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INBREEDING PATTERN AND REPRODUCTIVE SUCCESS IN A RURAL COMMUNITY FROM GALICIA (SPAIN)

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Summary. The present paper is based on information on marital patterns and reproductive performance (reconstituted families) in the rural community of Los Nogales, Galicia, Spain. Biodemographic data were used to analyse temporal changes and structure of consanguinity in the population, as well as consanguinity versus reproductive success. Of 2347 marriages celebrated between 1871 and 1977, 5·15% were between relatives (up to third degree). The population's inbreeding coefficient was above the Spanish average after 1890, and levels were high during the first part of the 20th century. A possible underestimation of inbreeding coefficients is attributed to the elevated frequency of extramarital births occurring in the Los Nogales population (13·47%). The structures of consanguineous matings, expressed as C22/C33 and C33/C44, turned out to be 0·86 and 0·82 respectively. Regarding migration, before 1920 consanguinity increased, but net migration was negative. In the period 1920–1929 consanguinity began to decrease, prior to maximum emigration. As for reproductive success, information from 1503 reconstituted families shows that complete fertility was slightly higher among consanguineous families despite a greater infant mortality. Lower infertility in consanguineous matings, as well as lower age at marriage and first maternity, could explain the above results.

Introduction

In a population, the probability of a consanguineous marriage depends on the number of relatives who are potential mates, according to their degree of relationship and age (Cavalli-Sforza, Kimure & Barrai, 1966; Hajnal, 1963). Biodemographic factors may influence the inbreeding pattern through the process of mate selection, which in turn is related to the migration pattern, as well as to the number of available mates, given the population distribution by age.

In Spain, where the Roman Catholic religion has prevailed, the incidence of matings among relatives can be estimated from the number of ecclesiastical dispensations granted prior to weddings. Since the paper of Valls (1960), studies on consanguinity have been abundant. Many of them are merely descriptive, despite the fact that when they correspond to small rural populations, biodemographic information may be easily available. In the present paper the consanguinity pattern is related to the biodemographic characteristics of a rural community from Galicia, Spain. The studied area consists of nine parishes belonging to the Los Nogales municipality (42°48′ north, 3°25′ west) in Lugo Province. This area has several characteristics that make it interesting for a study relating consanguinity patterns and biodemographic features: its socioeconomic level was very low during the studied period (1871–1977) due to its complicated geography (altitude: 520–1198 m), dispersion of settlements (52 hamlets for a census size of 5081 inhabitants in 1930) and very small property sizes (smallholdings). Most residents were engaged in subsistence agriculture and cattle raising, and it can therefore be assumed that there were no socioeconomic differences between consanguineous and non-consanguineous couples. Net migration has always been negative and, for the period studied, the level of permanent celibacy (individuals older than 50 years) was very high (25·97% for women and 19·72% for men). Finally, extramarital reproduction has been rather common in Los Nogales. Fuster (1985) reported that illegitimacy rates ranged between 15 and 20% at the end of the 19th century, falling to below 5% only since 1950.

The objective of the present paper is to analyse consanguinity (temporal change and structure) as well as consanguinity versus reproductive success, making use of the available biodemographic information for the Los Nogales population. First, the temporal variation of the inbreeding coefficients, as well as of the relative frequencies of various degrees of relationships, are analysed, paying special attention to the population's extramarital reproduction, emigration and the marital rate. Second, reproductive success is expressed in terms of live births, infant mortality and the number of children surviving to age 15, taking into account age at marriage and at first maternity, and the frequency of infertile couples.

Methods

For the period 1871–1977 data were obtained from civil (births, deaths) and parish (marriages) records. Complementary information came from the official census and the Lugo bishopric records on ecclesiastical dispensations. Family reconstitution (Fuster, 1982) provided 1503 reproductive histories corresponding to complete fertility.

Since the percentage of consanguineous matings is not a good indicator of a population's inbreeding level, the latter is expressed as an inbreeding coefficient (Cavalli-Sforza & Bodmer, 1971):

$$\alpha = \Sigma f_i F_i,$$

where F_i represents the inbreeding coefficient for each relationship and f_i the relative frequency with respect to total weddings.

The structure of consanguinity – that is the relative frequency of each degree of consanguineous mating – depends on the relative number of various degrees of relationships: C12 (uncle–niece), C22 (first cousin), C23 (first cousin once removed), C33 (second cousin), C34 (second cousin once removed) and C44 (third cousin). On occasions, this structure is expressed as C22/C33 or C33/C44, that is involving relationships between successive generations. According to Hajnal (1963), in both cases the expected ratios are 0·25 because in each generation the number of available relatives increases four times.

Results and discussion

The frequencies of different degrees of consanguineous matings are shown in Table 1. Of 2347 marriages, 168 were consanguineous. Due to a change in regulations in granting dispensations, after 1918 only second cousins (third degree) or closer relatives required a dispensation. Table 1 also shows the number of up to third degree consanguineous matings. Same-degree matings are the most frequent since they involve partners who belong to the same generation. In addition, consanguinity rates and inbreeding coefficients for each period (up to third or fourth degree) are shown. Of all matings, 5·15% were consanguineous, increasing to 8·40% when marriages up to third cousins are considered (1871–1919). The above figures are not especially high in comparison to other Spanish populations. For instance, in rural Toledo 6·57% of matings were consanguineous (Calderón, 1983). However, in Los Nogales during the 20th century, α coefficient values surpassed the Spanish average given by Pinto-Cisternas, Zei & Moroni (1979). The above can be explained by the fact that percentages indicate only the tendency for marriage among relatives, or the social approval of such marriages, and do not provide information on biological closeness. An increase in inbreeding coefficients in the last third of the 19th century, resulting in maximum inbreeding levels at the turn of the century (Fig. 1), is not an unexpected result. The same pattern has been described for populations as diverse as those of the Apennines (Pettener, 1985), the Azores (Smith, Abade & Cunha, 1992), Costa Rica (Madrigal & Ware, 1997) and Canada (De Braekeleer & Ross, 1991). Discarding under-reporting throughout the 19th century, a change of Vatican policy regarding the granting of dispensations (Pettener, 1985) for close relatives (uncle–niece, aunt–nephew and first cousins) at the end of that period could have encouraged an increase in the number of applications, thus resulting in higher inbreeding levels in Catholic countries. This interpretation seems more acceptable than those that suppose that all populations experienced a census or family size increase. Although the inbreeding coefficients calculated for Los Nogales before 1890 are similar to figures reported by Sánchez (1989), they seem low in comparison to other contemporaneous areas of northern Spain, such as la Cabrera (Blanco, 1998). In the case of Los Nogales, under-reporting or bias attributable to a limited number of marriages cannot be ruled out.

In Galicia and other areas of northern Spain, the consanguinity pattern was peculiar in the sense that a moderate percentage of consanguineous matings resulted in an elevated inbreeding coefficient. In Los Nogales, despite its rurality, population dispersion, complicated geography and prevalence of smallholdings, the inbreeding level was not comparable to that of other north-western Spanish regions, such as those reported by Bernis (1974) and Blanco (1998), who obtained inbreeding

Table 1. Consanguineous marriages by degree and period

Period	C12	C22	C23	C33	C34	C44	MCM	TMC3	TMC4	TM	$\%_3$	$\%_4$	α_3	α_4
1871–1879	0	1	0	4	1	3	0	5	9	246	2·03	3·66	5·0813	5·8752
1880–1889	0	0	0	3	3	4	1	4	11	301	1·33	3·65	3·6337	5·1910
1890–1899	0	5	1	8	4	9	0	14	27	318	4·40	8·49	14·7405	16·8288
1900–1909	1	11	3	8	6	6	1	24	36	301	7·97	11·96	37·4078	39·7438
1910–1919	1	11	2	8	5	6	0	22	33	215	10·23	15·35	46·5116	49·4186
1920–1929	0	6	1	9				16	16	200	8·00		27·3437	
1930–1939	1	2	0	2				5	5	139	3·60		20·2338	
1940–1949	0	5	1	5				11	11	260	4·23		16·2259	
1950–1959	0	6	0	8				14	14	211	6·63		23·6967	
1960–1971	0	3	0	3				6	6	156	3·85		15·0240	
1871–1971	**3**	**50**	**8**	**58**	**(19)**	**(28)**	**2**	**121**	**168**	**2347**	**5·15**			

C12, uncle–niece; C22, first cousin; C23, first cousin once removed; C33, second cousin; C34, second cousin once removed; C44, third cousin; MCM, multiple consanguineous matings; TM, total marriages.
Percentage of consanguineous matings and inbreeding coefficient α ($\times 10^4$) up to third (3) or fourth (4) degree.

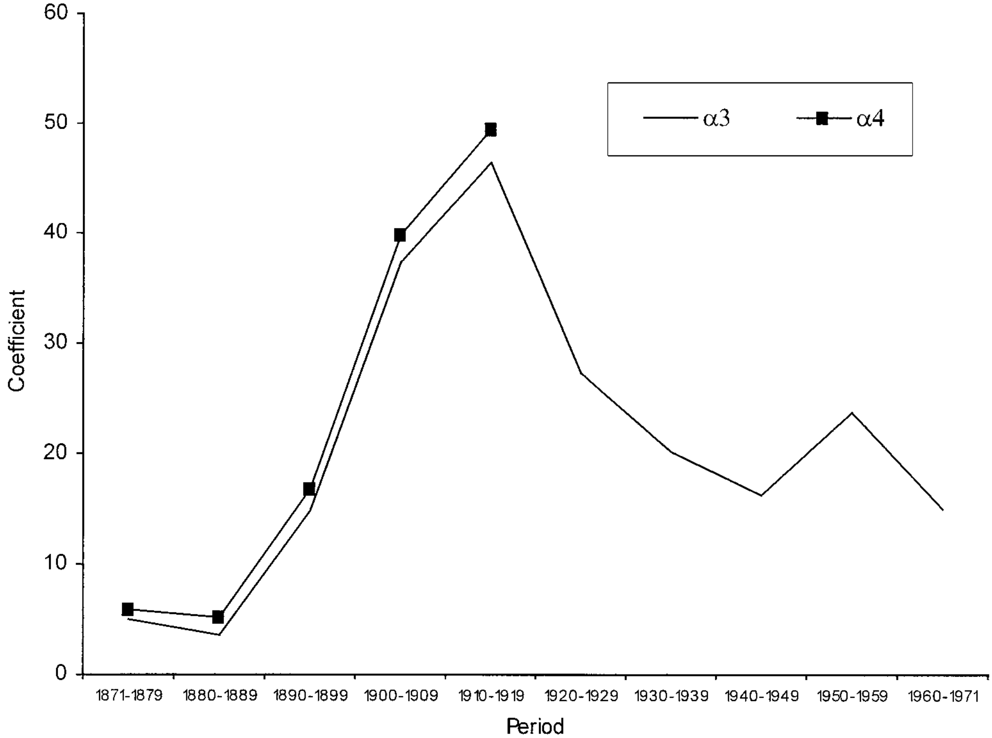

Fig. 1. Temporal evolution of up to third degree (α_3) and fourth degree (α_4) inbreeding coefficents ($\alpha \times 10^4$).

coefficients of 0·0045 and 0·0055 for the periods 1880–1949 and 1880–1979, respectively. These findings may be explained by the extremely high rate of extramarital reproduction in the studied area. In Los Nogales, from 1871 to 1975, 13·47% of 11,782 births were extramarital (Fuster, 1985), while in Spain as a whole a level of 6% was reached only in the period 1926–1930. In addition, 32% of illegitimate newborns were never given paternal recognition (Fuster, 1984, 1986a), resulting in a number of individuals for which it was not possible to trace complete pedigrees. Consanguinity was thus underestimated proportionately to the illegitimacy rate, since a fraction of mates were not detected as relatives.

Concerning the structure of consanguineous marriages, in Los Nogales (1871–1919) the C22/C33 and C33/C44 ratios are 0·86 and 0·82 respectively. Thus, they do not fit theoretical expectations since the number of relatives does not increase in proportion to the number of generations involved. The first ratio clearly exceeds that of 0·63 found by Varela, Lodeiro & Fariña (1997) for the archbishopric of Santiago de Compostela (Galicia), and it completely differs from the value of 0·23 for an area of central Spain, such as the Sierra de Gredos, Avila (Fuster, Jiménez & Colantonio, 2001). Ratios of about 0·46 for Toledo (Calderón, 1989) and Sigüenza-Guadalajara (Morales, 1992) archbishoprics are not very different from the figure reported by

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Table 2. Demographic characteristics of Los Nogales population

Year/period	Total census	Nuptiality rate	Net migration
1887	4918	5·6	
1915	4989	4·4	
1930	5081	2·79	
1940	5046	4·48	
1950	4180	6·12	
1960	3261	6·07	
1970	2544	3·53	
1887–1900			− 98
1900–1910			− 396
1910–1920			− 662
1920–1930			− 107
1930–1940			− 889
1940–1950			− 400
1950–1960			− 999
1960–1970			− 597

Gómez (1989) for León. In Alava Province, Calderón *et al.* (1993) found a C22/C33 ratio even higher than that in Los Nogales. This high value has sometimes been attributed to a preference for uncle–niece, aunt–nephew and first-cousin marriages in order to maintain or to enlarge the family inheritance. A factor to take into account is that if consanguinity is underestimated proportionately to the illegitimacy rate, the various degrees of relationship may be affected differently. According to this, a high C22/C33 ratio could be a consequence of a higher probability of interrupting genealogical links by illegitimacy as more generations became involved.

Migration has been reported to affect consanguinity. Thus, emigration may increase consanguinity since the number of potential mates would decease (Barrai, Cavalli-Sforza & Moroni, 1969; Morton, 1971). However, according to Cavalli-Sforza (1969), emigration produces a geographic dispersion of relatives. Studies on consanguinity in Spain have mostly referred to premarital migration expressed as endogamy rates (Fuster *et al.*, 1995) or proportion of mates with or without premarital migration (Calderón, 1989). These authors found that consanguineous matings were associated with a lower mobility. In Los Nogales net migration has always been negative, both for males and females (Table 2). Between 1887 and 1920 net migration became progressively negative, while the inbreeding coefficient increased. From 1920 to 1930 net migration, although negative, was closer to 0, but the inbreeding coefficient reduced from 0·004651 to 0·002734. Its population decreased by about one-fifth in the periods 1930–1940 and 1950–1969, coinciding with the time of maximum emigration. Thus, in Los Nogales the temporal change in the inbreeding coefficient did not fit with emigration, since before 1910 consanguinity increased with a negative net migration, and the continuous decrease of inbreeding began in 1920, previous to the maximum emigration.

Regarding the marital rate, periods of elevated nuptiality (Table 2) produce a higher demand for mates, thus increasing marriages among relatives, which could apply to Los Nogales and thus explain the initial increasing tendency for inbreeding. From 1871–1899 to 1900–1929 a reduction was observed in the proportion of first marriages from 85·22 to 81·88% (Fuster, 1982), perhaps corresponding either to a greater demand for mates (including relatives) or to differential emigration of unmarried people. This assertion cannot be confirmed since information on the number of people who left the area was not available.

The reproductive success in a population has been related to its inbreeding pattern. Agarwala, Schäffer & Tomlinj (2001) found for Amish and Mennonite individuals a very strong positive association between inbreeding and family size, as well as shorter birth intervals. Many authors accept that inbreeding has consequences for pre- and postnatal mortality. However, according to Bittles & Makov (1988), the demonstration of these effects is not conclusive. To relate inbreeding to complete fertility is informative because there are few studies based on non-Asiatic populations that have analysed both variables (Böök, 1957; Edmond & De Braekeleer, 1993; Georges & Jacquard, 1968). Table 3 shows that although after 1900 infant mortality in Los Nogales was slightly more elevated in consanguineous families, fertility and the number of children surviving to age 15 were higher among consanguineous couples ($\chi^2_{(24)}$; $p>0{\cdot}05$). The observed differences between consanguineous and non-consanguineous families may be explained by heterogeneity in a set of variables, such as marriage duration, first maternity age, etc. Considering the whole set of Los Nogales reconstituted families, a multivariate regression analysis proved (Fuster, 1986b) that both marriage duration and age at first maternity influence significantly the number of live births, as described for other Spanish rural communities (Luna & Fuster, 1990). Table 4 shows representative values for some of those variables for consanguineous families and for the total sample. Ages at marriage and at first maternity were, in both periods, slightly lower among consanguineous couples. The marriage duration (determined by the death of one of the mates) was more elevated among consanguineous couples which, in part, could be due to a higher proportion of first marriages. Lower first maternity and marital ages and longer marriage duration among consanguineous couples would explain their higher fertility. In a recent review on the effects of inbreeding on fertility, Bittles *et al.* (2002) state that a large component of the differentials in fertility could be attributed simply to marriage duration. Besides, a lower frequency of infertility among consanguineous matings (Table 3, bottom) also contributed to a larger mean number of live births in this group. Among other authors, Rao & Inbarag (1977) reported a lower infertility associated with consanguinity. The above is in agreement with the Bittles *et al.* (1991) assertions that studies from a number of different populations have demonstrated reduced levels of primary sterility in inbred marriages and that consanguinity is associated with earlier marriage and younger maternal age at first delivery.

Since the Schull & Neel (1963) paper on the effects of inbreeding on mortality, an unresolved issue in research on child survival is the extent to which familial mortality risk in infancy is due to biological influences net of sociodemographic and economic factors (Dorsten, Hotchkiss & King, 1999). According to Bittles & Makov (1988), reviews of research on the effects of inbreeding in human populations provide mixed

Table 3. Absolute and relative frequencies of live births and children surviving to the 1st and 15th birthday per reconstituted family. Mean number of live births, infant mortality, survivors to the 15th birthday and percentage of infertile couples

	1871–1899				1900–1929			
	Non-consanguineous		Consanguineous		Non-consanguineous		Consanguineous	
	n	%	*n*	%	*n*	%	*n*	%
Total live births	2744	100	239	100	1974	100	289	100
% surviving 1 year	2336	85·13	219	91·63	1747	88·50	251	86·85
% surviving 15 years	1900	69·24	181	75·73	1577	79·89	215	74·39
	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
Births/family	5·053	0·134	6·459	0·607	4·768	0·158	5·218	0·428
Infant mortality/family	0·751	0·045	0·540	0·139	0·548	0·043	0·690	0·157
Surviving 15 years/family	3·506	0·105	4·892	0·484	3·846	0·137	3·909	0·371
% infertility	7·366		2·703		6·763		3·636	

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Table 4. Average biodemographic characteristics of total reconstituted families and consanguineous families

Period	Family type	% first marriages	Age at first maternity	Age at marriage	Marriage duration	Illegitimacy per wife
1871–1899	Consanguineous	90·62	23·77	24·47	30·53	0·25
	Total	85·22	25·14	25·55	26·12	0·22
1900–1929	Consanguineous	89·13	25·02	24·69	29·12	0·12
	Total	81·88	25·90	25·41	28·11	0·15

results. In several north-western Spanish rural communities, higher infant mortality has been found to be associated with consanguinity (Álvarez-Edo, Rodríguez-Otero & Caro, 1985; Bernis, 1974; Blanco, 1998; Rodríguez-Otero *et al.*, 1991; Sánchez, 1989), but more surviving children were indicated only by Blanco (1998) and by Rodríguez-Otero *et al.* (1991).

Schull & Neel (1972) reported a more elevated number of pregnancies and live births, but net reproduction (surviving children) was similar in consanguineous and in non-consanguineous families. According to these authors, a higher fertility would have compensated for a decreased probability of survival. In Los Nogales, such a compensatory effect was found only for the 1900–1929 period (Table 3) while in the preceding period there was an over-compensation (net reproduction in consanguineous matings surpassed non-consanguineous). The lack of consistency in results provided by the bibliography indicates that attempts to prove the role played by consanguinity in reproductive success seem to be complicated by the presence of demographic, socioeconomic and cultural factors, which could mask any genetic influence of inbreeding. In the opinion of Bittles *et al.* (1991), the association between consanguinity and socioeconomic position complicates the study of the genetic effects of human inbreeding. When each of these variables is taken into consideration, virtually all studies to date have reported no significant difference in the numbers of surviving children in consanguineous and non-consanguineous families. For that reason, both biological and social considerations must be taken into account when judging the relation of consanguinity to reproductive behaviour and fertility.

It is concluded that in populations where extramarital reproduction is considerable, both the inbreeding coefficients as well as the different relationship ratios may be biased. The availability of biodemographic information may be helpful in order to understand a population's inbreeding pattern in terms of temporal evolution and structure, as well as reproductive aspects related to consanguineous matings.

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