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SPATIAL AND TEMPORAL VARIABILITY OF CONSANGUINITY IN THE FRENCH CERDAGNE (1836-1990)[1]

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ABSTRACT.- In this paper we have studied consanguinity in the population of the French Cerdagne (a Pyrenean valley) from 1836 until 1990. Calculation of consanguineous marriage frequencies and of the coefficient α reveals that consanguinity in this population is slightly lower than in other Pyrenean populations. Analysis of variability over time shows a decrease in the consanguinity levels during the above-mentioned period. The consanguinity pattern is similar in all parts of the area considered.

RESUMEN.- En este trabajo se ha estudiado la consanguinidad de la comarca pirenaica de la Cerdaña francesa desde 1836 a 1990. El cálculo de las frecuencias de matrimonios consanguíneos y del coeficiente α muestra que la consanguinidad de esta población es inferior, aunque no excesivamente, a la de otras poblaciones pirenaicas. El análisis de la evolución a lo largo del tiempo muestra un descenso de los niveles de consanguinidad durante todo el período estudiado. El modelo de consanguinidad es parecido en todas las zonas del área estudiada.

RÉSUMÉ.- Dans ce travail nous avons étudié la consanguinité de la région de la Cerdagne française dans les Pyrénées depuis 1836 jusqu'à 1990. Le calcule de la fréquence des mariages consanguins et de le coeficient α montrent que la consanguinité de cette population est inférieure, quoique pas excéssivement, à celle d'autres populations des Pyrénées. L'analyse de l'évolution à travers le temps a demontré une reduction des niveaux de consanguinité pendant la période étudiée. Ce modèle de consanguinité est semblable dans toutes les zones de la region étudiée.

Key-words: *Consanguinity, Pyrenees, Cerdagne.*

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Human consanguinity, i.e. the proportion of marriages between related people, is one of the most important factors that can change the genetic pool of a population (CAVALLI-SFORZA & BODMER, 1971; VALLS, 1982). The probability of the existence of identical genes at the same locus is greater in individuals who are the fruit of a consanguineous union, and this leads to a decrease in genetic variability which causes important evolutionary repercussions. The study of consanguinity is thus of great interest for human genetic studies.

Consanguinity is high in small Pyrenean populations that are isolated by orographic barriers. In this paper we study consanguinity in the Pyrenean population of the French Cerdagne, analyzing ecclesiastical dispensations from matrimonial registers. The study refers to the frequency of consanguineous marriage, the mean consanguinity of the population and the spatial and temporal variability of these two parameters.

1. Area considered

The French Cerdagne is situated in the Eastern Pyrenees and coincides with the headwaters of the Segre river. The traditional economic activities of the area are agriculture and cattle raising, but since the beginning of this century, tourism and leisure industries have grown. The population density is slightly higher than in most other eastern Pyrenean populations although since 1950 there has been a slight trend towards depopulation.

In order to study the spatial distribution of consanguinity we divided the area into five zones according to the geography, numbered 1-5: Zone 2 corresponds to the natural valley of Querol and zone 3 to the Angostrina valley. Zone 4 (or zone of Odelló) comprises all the villages on the E-NE slope of the mountains. The plain is divided into two zones: 1 and 5. Zone 1 or zone of Oceja comprises the area adjacent to the Spanish border. Zone 5 or zone of Sallagosa is included between zone 1 and zone 4 (Fig. 1).

2. Material and methods

This study analyzed a sample of 4.800 marriages which took place in the French Cerdagne over a period of 155 years, from 1 February 1836 until 31 December 1990. There were 168 consanguinity dispensations. The information was introduced into a Personal Computer in a database created with dBase III+. SPSS-X run on an IBM 3090 was used for statistical analysis.

3. Types of consanguineous marriages and inbreeding coefficient

Consanguineous marriages are classified into different types according to the degree of relationship between the spouses. Table 1 shows the most

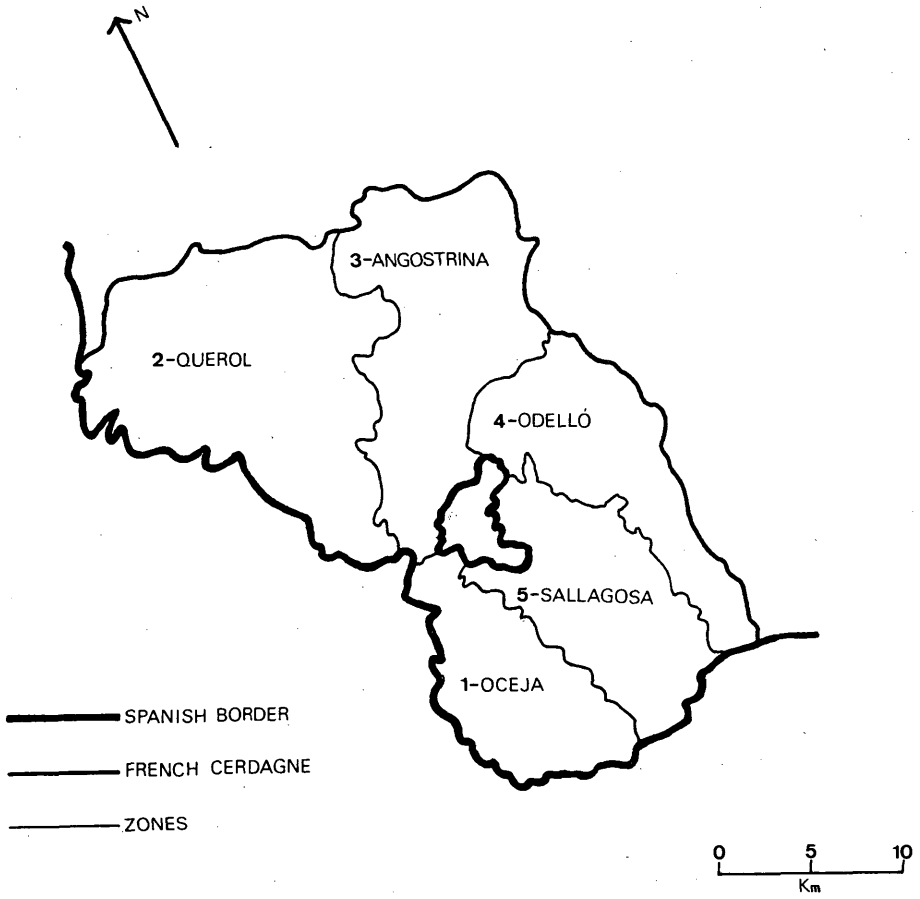

Fig. 1. Zones of the French Cerdagne. *(Zonas de la Cerdaña francesa).*

common types of consanguineous matings, the code used in this study and their inbreeding coefficient. The inbreeding coefficient, F, is equal to the probability that one individual has two alleles identical by descent (a copy of the same allele) at a given locus. This coefficient was originally defined by Sewall Wright (1922) but the definition given is due to Malécot (in CAVALLI-SFORZA & BODMER, 1971). F is calculated by the expression:

$$F = (1/2)^{(n+1)}$$

where *n* is the number of generations between the person considered and the common ancestors of their parents.

TABLE 1

Codes of consanguineous marriages and Wright consanguinity coefficient.
(Códigos de matrimonios consanguíneos y coeficiente de consanguinidad de Wright).

description	*degrees of relationship (Roman Catholic Usage)*	*code*	*F*
uncle-niece or aunt-nephew	1 in 2	1	1/8
first cousins	2 (2 in 2)	2	1/16
first cousins once removed	2 in 3	3	1/32
second cousins	3 (3 in 3)	4	1/64
second cousins once removed	3 in 4	5	1/128
third cousins	4 (4 in 4)	6	1/256

The mean consanguinity in a population is obtained by computing the average F of its individuals and represented by the Bernstein coefficient, α (CAVALLI-SFORZA & BODMER, 1971). The value of α depends on the number of consanguineous marriages of each type, as each one contributes a different degree of consanguinity. The Bernstein coefficient is given by:

$$\alpha = (p_i * F_i)$$

where F_i and P_i are the inbreeding coefficient and the relative frequency of the i-th type of consanguineous marriage.

4. Results and discussion

4.1. *The frequency of consanguineous marriages*

The frequency of consanguineous marriages in the French Cerdagne is lower than that of other Pyrenean populations studied since the second half of the nineteenth century (ABELSON, 1978; VALLS, 1983; TOJA & LUNA, 1985; PALACIOS, 1986; TOJA, 1987) with the exception of Llívia village, where there were only 11 consanguinity dispensations during the period 1871-1984 (PALLARÈS, 1990).

Table 2 shows the percentage of the different types of consanguineous marriages, their Bernstein coefficient and their contribution to the total value of α. Unions between people of equal degree are more frequent than those between people of unequal degree because the former involve persons of the same generation and, consequently, of similar age. Taking only the matings of unequal degree, the most frequent marriages are those of remote inbreeding, which is understandable if we consider that the lower the degree of relationship, the more relations a person has (this is also true for unions of equal degree, but in this case there is no difference in frequency).

TABLE 2

Frequencies of the different types of consanguineous marriages and their contribution to total consanguinity. *(Frecuencias de los diferentes tipos de matrimonios consanguíneos y su contribución a la consanguinidad total).*

codes	*degrees*	*N*	%	$\alpha*10^3$	%
1	1 in 2	0	0.00	0.000	0.00
2	2 (2 in 2)	66	39.29	0.859	74.65
3	2 in 3	9	5.36	0.059	5.12
4	3 (3 in 3)	57	33.93	0.186	16.49
5	3 in 4	17	10.12	0.028	2.43
6	4 (4 in 4)	19	11.30	0.016	1.31
all		168	100.00	1.152	100.00

4.2. *The Bernstein coefficient*

The value of α is low ($\alpha = 1.152*10^{(-3)}$) but comparable with the values observed in other Pyrenean populations during a similar period (VALLS, 1983; TOJA & LUNA, 1985; PALACIOS, 1986; TOJA, 1987). Most of the consanguinity is due to type 2 marriages (between first cousins) because these are the most frequent and have a high value of F (Tables 1 and 2). The contribution of type 4 marriages is also rather important, since they have a high frequency and an F value of 1/64. The contribution of the rest of consanguineous marriages is not high (8.86% of total value of α). There is no type 1 marriage (between uncle-niece or aunt-nephew) but this is as expected, since it is not a common type of marriage (VALLS, 1983; TOJA & LUNA, 1985; PALACIOS, 1986) and the Catholic Church has not conceded dispensations for this degree since 1935 (SUTTER & GOUX, 1962). Notice that although the percentage of consanguineous marriages in the French Cerdagne is lower than in other Pyrenean populations, the mean consanguinity does not differ significantly. This is due to a higher percentage of marriages between closer relations in the French Cerdagne, especially of type 2, which have greater values of F.

4.3. *Spatial variability*

In the analysis of spatial variability we did not take into account the zone of Angostrina because the ecclesiastical registers in this zone did not begin until 1911 and this could cause bias. This spatial limitation does not invalidate the previous results, nor those referring to the evolution of α over time.

The percentages of consanguineous marriages are similar in all the zones of the area considered. Thus the α values are not so different in the four

zones, with a maximum value in the zone of Oceja ($\alpha = 1.686*10^3$) and a minimum in the zone of Sallagosa ($\alpha = 0.852*10^3$). As occurred when we considered the full area, type 2 marriages (between first cousins) and type 4 marriages (between second cousins) are the most frequent in each zone: taken together they always represent more than 60% of consanguineous marriages. The prevalence of these two types of consanguineous marriages is especially clear in the zone of Sallagosa, where there is no type 3 marriage (first cousins once removed).

Fig. 2 shows the contribution by zone of each type of consanguineous marriage to total consanguinity. In all zones we notice a similar pattern to that described for the whole area: a high contribution of type 2 marriages, then, with a great difference, follows type 4, next comes type 3 and at last types 5 and 6. This pattern is very clear in the Sallagosa zone, where there is no type 3 marriage, and types 5 and 6 marriages are infrequent.

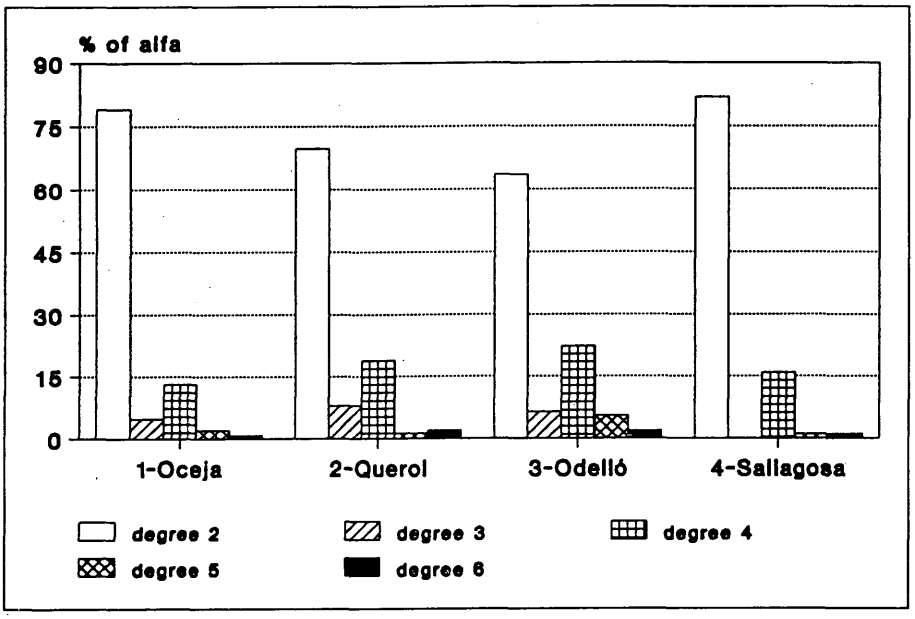

Fig. 2. Contribution of each degree to total consanguinity by zones. *(Contribución de cada grado a la consanguinidad total por zonas).*

4.4. *The variability of consanguinity over time*

Fig. 3 shows the evolution of coefficient α over time by decades. In this figure α is separated into two components: one deals with the closer consanguineous marriages (types 2 and 3) and the other deals with remote consanguineous marriages (types 4, 5 and 6).

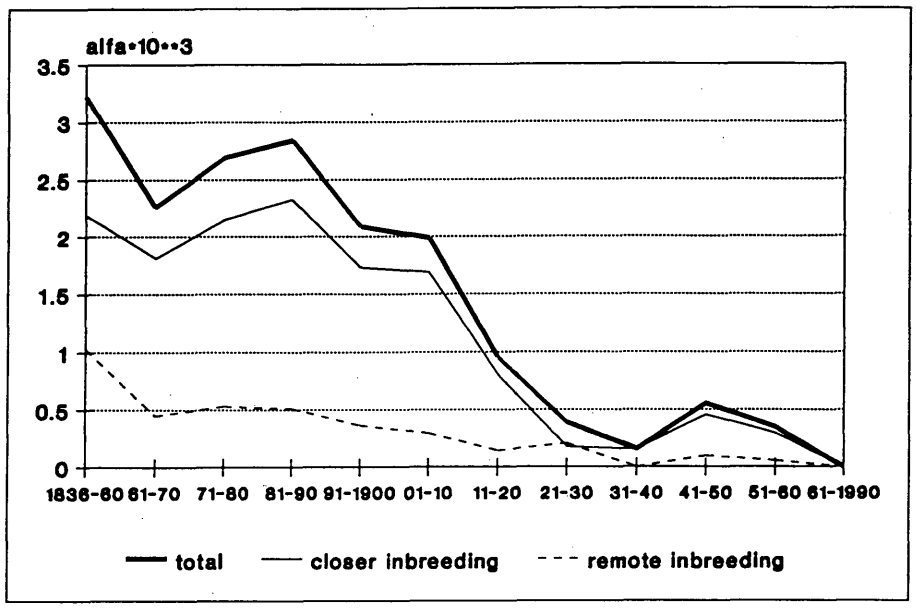

Fig. 3. Evolution of the components of the consanguinity coefficient. *(Evolución de los componentes del coeficiente de consanguinidad).*

The value of α is low in all decades and it decreases over the period considered. This is different from that observed in several populations of the southern slope of the Pyrenees, where there was a gradual increase in consanguinity levels during the last century, a faster increase in the first decades of this century and a very fast decrease up to the present (VALLS, 1983; PALACIOS, 1986; TOJA *et al.*, 1986; TOJA, 1987).

Although the ratio between the two components of α is near 1:1 most of the time, the closer consanguineous marriages contribute more to the total value of α since they have a high coefficient of inbreeding. In the periods 1836-60 and 1921-30 there is a more important contribution of remote consanguineous marriages, which are more frequent although their F is smaller (value of α for 1931-40 is not valid because in this decade there was only one consanguineous marriage). Thus the decrease in the consanguinity

levels during the period studied is due to a decrease in both remote and closer types of consanguineous marriage.

However there are three decades in which α increases: 1871-80, 1881-90 and 1941-50. The increase in the first and in the last correspond to an increase in consanguineous marriage frequencies. Indeed in the decade 1881-1900 there was an increase in α coefficient although there was a decrease in the frequency of consanguineous marriages. The explanation is that the number of closer consanguineous marriages —which have a more important contribution to the α coefficient— decreases faster than the number of remote marriages.

The low levels of α throughout the period are consistent with a high population movement between villages in the French Cerdagne and the exterior. For example, taking the whole period considered (1836-1990) 73% of marriages are exogamous (one or both spouses were born outside the French Cerdagne) compared with only 27% of endogamous marriages (both spouses were born in the French Cerdagne). These percentages are not constant over time, but exogamous marriages account for at least 50% of all couples in all decades (VIGO, 1991). Thus we can explain the lower levels of consanguinity is the French Cerdagne compared with other Pyrenean populations.

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