltar kept by the Government's Secretariat Office, the Gibraltar Status Ordinance of 1967; records of births, deaths and marriages kept by the Jewish community of Gibraltar, and historical and geneaological information held in various archives in Gibraltar and London. Information derived from these sources was used to reconstruct biological families using family reconstitution techniques. The general strategy employed in the reconstruction of families and the process of record-linking reconstituted families followed the procedure given by Rokala and Polesky (1973).

The reconstruction of Jewish families resident at Gibraltar proved to be extremely time-consuming and difficult owing to the brevity of nominative information contained in the Sephardic registers of vital events. Individuals with a marriage record formed the basis of the analysis presented here as they offered the most expedient means of conducting an examination of the breeding structure of the Sephardic community. A total of 719 Jewish marriages were recorded in Gibraltar over the study period. Approximately 2000 birth and 1300 death entries were examined and successfully linked to their family of procreation and orientation. It should be emphasized here that the exclusion of individuals without a marriage record neglects the potential contribution of those individuals who entered Gibraltar after marriage in another community and as much underestimates the size of both the mating and breeding population as well as the magnitude of gene flow into the community.

Data on reconstituted families with a marriage record was translated into a SPSS compatible format and then transferred onto IBM punch cards. Analysis was facilitated primarily through electronic data processing provided by self-generated SPSS sub-programs (Nie, et al. 1975). Reproductive performance was measured in terms of completed family size. The female reproductive period was judged complete if any one of the following conditions were met: 1. the female died after 45 years of age, 2. had her last child after the age of 45, 3. married for the first time after the age of 45, 4. both husband and wife remained alive for 25 years after their marriage. Each female was assigned to a marriage cohort ac-

cording to the data of her first marriage. Four marriage cohorts were reconstructed, each spanning a thirty-year interval. The thirty-year interval approximates a biological generation among the Sephardic Jews of Gibraltar where initiation of the reproductive period is comparatively late.

Completed reproductive performance was evaluated in terms of the mean number of children everborn, variance in family size, and its respective components: 1. children dying prior to sexual maturity, 2. unmarried survivors, and 3. married children. The fertility component of unmarried surviors was differentiated on the basis of whether or not the survivor could be linked to a death record or was alive as of December 31st, 1970. Unmarried survivors who could not be accounted for by the above criteria represent at present an aggregate of two indistinguishable states, i.e., individuals who were 'lost' geneaologically by virtue of (i) emigration, or (ii) insufficient information to link an individual to his/her marriage or death record. The married child fertility component was also further differentiated according to whether or not the individual proved fertile.

Following Crow (1958) the total amount of potential change occuring within a human population through the action of natural selection may be measured by the Index of Total Selection Intensity. Assuming that the variance in fitness due to familial differentials in mortality and fertility are completely heritable, the index sets the upper limit to the rate of change that may occur through the action of natural selection. However, since only a fraction of the differences in liability and fertility have a genetic basis, the term 'potential' or 'opportunity' is used in describing the index.

Since his original formulation, Crow (1973) and others have introduced a number of refinements and modifications to the index. A treatment of the various improvements and a thorough discussion of the index can be found in Spuhler (1976).

The Index of Total Selection Intensity (I_t) is partitioned into a mortality component (I_m) and fertility component (I_f). The mortality component is defined as,

$$I_m = p_d/(1 - p_d)$$

where p_d is the proportion of all livebirths dying prior to the age of sexual maturity. Following Matsunaga (1966), the fertility component, I_f, can be partitioned into I_1, the intensity due to non-reproducing married females and I_f', the intensity due to variations in the number of children among fertile married females:

$$I_l = p_o/(1 - p_o)$$
$$I_f' = V_f/(\bar{x}_f)^2$$
$$I_f = I_l + (1/(1 - p_o))\, I_f'$$

where p_o is the number of married women who had completed their reproductive period having no offspring and $\bar{x}_f$ and V_f are, respectively, the mean and variance of the number of livebirths per fertile women whose reproduction is judged complete. The total index may be represented as:

$$I_t = I_m + (1/(1-p_d))\, I_f.$$

The sampling errors of I_m, I_f and I_t, originally obtained by Barrai and Fracarro (1965), are based on the method outlined by Kendall and Stuart (1958).

One assumption almost universally held by investigators using Crow's index is that all surviving children who do not emigrate or die during the reproductive period enter marriage and thus participate in the local breeding population. As data presented later will indicate, this is not the case among the Separdic Jews of Gibraltar where a high rate of celibacy persisted throughout the 19th and 20th centuries. The modification to Crow's index proposed here enters women who remained celibate throughout their reproductive period into the appropriate marriage cohort as women who had not borne any children. Using the method outlined earlier, substitution of p_o for p_d permits the calculation of the standard error for I_l.

Results

Information of the secular change in reproductive success and its components presented in Table 1 demonstrates that over the 120 year study period the number of children everborn declined both in absolute and relative terms. The decline in fertility approximates an average reduction for each marriage cohort of 0.7 livebirths per fertile female. Variability in completed family size underwent a similar reduction in magnitude, but in relative terms, the variance remained high over the study period. The magnitude of fertility differentials is reflected in the fact that the ratio of the variance to the mean number of livebirths among reproducing women remained equal to or greater than 1.5 for the four marriage cohorts. Infertility among the Sephardic Jews of Gibraltar remained relatively high in magnitude over time, ranging from 21 to 37%.

Table 1

Evolution of the Components of Reproductive Success for Sephardic Women whose Reproduction is Judged Complete

Period of Marriage	Number of Women			Number of Children	$\bar{X}_f$	S_f^2	Proportion of Children				
							Unmarried			Married	
	All	Fertile	% Fertile				Dying < 15	Dying ≥ 15	'Lost'	Non Fertile	Fertile
1820-849	201	137	68.2	715	5.219	8.305	0.200	0.236	0.267	0.055	0.242
1850-879	180	133	78.9	590	4.436	7.505	0.176	0.239	0.298	0.066	0.220
1880-909	184	116	63.0	434	3.741	6.437	0.097	0.180	0.307	0.111	0.307
1910-939	154	100	64.9	299	2.990	4.495	0.080	0.181	0.308	0.211	0.221
Total	719	486	67.6	2,038	4.193	6.856	0.156	0.217	0.290	0.093	0.246

Pre-reproductive mortality during most of the 19th century remained relatively high. From 1880 onwards, however, pre-reproductive mortality declined markedly to a level nearly one-half that of the earlier period. Using the arcsin test for the equality of two percentages (Sokal and Rohlf, 1969) the decline in prereproductive mortality between cohort II and cohort III was highly significant ($p < 0.001$). As Table I indicates, relatively few children were removed from the gene pool through death, with approximately 84% of all children surviving to sexual maturity. However, the majority of these survivors did not enter marriage but remained unmarried, emigrated or were lost through insufficient information. Analysis of unmarried survivors revealed that the 'lost' subcomponent typically made the greater contribution and over time it has become quantitatively more important. No significant disparity between the sexes was observed in either subcomponent. The proportion of children marrying and establishing a household in Gibraltar is comparatively low as only one-third of the children everborn entered marriage. The fertile subcomponent was consistently greater in magnitude than the non-fertile subcomponent. With the exception of the last cohort, nearly three-quarters of all married children reproduced themselves in the next generation. The increase in the number of infertile unions seen in the 1910-1939 cohort can be attributed in part to the fact that some mariages may not have as yet produced offspring as well as the fact that the number of marriages to non-Jews increased significantly in the 20 century. The percentage of marriages to non-Jews was 0, 3.7, 8.1 and 13.2% respectively for the four marriage cohorts. There was a significant disparity between the sexes with respect to intermarriage, with considerably more marriages to non-Jews by Jewish males than vice versa ($\chi_1^2 = 22.56$).

Information on reproductive success as measured by children everborn and surviving to sexual maturity for native- and foreign-born males is given in Table 2 and for females in Table 3. The results indicate that migrant males exhibit a smaller completed family size than their native-born counterparts. While the fertility differential between females is of a similar nature, the magnitude of the differential is not as great as that for males. When the examination is restricted to reproducing individuals exclusively, foreign-born males exhibit a slightly larger overall completed family size than the native-born males. The differential favoring migrant males is primarily the result of an increased birth rate of the foreign-born males of the (1880-1909) marriage cohort. The fertility pattern among females of similar status remained virtually unchanged with a slightly larger family size observed among native-born females. The secular trend

Table 2

Number of Children Everborn and Surviving Past 15 for Native and Foreign-Born Males whose Reproduction is Judged Complete by Year of Marriage

		Everborn				Survivors			
		All		Fertile		All		Fertile	
Marriage		Native	Migrant	Native	Migrant	Native	Migrant	Native	Migrant
1820-849	$\bar{X}$	4.319	2.964	5.552	5.030	3.363	2.446	4.324	4.152
	SD	3.478	3.390	2.945	3.005	2.692	2.873	2.268	2.623
	SE	0.299	0.453	0.287	0.523	0.232	0.384	0.221	0.457
	n	135	56	105	33	135	56	105	33
1850-879	$\bar{X}$	3.582	2.378	4.550	4.191	2.972	1.838	3.775	3.238
	SD	3.069	2.919	2.746	2.713	2.664	2.351	2.445	2.278
	SE	0.258	0.480	0.261	0.592	0.224	0.387	0.232	0.497
	n	141	37	111	21	141	37	111	21
1880-909	$\bar{X}$	2.623	1.960	3.667	4.900	2.369	1.760	3.312	4.400
	SD	2.743	3.089	2.585	3.071	2.440	2.773	2.279	2.757
	SE	0.241	0.618	0.268	0.971	0.214	0.555	0.236	0.872
	n	130	25	93	10	130	25	93	10
1910-939	$\bar{X}$	2.243	2.071	3.077	3.222	2.056	2.000	2.821	3.111
	SD	2.227	2.526	2.056	2.489	2.037	2.353	1.878	2.261
	SE	0.215	0.675	0.233	0.830	0.197	0.629	0.213	0.754
	n	107	14	78	9	107	14	78	9
Total	$\bar{X}$	3.253	2.515	4.313	4.548	2.731	2.099	3.620	3.795
	SD	3.051	3.117	2.787	2.882	2.539	2.653	2.307	2.505
	SE	0.135	0.271	0.142	0.142	0.337	0.112	0.117	0.293
	n	513	132	387	73	513	132	387	73

Table 3

Number of Children Everborn and Surviving Past 15, for Native and Foreign-Born Females whose Reproduction is Judged Complete by Year of Marriage

		Everborn				Survivors			
		All		Fertile		All		Fertile	
Period of		Native	Migrant	Native	Migrant	Native	Migrant	Native	Migrant
1820-849	$\bar{X}$	3.637	2.714	5.235	4.750	2.911	2.143	4.189	3.750
	SD	3.418	3.251	2.903	2.872	2.767	2.410	2.377	1.893
	SE	0.248	1.229	0.253	1.436	0.201	0.911	0.207	0.946
	n	190	7	132	4	190	7	132	4
1850-879	$\bar{X}$	3.263	3.435	4.313	4.938	2.704	2.696	3.574	3.875
	SD	3.023	3.202	2.745	2.670	2.634	2.566	2.460	2.187
	SE	0.245	0.668	0.256	0.668	0.214	0.535	0.229	0.547
	n	152	23	115	16	152	23	115	16
1880-909	$\bar{X}$	2.492	2.100	3.722	3.231	2.280	1.650	3.405	2.539
	SD	2.720	2.732	2.542	2.803	2.470	1.954	2.296	1.898
	SE	0.250	0.611	0.286	0.778	0.227	0.437	0.258	0.526
	n	118	20	79	13	118	20	79	13
1910-939	$\bar{X}$	2.011	2.760	2.950	3.450	1.852	2.520	2.717	3.150
	SD	2.236	2.471	2.135	2.282	2.037	2.312	1.932	2.159
	SE	0.238	0.494	0.276	0.510	0.217	0.462	0.249	0.483
	n	88	25	60	20	88	25	60	20
Total	$\bar{X}$	3.026	2.787	4.295	3.943	2.547	2.307	3.617	3.264
	SD	3.051	2.839	2.785	2.612	2.583	2.307	2.367	2.095
	SE	0.130	0.328	0.142	0.359	0.110	0.266	0.120	0.288
	n	548	75	386	53	548	75	386	53

Table 4

Comparison of Period of Marriage, Birthplace and Reproductive Success of Females

Period of Marriage	Birthplace	Nonfertile	Fertile	Total
1820–49	Native	58	132	190
	Migrant	3	4	7
	Both	61	136	197
1850–79	Native	37	115	152
	Migrant	7	16	23
	Both	44	131	175
1880–09	Native	39	79	118
	Migrant	7	13	20
	Both	46	92	138
1910–39	Native	28	60	88
	Migrant	5	20	25
	Both	33	80	113
Total		184	439	623

Hypothesis Tested[a]	df	G
PM × R Independence	3	2.82
PM × BPL Independence	3	27.86**
1820 vs 1850	1	1.56
1880 vs 1910	1	0.50
1820 + 1850 vs 1880 + 1910	1	25.80**
BPL × R Independence	1	0.00
PM × BPL Interaction	3	2.24
PM × BPL Independence	10	32.92

[a] Where PM equals period of marriage, BPL equals birthplace and R equals reproductive performance.

**$p < .01$

in the female fertility pattern is more irregular than that of males, but, given the extremely small sample size, this is not unexpected.

Given the reversal in reproductive performance noted above, analysis using the G test statistic (Sokal and Rohlf, 1969) was conducted on the relationship between period of marriage, birthplace and fertility. The results are presented in Tables 4 and 5. The latter table indicates, as expected, that there is a significant association between the three variables among the males studied, with approximately one-half of the

Table 5

Comparison of Period of Marriage, Birthplace and Reproductive Success of Males

Period of Marriage	Birthplace	Nonfertile	Fertile	Total
1820–49	Native	30	105	135
	Migrant	23	33	56
	Both	53	138	191
1850–79	Native	30	111	141
	Migrant	16	21	37
	Both	46	132	178
1880–09	Native	37	93	130
	Migrant	15	10	25
	Both	52	103	155
1910–39	Native	29	78	107
	Migrant	5	9	14
	Both	34	87	121
Total		185	460	645

Hypothesis Tested[a]	df	G
PM × R Independence	3	3.58
PM × BPL Independence	3	17.03**
1820 vs 1850	1	3.58
1880 vs 1910	1	1.18
1820 + 1850 vs 1880 + 1910	1	12.26**
BPL × R Independence	1	19.62**
PM × BPL × R Interaction	3	3.22
PM × BPL × R Independence	10	42.46**

[a] Where PM equals period of marriage, BPL equals birthplace and R equals reproductive performance.

**$p < .01$

pooled G value the result of the interdependence of birthplace and reproductive success (see Table 5). As suggested earlier, there are in fact significantly more non-reproducing males among migrants. Thus, the lower reproductive performance observed among foreign-born males is not one of an overall depression in the fertility but rather the result of a greater proportion of childless unions.

Secular change in the total index of selection intensity and its components is given in Table 6. The maximum of selection possible was moder-

Table 6

Total Index of the Opportunity for Selection and Its Components Based on Completed Sibships

	Fertility Component								Morality Component	Total Index
Period of Marriage	N	N_f	$\bar{X}_f$	V_f	I_f'	P_o	I_i	I_f	P_d	I_m	I_t
1820–849	201	137	5.219	8.305	0.305	0.318	0.465	0.912 ± 0.105	0.200	0.250 ± 0.043	1.390 ± 0.142
1850–879	180	133	4.436	7.505	0.381	0.211	0.267	0.750 ± 0.099	0.176	0.214 ± 0.040	1.220 ± 0.133
1880–909	184	116	3.741	6.437	0.460	0.370	0.587	1.317 ± 0.155	0.097	0.107 ± 0.030	1.366 ± 0.179
1910–939	154	100	2.990	4.495	0.503	0.351	0.541	1.316 ± 0.162	0.080	0.087 ± 0.029	1.517 ± 0.183

Table 7

Total Index of the Opportunity for Selection, and Its Components Based on Completed Sibships and Celibate Females who Survived Past 45 Years of Age

	Fertility Component								Mortality Component	Total Index
Period of Marriage	N	N_f	$\bar{X}_f$	V_f	I_f'	P_o	I_i	I_f	P_d	I_m	I_t
1850–879	225	133	4.436	7.505	0.381	0.409	0.692 ± 0.055	1.337 ± 0.146	0.176	0.214 ± 0.040	1.837 ± 0.186
1880–909	214	116	3.741	6.437	0.460	0.458	0.845 ± 0.063	1.694 ± 0.131	0.097	0.107 ± 0.030	1.983 ± 0.232
1910–939	176	100	2.990	4.495	0.503	0.432	0.761 ± 0.066	1.647 ± 0.201	0.080	0.087 ± 0.029	1.877 ± 0.224

ate in magnitude, and ranged from 1.269 to 1.517. The mortality component, I_m, declined in absolute magnitude over time and underwent a significant reduction for the marriage cohort of 1880 ($p < .05$, for 1850 vs 1880). The fertility component, I_f, made the larger contribution to the total I_t, where typically 80% or more of I_t derives from I_f. The opportunity for change through fertility differences increased in magnitude after 1879, but the difference between the cohorts was not statistically significant. Typically 40% or more of I_f derived from non-reproducing females, I_i. The proportion of infertile married women was relatively high and ranged from 26.1 to 37.0%.

Table 7 sets out revised rates of Crow's index and its components following the modification proposed earlier to incorporate information on celibate women. Examination of the reconstituted families revealed that 45 females who issued from the 1820-1849 marriage cohort survived past the age of 45 as spinsters, 30 from the 1850-1879 cohort, and 22 from the 1880-1909 cohort. The results indicate that the subcomponent, I_i, was significantly underestimated at the 0.05 level or better for each marriage cohort when I_i is based on married females only. Correspondingly, the total fertility component, I_f, was underestimated, and significantly so for the 1850 and 1880 marriage cohorts. The total index followed the same pattern of underestimation, and I_t for the 1850-1879 marriage cohort was significantly lower when the calculations were based on married females exclusively.

Discussion

Reproductive Success

It is apparent from the data presented here that only a fraction (24.7%) of the children produced over the study period actually participated in the breeding structure of the Sephardic community of Gibraltar. The proportion of 'successful offspring' issued from Jewish women at Gibraltar is approximately one-half that reported by Jacquard (1971) for French Canadian couples at l'Isle aux Coudres, Quebec. Ranked in terms of their overall magnitude, the 'non-successful' components of reproductive performance for the Jewish sample were, respectively: 1. emigration or loss through record-linking difficulties, 2. adherence to celibacy, or death during the reproductive period, 3. death prior to sexual maturity and 4. married offspring who did not reproduce themselves within the local breeding community or by virtue of marriage to non-Jews. At the in-

trapopulational level, reproductive success cannot be simply equated to the number of surviving offspring per female and, while comparative interpopulational data is lacking, it is reasonable to propose that closer examination be given to those factors that affect reproductive performance in other human populations.

Within the population, emigration can be regarded as a 'loss' component of reproductive success since these individuals do not participate in the formation of the next generation at Gibraltar. As indicated earlier, the present study is limited in that emigration could not be distinguished from loss through record-linking difficulties. Moreover, the figures reported here for reproductive performance are biased according to whether or not a successful link was made. Thus factors which lower the probability of performing a successful genealogical link interfere with the evaluation of the components of reproductive performance. Such factors include: 1. variable quality of nominative information contained in the records themselves, 2. problems arising from surname and given name changes, from variations in name spellings and from mis-spellings or copy errors, 3. the small number of given names used in the naming of Jewish offspring, and 4. the absence of birth records for married children born to parents who resided temporarily outside of Gibraltar during the course of a birth. While a comprehensive examination of emigration has yet to be undertaken, Serruya (1969) reports that Jewish movement out of Gibraltar to England and America increased substantially at the turn of the 20th century. A decline in the commercial prosperity on the Rock, the virtual disappearance of the Jewish settlements at Tetuan and Tangier, and The Alien Order of Council (1885) are expected to be important factors in stimulating movement out of Gibraltar.

In addition to emigration, celibacy and death during the reproductive period played an important role in dampening the reproductive success of Sephardic women in Gibraltar. Of the 442 unmarried surviving children issued in this study period, 19.45% were still alive as of December 31st, 1970, 21.49% had died during the reproductive period, and 69.05% survived past 45 and remained unmarried. Celibacy, the largest subcomponent identified here, was uniformly distributed between the sexes and decreased in frequency over time. A number of factors have contributed to the high rate of celibacy observed among the Sephardic Jews of Gibraltar, but five factors identified here include:

1. the desire of a male to attain a certain standard of living before entering marriage and as a consequence of not meeting this expectation remaining celibate,

2. the lack of appropriate mates as defined by the strict orthodox rules of the Sephardic community,
3. the inhibitory effect of governmental sanctions against native-born women who marry a non-Gibraltarian,
4. a restrictive town setting which fosters friendship between sexes and inhibits dating unless there is the intention of marriage, and
5. testimony of informants that individuals are more likely to remain celibate if the father dies at an early age.

The mean and variance in the number of children dying prior to sexual maturity is a measure of mortality of genetic interest. Prereproductive mortality represents 'evolutionary wastage' as these individual fail to enter the gene pool and hence are unable to participate in the formation of the next filial generation. The comparatively high rate of pre-reproductive mortality observed among the first two marriage cohorts (1820 to 1879) was inflated by a series of infectious epidemics, particulary yellow fever and cholera, that prevailed within the fortress from 1828 to 1865. Preliminary results yielded by an analysis of civil records detailing cause-specific mortality indicate that from 1869 to 1909 the major cause of death among pre-reproductive Jews was infectious diseases (62.87%). Leading causes of death during this period were air-borne diseases, particularly bronchitis, influenza and pneumonia (15.44%) and water- and food-borne diseases, particularly diarrhorea, dysentry, and gastroenteritis (11.76%). A detailed examination of infant mortality revealed that deaths under one year underwent a dramatic reduction after 1909 and that the following factors were responsible:

1. a reduction in population size after the turn of the century and concommittantly less crowding within the fortress,
2. a new public water and sewer system was undertaken in 1868 and later improved in 1900,
3. greater reliance on the automobile and the decline in horse traffic, with the subsequent reduction of animal waste on the streets,
4. the introduction of new sanitary measures, with the removal of refuse twice as frequently during the summer months, and
5. a safer and more hygenic source of food for infants, with the practise of boiling milk.

Marriages to non-Sephardim can also be viewed as a 'loss' component as these individuals and their subsequent offspring are excluded from membership in the Sephardic community at Gibraltar. Reproductive loss through marriage to non-Jews removed only 2.43% of all surviving children. Examination of the children who married non-Jews revealed a sig-

nificant difference between the sexes ($G_1 = 35.54$), with males accounting for 86.7% of the mixed marriages. The 1820-1849 marriage cohort was devoid of children marrying non-Jews. The frequency of male children who participated in religious exogamy increased significantly over the latter three marriage cohorts ($G_2 = 13.52$), while no such tendency was observed among female offspring ($G_2 = 0.24$). The breakdown of religious homogamy in recent years is in part related to: 1. the deline in the nearby Sephardic communities of Tangier and Tetuan in terms of size and religious cultural activity (Cohen, 1971), 2. increased socio-economic and biological communication with non-Jews across the Spanich border, and 3. deterioration of strong spiritual leadership in the Sephardic community at Gibraltar (Levy, 1967).

Migration and Reproductive Performance

The present research on the Sephardic community of Gibraltar yields findings similar to other investigators who report that migrants have a lower reproductive performance than native-born (Yanase, 1965; Swedlund, 1971; Ward and Raspe, 1973 and Skolnick, et al. 1976). Similar to the findings of Skolnick and co-workers (1976), migrant males exhibit a smaller completed family size than their native-male counterparts, and while the fertility differential between females is of a similar nature, the magnitude of the differential is not as great as that of males. However, the lower reproductive performance observed among migrant males is not one of an overall depression in fertility but rather the result of a significantly greater proportion of childless marriage unions. Over the entire study period, less than 50% of marriages involving foreign-born males resulted in fertile unions. The high rate of infertility observed among migrant males can in large part be attributed to the difficulty of attaining permanent residential status within the fortress. Legislation introduced by the Government of Gibraltar then acted to reduce the rate of immigration into Gibraltar as well as the contribution of foreign-born individuals to the next filial generation. The implication of this finding assumes even greater weight when it is realized that this legislation remains in force today and applies to all foreign ethnic/religious groups.

Selection Intensity

The intensity of natural selection was estimated by Crow's index, Despite the criticism of Li (1963) and Morton (1968), Crow's index has practical utility. The total index, I_t, computed for the marriage cohorts of the Sephardic community ranged between 1.27 to 1.52. The calculated

rates of selection intensity were intermediate in magnitude by comparison with the fifty-three populations recently reviewed by Spuhler (1976). The mortality component, I_m, was low in magnitude compared with values observed for other populations and declined significantly for the marriage cohort of 1880-1909. As expected for an industrialized country, the fertility component, I_f, gave the larger contribution to the total index; typically 80% of I_t derived from I_f. The absolute and relative magnitude of I_f increased over time following the deline in mean completed family size and the reduction in the rate of pre-reproductive mortality. A further contributing factor to the magnitude of selection due to fertility differentials is the high proportion of married females who remained childless throughout their reproductive period. The importance of the nonfertile subcomponent, I_i, assumed even greater significance when Crow's index was modified to include women who remained celibate throughout their reproductive period. The results reported here demonstrate that the total fertility component increased significantly when celibate women were included in the computation of the I_i subcomponent. The modification introduced here may also have practical import when assessing fertility differentials among populations where the frequency of celibacy is reported to be high in magnitude (e.g., Gomila, 1975 and Friedl and Ellis, 1976).

The implications of these findings are noteworthy when it is recognized that the secular trends in mortality, fertility and celibacy observed among the Sephardic Jews of Gibraltar are representative of a pattern reported for industrialized countries of Western Europe by Hajnal (1965). During industrialization, the characteristic demographic pattern was one of declining pre-reproductive mortality, followed later by a decline in the fertility. As noted earlier, the maximum amount of selection possible actually increases as the mean number of offspring decreases, and thus fertility differentials can be assumed to have played an increasingly stronger role over time. Concomitant to the decline in fertility, the frequency of celibacy increased and consequently, the fertility differentials that existed became even more marked. This latter point is seldom acknowledged in the literature and takes on even more significance when secular changes in the frequency of celibacy are considered. For example, Hajnal (1965) reports that the rate of celibacy has declined among the industrialized nations of Western Europe since the Second World War. One may infer from this that as more women enter the breeding population and contribute effectively, the relative evolutionary potential due to differentials in reproductive success will be accordingly deemphasized.

Interpretation of these findings is, however, hampered somewhat as 'family planning' has assumed greater significance among some Western industrialized countries in recent years. Nonetheless, it would seem reasonable from this perspective to propose that research into: the frequency of celibacy at the inter- and intrapopulation level, secular changes in the rate of celibacy, and the socio-economic factors promoting an increased rate of celibacy may prove fruitful to the comprehension of contemporary human evolution.

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Literature Cited

Carmelli, D. and L. L. Cavalli-Sforza 1979 The genetic origin of the Jews: A Multivariate Approach. Human Biol. 51: 41-61.

Cohen, H. J. 1971 Tangier. *In:* Encyclopedia Judica, Vol. 15, pp. 790-793. Macmillan, New York.

Coleman, D. A. 1973 Marriage movement in British cities. *In:* Genetic variation in Britain. D. F. Roberts and E. Sunderland (eds.), pp. 33-58, Taylor and Francis, London.

_____ 1977 The Geography of marriage in Britain, 1920-1960. Ann. Hum. Biol. 4: 101-132.

Corcos, D. and R. Cohen 1971 Morocco. *In:* Encyclopedia Judica. Vol. 12, pp. 326-347. Macmillan, New York.

Crow, J. F. 1958 Some possibilities for measuring selection intensities in man. Human Biol. 30: 2-13.

_____ 1973 Some effects of relaxed selection. Proceedings of Internat. Congress of Human Genetics (Paris, 1971) pp. 155-166.

Friedl, J. and W. S. Ellis 1976 Celibacy, late marriage and potential mates in a Swiss isolate. Human Biol. 48: 23-35.

GOLDSCHMIDT, E. (ed.) 1963 The genetics of migrant and isolate populations. Williams and Wilkins, Baltimore.

GOMILA, J. 1975 Fertility differentials and their significance for human evolution. *In:* The role of natural selection in human evolution. F. M. Salzano (ed.), pp. 155-185 North-Holland Publishing co., Amsterdam.

GOODMAN, R. M. 1976 Genetic disorders among the Jewish people. *In:* Modern trends in human genetics. A. E. H. Emergy (ed.), Vol. 2, pp. 270-307. Butterworths, London and Boston.

GOVERNMENT OF GIBRALTAR 1970 Report of the Census of Gibraltar, taken on the 31st December, 1970. Garrison Library Printing Office, Gibraltar.

HAJNAL, J. 1965 European marriage patterns in perspective. *In:* Population in history. D. V. Glass and D. E. C. Eversley (eds.), pp. 101-143. Aldine, Chicago.

HIORNS, R. W., G. A. HARRISON AND C. F. KÜCHEMANN 1973 Factors affecting the genetic structure of populations: an urban-rural contrast in Britain. *In:* Genetic variation in Britain. D. F. Roberts and E. Sunderland (eds.) pp. 17-32 Taylor and Francis, London.

JACQUARD, A. 1971 Limitation des naissances et variance du nombre d'enfants. Unpublished report, W.H.O., Geneva. *Cited in:* The role of natural selection in human evolution. F. M. Salzano (ed.) 1975 p. 184. North-Holland Publishing Co., Amsterdam.

LEVY, A. 1967 The Jewish life on the Rock. Jewish Chron., London No. 5117, p. 7.

LI, C. C. 1963 Genetic aspects of consanguinity. Amer. J. Med. 34: 702-714.

MARGOLIS, E., J. GUREVITCH AND D. HERMANI 1960 Blood groups in Sephardic Jews. Amer. J. Phys. Anthrop. 18: 197-198.

MATSUNAGA, E. 1966 Possible genetic consequences of family planning. J. Amer. Med. Assoc. 198: 533-540.

MORTON, N. 1968 Problems and methods in the genetics of primitive groups. Amer. J. Phys. Anthrop. 28: 191-202.

NEEL, J. W. 1975 The study of "natural" selection in man: last chance. *In:* The role of natural selection in human evolution. F. M. Salzano (ed.), pp. 355-368. North-Holland Publishing Co., Amsterdam.

NIE, N. H. C. H. HULL, K. G. JENKINS, K. STEINBRENNER, AND D. H. BENT, 1975 SPSS Statistical package for the social scientist. 2nd edition. McGraw-Hill, Toronto.

PATAI, R. 1971 Tenets of Jacob: The Diaspora—yesterday and today. Prentice-Hall, Englewood Cliffs, N.J.

ROKALA, D. A. AND H. F. POLESKY 1973 Demographic and genetic structures of reservation populations. 1. The Greater Leech Lake (Ojibwa) Reservation. Social Biol. 20: 427-437.

SERRUYA, S. A. 1969 Gibraltar under seige. Jewish Chron. No. 5226, p. 7.

SKOLNICK, M., L. L. CAVALLI-SFORZA, A. MORONI AND E. SIRI 1976 A preliminary analysis of the genealogy of Parma Valley, Italy. J. Hum. Evol. 5: 95-115.

SOKAL, R. R. AND F. J. ROHLF 1969 Biometry. Freeman, San Francisco.

SPUHLER, J. N. 1976 The maximum opportunity for natural selection in some human populations, *In:* Demographic anthropology: Quantitative approaches. E. B. Zubrow (ed.) pp. 185-221. University of New Mexico Press, Albuquerque.

SPUHLER, J. N. AND P. J. CLARK 1961 Migration into the human breeding population of Ann Arbor, Michigan 1900-1950. Human Biol. 33: 223-235.

SWEDLUND, A. C. 1971 The Genetic structure of an historical population: A study of marriage and fertility in Old Deerfield, Massachusetts. Research Report No. 7 Department of Anthropology, University of Massachusetts, Amherst.

SZEINBERG, A. 1973 Investigation of genetic polymorphic traits in Jews. Israel J. Med. Sci. 9: 1171-1180.

WARD, R. H. AND P. D. RASPE 1973 Inbreeding levels stabilized by flexible breeding structure. Proc. XIIth Internat. Congr. Genet. 74: 291-292.

YANASE, T. 1964 Degree of endogamy and effective migration rate in isolated populations. Japan Acad. Sci. Proc. 41: 159-174.