

# Isonymic Analysis of Population Structure in Gredos, Spain

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## ABSTRACT

*For the period 1875–1975 an isonymic analysis was made based on 41,696 marriages celebrated in three valleys (Tormes, Alberche and Tietar) from Gredos (Spain). Total inbreeding (Ft) was lower in the Tietar valley (0.0103–0.0136), followed by the Tormes (0.0125–0.0255) and the Alberche (0.0153–0.0200). In the latter, random inbreeding (Fr) surpassed non random (Fn). Correlation coefficients were obtained to confirm an association of inbreeding from isonymy with valley and village endogamy rates, locality census, altitude, and  $\alpha$  inbreeding. Fn correlated positively with average valley endogamy and village endogamy and with altitude, but inversely with census size. Contrarily, Fr related significantly to village endogamy. The non-random component from isonymy related positively to inbreeding from dispensations. Except for village endogamy, both variables show the same relationships to variables, such as altitude, which reflect limitations to mobility; or valley endogamy indicating the disposability of potential mates which in turn depends on the census size.*

**Key words:** surnames, isonymy, inbreeding, Gredos, Spain

## Introduction

It is possible to establish the influence of limited mobility on population genetic structure by using surnames which allow the study of inbreeding levels following the Crow and Mange<sup>1</sup> method and the inter-population relationship of Lasker<sup>2</sup>.

The Spanish system of surname transmission includes two names (paternal and maternal). Schematic representations of this system are reported by several authors<sup>3,4</sup>. Shaw<sup>5</sup> was the first to indicate the advantages of this system, which Lasker<sup>6</sup> summarized by doubling the number of surnames and distinguishing between patrilineal and matrilineal kinship.

Sierra de Gredos is restricted to the province of Avila and occupies a surface of 2,400 Km<sup>2</sup>. The Tormes and the Alberche valleys are located at the northern slope, while the southern slope (Tietar Valley) opens onto the Castilian Plateau, which extends throughout most of central Spain (See Fuster et al.<sup>7</sup>, for a map).

Marriages celebrated between 1875–1975 in 48 parishes consisting of 40 municipalities (9 of which belong to the Tormes, 13 to the Alberche and 18 to the Tietar valley) were analyzed. The 1877–1970 mean number of in-

habitants was 7,117, 18,331 and 35,113 respectively. From 1960 onwards, emigration towards more developed regions has taken place, contributing to a census decrease in some localities. Agriculture predominates in Gredos, though besides a modest forest industry, tourism has recently been developed in several villages.

The Sierra de Gredos, with a maximum altitude of 2,600 m and only three north-south natural passes, has limited mobility among valleys. Gredos valley heterogeneity regarding altitude, census size and marital endogamy justify an analysis of inbreeding by isonymy per valley. Supplementing previous studies of the migration pattern and of consanguinity<sup>7,8</sup>, the present research explores the intra and inter-valley variation of the diverse components of kinship, including their temporal change.

## Materials and Methods

A sample of 41,696 weddings, celebrated in three valleys (Tormes, Alberche and Tietar) from the Gredos mountain range, provided information consisting of 4 surnames per couple.

Instead of the usual analysis according to wedding place, data for the present research were organized by means of the groom’s place of residence which, in most cases, corresponds to the locality of reproduction. Marriages were assigned to any of the three valleys considered, and families whose reproduction was expected to occur in localities external to any of the 40 municipalities belonging to the Gredos valleys were not taken into account.

Total inbreeding from isonymy (Ft) can be directly calculated from marital isonymy. The contribution of random (Fr) to the total inbreeding coefficient (Ft) was determined by the distribution of surnames, while the non random inbreeding (Fn), due to other factors, such as tendency for mating among relatives, was estimated from Ft and Fr. Since in Spain two surnames are taken by any individual (the first given by the father and the second by the mother), the expected random isonymy and the corresponding Fr inbreeding coefficients were calculated according to the Pinto-Cisternas et al.<sup>3</sup> method, a modification of the Crow and Mange<sup>1</sup> prior procedure which considers only one surname per individual. Fr is defined as  $(\sum p_{i1}q_{i3} + \sum p_{i1}q_{i4} + \sum p_{i2}q_{i3} + \sum p_{i2}q_{i4})/4$ , where pi represents the frequency of surname i among husbands and qi among wives; 1 to 4 indicates the surname origin (1 and 3 paternal, 2 and 4 maternal). According to Pinto-Cisternas et al.<sup>3</sup> Fr, Fn and F are homologous to  $F_{ST}$ ,  $F_{IS}$  and  $F_{IT}$  in Wright’s nomenclature, respectively. The first notation was preferred in this paper due to its frequent use in inbreeding studies by isonymy<sup>9–12</sup>.

Each valley census size per period corresponds to the number of inhabitants at the central year of the period. Valley and village endogamy rates were obtained according to the proportion of husbands and wives born the same valley or village, respectively.

## Results and Discussion

The Gredos valleys are heterogeneous regarding the average size and altitude of villages as well as endogamy rates, both calculated by village or by valley (Table 1). Irrespective of period, the highest percentage of intra-valley marriages occurred in the Tormes, but for village endogamy, these occurred only during the two last periods (1935 to 1975). In this valley a much reduced number of village inhabitants may have limited endogamous marriages. However, the Tormes valley, as a whole, could have provided enough potential mates to cause an elevated intra-valley endogamy rate.

In Table 2 are shown the results corresponding to the three components of the inbreeding coefficient obtained for the periods considered. For comparison purposes the inbreeding coefficient from dispensations ( $\alpha$ ) is included, although the fact should be kept in mind that surnames overestimate inbreeding, as reported by several authors<sup>13–15</sup>. Regarding temporal variations of the inbreeding components estimated from isonymy, no clear pattern was found. The only noticeable result corresponds to higher values of inbreeding by isonymy between 1915 and 1954, a variation similar to that of the inbreeding coefficient estimated from ecclesiastical dispensations<sup>7</sup>. In absolute terms, maximum inbreeding (both from dispensations and from surnames) corresponds to the Tormes and minimum to the Tietar, the Alberche having intermediate values, but closer to the Tietar than to the Tormes, mainly in the case of dispensations.

Considering inter-valley variation, Ft coefficients are slightly lower in the Tietar valley (0.0103–0.0136), followed by the Tormes (0.0125–0.0255) and the Alberche (0.0153–0.0200). In the Alberche valley Fr always surpasses Fn, while Fn predominates in the Tormes. As shown in Table 1, the Alberche valley has higher village endogamy, regardless of period (Table 1). On the con-

**TABLE 1**  
AVERAGE VILLAGE CENSUS, WEIGHTED ALTITUDE AND ENDOGAMY PER VALLEY AND PERIOD

Period	Average census and altitude (m)			Endogamy type	Tormes		Alberche		Tietar	
	Tormes	Alberche	Tietar		N	ER (%)	N	ER (%)	N	ER (%)
1875–1894	572	1129	1518		696	94.68	2049	88.58	4416	83.56
1895–1914	648	1251	1739		787	95.68	2758	84.45	4696	85.35
1915–1934	652	1416	1924	Valley	703	93.74	3077	86.81	4727	86.84
1935–1954	646	1498	2235	endogamy	619	94.67	2497	85.06	4621	84.98
1955–1975	502	1363	2047		380	93.42	2153	81.56	3945	90.14
1875–1894	1295	993	661		696	73.13	2049	81.60	4416	75.57
1895–1914	1290	971	655	Village	787	75.73	2758	78.79	4696	76.72
1915–1934	1277	959	644	endogamy	703	78.81	3077	82.35	4727	77.39
1935–1954	1277	972	634		619	78.84	2497	77.57	4621	74.57
1955–1975	1285	952	625		380	79.74	2153	74.41	3945	68.95
Total					3185		12534		22405	

ER – valley and village endogamy rates in %, N – number of marriages, endogamy rates obtained considering valley and village as the population units

**TABLE 2**  
RANDOM (Fr), NON-RANDOM (Fn) AND TOTAL COEFFICIENTS (Ft) OF INBREEDING BY ISONYMY AND INBREEDING COEFFICIENT ( $\alpha$ ), PER VALLEY AND PERIOD

Valley	Period	Fr	Fn	Ft	$\alpha$
Tormes	1875–1894	0.00474903	0.00777703	0.01248913	0.0026042
	1895–1914	0.00563163	0.01091722	0.01648736	0.0035538
	1915–1934	0.00584351	0.01141036	0.01718720	0.0041341
	1935–1954	0.00623901	0.01937383	0.02549196	0.0041650
	1955–1975	0.00589752	0.01461041	0.02042176	0.0017270
Alberche	1875–1894	0.01060138	0.00946349	0.01996455	0.0007092
	1895–1914	0.00882281	0.00778167	0.01653583	0.0008158
	1915–1934	0.00899769	0.00795547	0.01688158	0.0012086
	1935–1954	0.00895069	0.00778261	0.01666364	0.0010763
	1955–1975	0.00829833	0.00707533	0.01531495	0.0001379
Tietar	1875–1894	0.00482928	0.00548212	0.01028493	0.0007749
	1895–1914	0.00536417	0.00652434	0.01185351	0.0007952
	1915–1934	0.00535274	0.00833751	0.01364562	0.0014412
	1935–1954	0.00544131	0.00683997	0.01224406	0.0010448
	1955–1975	0.00525514	0.00554023	0.01076625	0.0002812

Inbreeding coefficient  $\alpha$  calculated from ecclesiastical dispensations, up to third degree

trary, the Tormes has always maximum valley endogamy, indicating that valley endogamy could be related to Fn, and Fr to village endogamy. The reduced village sizes in the Tormes would have limited the number of potential mates, thus encouraging the establishment of couples among inhabitants of the valley, while in the Alberche more marriages could have taken place within each village.

Regarding the above results, each valley differential census size was taken into account. In the Tormes valley, the combination of small village size, maximum altitudes and therefore greater geographical isolation, could be expected to have produced high F coefficients but, on the contrary, low coefficients in the Tietar (larger village size, minimum altitudes and lower geographical isolation). Furthermore, according to Relethford<sup>16,17</sup>, a different total number of surnames may affect the results since Fr is expected to be smaller in large populations, a result which is true for the Tietar.

Correlation coefficients between variables were obtained to confirm whether Fr and Fn differences can be related to the endogamy rates both at valley and village levels, average locality census per valley and weighted altitude. Correlations with the  $\alpha$  inbreeding coefficient obtained from ecclesiastical dispensations (Table 2, right) were also calculated. Because several of these variables do not fit a normal distribution, a non parametric correlation was applied (Table 3).

The most frequent significant correlations for the variables shown in Table 3 exist for Fn. Fn related positively to the average valley endogamy and village endogamy, as well as to altitude and  $\alpha$  coefficient, and in-

versely to census size. The inbreeding from dispensations ( $\alpha$ ), with the exception of village endogamy, showed the same association with the remaining variables.

The positive correlation between Fn and altitude, and negative with village size, is in agreement with the relationship between  $\alpha$  and the same variables found in a review based on published inbreeding data from ecclesiastical dispensations<sup>18</sup>.

Contrarily, Fr relates significantly to village endogamy, but not to valley endogamy, census or altitude. The lowest correlation coefficients were found between valley and village endogamy rates (0.143) and between Fr and valley endogamy (–0.182), suggesting that in Gredos random factors affecting marriages are restricted to village level. The non-random component of inbreeding estimated from isonymy (Fn) may represent marriages between relatives, but Fr concerns only village endogamy.

Valley endogamy correlates negatively to the average number of village inhabitants in each valley (–0.600,  $p < 0.05$ ) but that of village does not correlate significantly. The negative significant correlation existing between Fn and the average village census is concordant with the availability of non-related mates in each village.

Finally, altitude correlates significantly with all factors other than village endogamy and Fr: at highest altitude villages are smaller, and larger preferential inbreeding exists among valley localities.

In Gredos the marital migration pattern was characterized by north-south mobility restriction<sup>8</sup>. The southern Gredos slope (Tietar) was more open to immigrants from areas outside the other two valleys, which is in agreement with the geographical characteristics of this

**TABLE 3**  
NON-PARAMETRIC ( $\rho$ ) CORRELATION COEFFICIENT AMONG RANDOM (Fr), NON-RANDOM (Fn) AND TOTAL COEFFICIENTS (Ft)  
OF INBREEDING BY ISONYMY; INBREEDING COEFFICIENT ( $\alpha$ ), CENSUS AND THE ENDOGAMY RATES (ER)

	Fr	Fn	Ft	$\alpha$	Census	Valley ER	Village ER
Fn	0.468						
Ft	0.743*	0.904***					
$\alpha$ coefficient	-0.061	0.732*	0.504				
Census size	-0.239	-0.696*	-0.679*	-0.579**			
Valley ER	-0.182	0.618**	0.375	0.721*	-0.600**		
Village ER	0.725*	0.711*	0.829***	0.343	-0.386	0.143	
Altitude	0.214	0.675*	0.621**	0.654*	-0.946***	0.643**	0.346

Inbreeding coefficient  $\alpha$  calculated from ecclesiastical dispensations, up to third degree. Endogamy rates obtained considering valley and village as the population units. \* $p < 0.01$ , \*\* $p < 0.05$ , \*\*\* $p < 0.001$

mountain range, the Tormes valley located at a higher altitude than the Tietar. In terms of surname variation, the smaller Fr and Fn coefficients correspond to the Tietar. In addition, each valley population size and endogamy are reflected in the distribution of surnames, mainly affecting the Ft and Fn coefficients, while Fr shows a less differentiated pattern.

The correlation coefficients obtained in the present analysis confirm that inbreeding relates positively to the non-random component from isonymy, to variables which reflect limitations of mobility (altitude), and to valley en-

dogamy, which in turn depends on the census size determining the disposability of potential mates within every village.

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### ANALIZA IZONIMIJE POPULACIJSKE STRUKTURE U GREDOSU, ŠPANJOLSKA

#### SAŽETAK

U razdoblju od 1875. – 1975. godine provedena je analiza izonimije temeljena na 41.696 brakova sklopljenih u tri doline iz Gredosa, Španjolska (Tormes, Alberche and Tietar). Ukupno srođivanje (Ft) bilo je najniže u dolini Tietar (0,0103-0,0136, zatim u dolini Tormes (0,0125-0,0255) pa u dolini Alberche (0,0153-0,0200). U potonjoj je slučajno sro-

đivanje (Fr) nadmašivalo neslučajno (Fn). Izračunati su korelacijski koeficijenti kako bi se potvrdila povezanost između srođivanja izračunatog na temelju analize izonimije sa stupnjem endogamije na razini sela i doline, veličinom populacije lokaliteta, nadmorskom visinom i srođivanjem. Fn pokazuje pozitivnu povezanost s prosječnim stupnjem endogamije na razini sela i doline te s nadmorskom visinom, ali i negativnu povezanost sa veličinom populacije. Nasuprot tome, Fr pokazuje značajnu povezanost sa stupnjem endogamije sela. Osim sa stupnjem endogamije sela, obje varijable pokazuju istu povezanost s varijablama kao što su nadmorska visina te stupanj endogamije doline. Nadmorska visina održava ograničenje mobilnosti, a stupanj endogamije doline indicira dostupnost potencijalnih partera, što opet ovisi o veličini populacije.