Determinants of marital behaviour in five Apennine communities of Central Italy inferred by surname analysis, repeated pairs and kinship estimates

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Running title: Determinants of marital behaviour in Central Italy

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Abstract

The work makes use of surname analysis, repeated pairs and kinship estimates in 11,009 marriage records celebrated in five communities of the Italian Central Apennine (Celano, Lecce dei Marsi, Ortucchio, Roio, Villavallelonga) from 1802 to 1965 with the objective to deepen the knowledge of the relative influence of several determinants on their marital behaviour. These towns are part of the same geographic and economic environment: the slopes of the ancient Fucino lake. This work further deepens results from previous studies on the bio-demographic model of the region. The data were analyzed by three periods of approximately 50 years. Results show the highest inbreeding coefficients in the pastoral towns of Roio and Villavallelonga. Repeated pair analysis highlights a certain degree of population subdivision which declined in time in Celano, Lecce dei Marsi and Ortucchio. The highest and increasing values of RP-RPr in time in Roio suggest a general reduction in genetic heterogeneity. This is possibly due to the celebration of marriages among families selected on the economic basis of pastoralism, as this town historically had a leading tradition of sheep-farming. Villavallelonga, excluding isonymous marriages, shows increasing repeated pair unions in time, thus revealing a substructure with marriages among preferred lineages. This is in line with previous results on consanguineous marriages pointing out the tendency of avoiding unions between close relatives in this small geographic isolate. In conclusion, this study demonstrates the influence of geographical (altitude) and social factors (pastoralism) on the marital structures of the investigated populations.

Keywords: marriage records, isonymy, repeated pairs, local kinship, isolated populations

Introduction

Surname analysis proved to be a useful tool for evaluating the demographic history of human populations, through the persistence, entrance or extinction of surnames, and for estimating the effects of potential isolation factors, such as environmental and cultural barriers, on the marital structure of small isolated groups (Devor, 1980; Sivakova et al., 1995; Morelli et al., 2002; Calderón et al., 2005; Alvarez et al., 2010; Boattini et al., 2011; Román-Busto et al., 2012).

The method relies on the utilization of surnames as an analogous of a male unilinear genetic marker. However, together with its potentialities, the limits of this approach are to be taken into account. In fact, within the main factors affecting the use of surnames in *'biological history'*, it is noteworthy to mention 1) their polyphyletic origin that can bias the analyses (Relethford, 1988a) and 2) their recent origin and stabilization which occurred after the Council of Trent (1545). Since then, the priests noted the surnames of each individual of the community in the parish books of Baptisms, Marriages and Deaths, thus allowing the study of peopling events through at least three centuries.

Despite these limitations, surname analysis has been widely used to evaluate the mating structures and the demographic events of human populations subject to isolation factors in many Western Countries (Paoli et al., 1999; Santos et al., 2005; Boattini et al., 2006; Prost et al., 2008; Lucchetti et al., 2011). This is due to the large availability of long lasting series of data that allow to minimize the biases, on one side, and to the simple and inexpensive collection of these kind of data compared to the genetic ones, on the other.

Italy is characterized by a history of internal migrations, as well as from and towards abroad (Lucchetti et al., 1996; Arru and Ramella, 2003; Ago and Vidotto, 2010). At the national level, this is evidenced by its elevated linguistic diversity and by the presence of ethno-linguistic minorities (Toso, 2008). Moreover, the geographic characteristics of the Country with its two main mountain chains, the Alps and the Apennines, provided the ideal conditions for the settlement of many isolated communities.

Therefore, Italy represents one of the most interesting case studies in the European landscape to investigate the effects of geographical and cultural factors of isolation on mendelian populations (Toso, 2008; Steinicke et al., 2011). Indeed, several of these minorities have been studied to evaluate their degree of isolation by means of endogamy rates and inbreeding levels (Martuzzi Veronesi et al., 1996; North and Crawford, 1996; Paoli et al., 1999; Danubio and Amicone, 2001). Other isolated groups, more recently, were analysed both from the molecular and biodemographic point of view, in order to understand the interactions between linguistic, geographic and genetic factors (Mogentale Profizi et al., 2001; Verginelli et al., 2003; Pichler et al., 2006; Achilli et al.,

2007; Colonna et al., 2007; Destro Bisol et al., 2008; Thomas et al., 2008; Messina et al., 2010; Sella et al., 2010; Boattini et al., 2010; Boattini et al., 2011; Coia et al., 2012; Montinaro et al., 2012; Capocasa et al., 2013).

The present work re-analyses the marital structure in five sample villages located in the Central Apennines with the objective of further deepening the research (Amicone and Danubio, 1998; Danubio and Amicone, 2001; Danubio et al., 2004). At first, some explorative analyses of the levels of inbreeding were conducted and possible patterns of non-random mating strategies were examined. These were followed by the evaluation of the degree of genetic isolation conducted by considering the possible relations between isonymic structure, population sizes and altitude, and those between kinship and geographic distances. This is of particular interest because the studied region, the Province of L'Aquila (Fig. 1), has geographical and ecological peculiarities. Geographically, it cannot be considered a high mountain zone as it never exceeds 3000 m a.s.l.; however, two-thirds of its territory is mountainous and its climate is typical of high altitudes. Consequently, the 'life models' developed through time by its communities closely resemble those of mountain isolates in terms of available resources and opportunities for their exploitation.

In general, mixed agricultural-pastoral subsistence regimens were historically developed throughout the whole territory of the Province with the micro-geographical prevalence of one over the other, depending upon the surrounding environment (De Matteis, 1993). Moreover, within this territory is the Fucino Plain, a very fertile area, that was occupied in the past by one of the largest lakes in Italy that was definitively drained in the middle of the 1800s. Four of the studied villages are settled around the lake shore at different distances and altitudes. Here, the environment and the subsistence regimens were additionally affected by the periodic variations in the level of the shore (Danubio and Amicone, 2001; Danubio et al., 2001; Gruppioni and Danubio, 2006). Hence, the research is aimed at evaluating similarities and differences in the biodemographic behaviour of the area.

Materials and methods

The sample

The five investigated villages were:

1) *Roio*. The village was one of the castles that contributed to the rising of the town of L'Aquila in the 11th and 12th centuries. At present it is a part of the Municipality of L'Aquila. It includes four settlements located within a maximum range of 3 km and at an altitude of 700-850 m a.s.l. Its population never exceeded 2,000 inhabitants until the 1900s. The main subsistence activity has always been pastoralism. The shepherds of Roio possessed very large flocks and were considered the leading shepherds of the Province of L'Aquila.

On the slopes of the ancient Fucino lake:

2) *Celano*. The town is located 800 m a.s.l. at the slopes of the Velino-Sirente mountain complex, standing above the shore of the ancient Fucino lake. From the demographic point of view, the town was the largest around the shore of the lake until the end of the 19th century, with an increasing population from aprox. 3,500 inhabitants at the beginning of the 19th century to more than 10,000 in the 1930s. Despite standing above the lake, the town developed an agricultural subsistence economy historically detached from the daily influence of the lake.
3) *Lecce dei Marsi*. The village is located on the eastern shore of the ancient lake, at an altitude of 740 m a.s.l. Its population never exceeded 2,000 inhabitants until the 1900s, and its economy was mainly based on pastoralism.
4) *Ortucchio*. The village, located 680 m a.s.l., was particularly affected in the past by periodical rising of the lake waters, when it became an island. Its population, always less than 2,000 inhabitants, mainly practiced agriculture, integrated with fishing.
5) *Villavallelonga*. This village is located at the end of a valley south of the ancient lake, at an altitude of 1005 m a.s.l. Its first settlement dates back to the 17th century by a group of shepherds. It was the most isolated village and showed the tendency towards depopulation since the 1880s.

The records were collected from parish books of marriages starting from the beginning of the 19th century until the present. Marriages were recorded only when the year of marriage was clearly provided. However, for all the populations investigated data available cover at least one century. In order to observe trends in mating patterns and to reduce the limitations due to the occasional lack of parish books, the marriages were analyzed by three time periods of 50 years approx. (Table 1). A total of 11,009 marriages were recorded: 5,088 in Celano, 1,639 in Lecce dei Marsi, 1,203 in Ortucchio, 1,468 in Roio and 1,611 in Villavallelonga.

Statistical analyses

The total inbreeding coefficient (F) and its random (Fr) and non random (Fn) component were calculated according to Crow (1980) (method B; see Danubio et al., 2004). The coefficient of repeated pairs of surnames (RP) and the random expectation (RPr) were computed following Lasker and Kaplan (1985) and Chakraborty (1985, 1986). Percentages of excess RP above that expected at random was performed as reported in Relethford (1992). Kinship values by surnames within (r_{ii}) and between (r_{ij}) populations were estimated as one-quarter of the random isonymy coefficient in accordance with Relethford (1988b). Coefficient of determination r^2 between local kinship and altitude were calculated using Past software version 2.07. In order to analyse the

relationships between genetic similarity and geographic distances, probabilities of correlation between geographic and genetic distances were derived using a directional hypothesis as required by basic models of genetic population structure, i.e. that the correlation should be negative. Probability values were assessed using the Mantel test (Mantel, 1967) performing 10000 permutations. Geographic distances were calculated according to the minimum road distance. Genetic distances (D^2) and average genetic distances were derived from the kinship values (Relethford, 1988b).

Results

Isonymy and inbreeding coefficients

The five investigated communities show different frequencies of isonymous marriages (Table 2). The highest values are found in the pastoral villages of Roio, Lecce dei Marsi and Villavallelonga in all periods, opposed to the town of Celano and the village of Ortucchio. There is an increasing tendency in Roio, VillaVallelonga and Celano, whereas it shows a decrease in Lecce dei Marsi and the highest value in Ortucchio in the period 1851-1900.

The total inbreeding coefficients (F) display an almost similar situation. The highest values are found in the pastoral villages of Lecce dei Marsi, Roio and Villavallelonga with the latter showing the highest values on average. However, the trends are interesting: they increase in Roio, Villavallelonga, and, albeit very slightly, in Celano. They decrease in Lecce dei Marsi and increase in Ortucchio in the second half of the 19th century. In particular, the random component (Fr) is stable in time in Celano and in Lecce dei Marsi. The observed increases of F in the former, as well as the decreases in the latter, are due to the variations of the non-random component (Fn). The Fr component progressively decreases in Ortucchio, whereas the Fn component is responsible of the observed trend of F. Finally and interestingly, both in Roio and Villavallelonga, Fr increases in time, but associated to values of the Fn component that increase in the former and remain stably negative in the latter.

Repeated pairs of surnames analysis

Decreasing in time values of RP were found in Celano, Lecce dei Marsi and Ortucchio, whereas Roio and Villavallelonga display increasing values in time (Table 3). Concerning RP-RPr values, Celano has the lowest values and Villavallelonga shows negative values in two of the three considered periods. Interestingly, when excluding isonymous marriages, the trend of RP-RPr in Villavallelonga is reversed.

Estimation of kinship and genetic distances

Local kinship values do not show significant correlation with altitude when considering the five groups (r^2=0.722, p=0.064; Table 4). However, when excluding the lowest kinship value observed in Celano, the correlation is turns significant (r^2=0.950, p=0.025) (Fig. 2). These results suggest to consider the altitude as a possible factor of genetic isolation in the area.

The multi-dimensional scaling plot based on genetic distances (Fig. 3) highlights two interesting points. Firstly, there is a clear differentiation of Villavallelonga, Roio and Lecce dei Marsi, the pastoral groups, among them and from Celano and Ortucchio. The latter two cluster close to each other at the centre of the plot, thus resulting more genetically related. Secondly, Villavallelonga is the most outlier population and, indeed, it shows the highest average genetic distance (263.162) which is about 1.5-2.2 times higher than the other populations. In general, by means of the Mantel test, we found a substantial lack of correlation between genetic and road distances matrices (r=0.141, p=0.228; Table 5).

Discussion

The investigated communities are settled in the mountainous territory of province of L'Aquila, characterised by climatic and environmental peculiarities that influenced and significantly directed their historical socio-economic development. Indeed, previous studies on their marriage patterns highlighted a marked and stable seasonality of marriages in several centuries. Celano and Ortucchio showed a seasonality model typical of the rural societies, with summer migrations and marriages preferably in the winter period. Lecce dei Marsi, Roio and Villavallelonga, on the other side, follow the pastoral model, characterised by marriages concentrated mainly in the summer season due to the tradition of winter transhumance. The reproductive isolation analyses evidenced a marital structure which differ from that observed in other Italian and European isolates (Malacarne et al., 2005; Sella et al., 2010; Boattini et al., 2011). In fact, it was characterised by high endogamy rates, relatively low consanguinity rates and low frequencies of marital isonymy until the mid 1900s. The highest inbreeding coefficients and with increasing values from the 1850s to the 1950s were found in the pastoral towns of Roio and Villavallelonga, the latter settled at highest altitude (Amicone and Danubio, 1998; Danubio et al., 2001; Danubio and Amicone, 2001; Danubio et al., 2002; Danubio et al., 2004; Gruppioni et al., 2005).

The results of the present investigation referring to repeated pair analysis and kinship estimates complete this overview as they measure the extent of possible preferential interlineage mating, on one side, and evaluate genetic distances by surnames, on the other. A certain degree of population subdivision which declined in time in Celano, Lecce dei Marsi and Ortucchio is evidenced by an

excess of RP over RPr. Indeed, these towns are part of the same geographic and economic environment: the slopes of the ancient Fucino lake (Amicone and Danubio, 1998; Danubio et al., 2001). The highest and increasing values of RP-RPr in time in Roio suggest a general reduction in genetic heterogeneity possibly due to the celebration of marriages among families selected on the economic basis of pastoralism. Indeed, the shepherds of Roio were considered the leading shepherds of the Province of L'Aquila and they possessed very large flocks, composed of very precious sheep, the *gentile di Puglia* breed (Piccioni, 1997).

Finally, it is noteworthy mentioning the peculiarity of Villavallelonga. The results herein reported show increasing values of F and stably negative values of Fn. Moreover, results reported by Danubio and Amicone (2001) on consanguinity coefficients α (Bernstein formula) calculated from marriage dispensations taking into account the different degrees of relationship between the spouses, revealed the higher contribution of marriages between distant relatives. In the present study, when excluding isonymous marriages from the RP analysis, repeated pair unions tend to increase, thus revealing a substructure with marriages among preferred lineages. The explanation of this behaviour is to be related to the tendency of avoiding unions between relatives in a small geographic isolate settled at the end of a valley at an altitude of 1005 m a.s.l. It can be argued that the main determinants of the observed trend in Villavallelonga were its geographic position, the reduced size of the population and its progressive depopulation. In the other cases the small size of the populations and the national economic events of the second half of the 19th century (De Matteis, 1993) played a major role in the observed trends of the inbreeding coefficients. It is worth mentioning that Villavallelonga is the outlier population, as it displays the highest genetic distances from all others.

Altitude proved to be a factor of isolation in shaping the genetic structure of these groups. In fact, a positive correlation was detected between altitude and intra-population kinship values and this is in accordance with the literature (Cavalli Sforza and Bodmer, 1971; Franceschi and Paoli, 1994; Fuster et al., 1996; Morelli et al., 2002). But in the case of these communities, we stress the importance of pastoralism as a main factor playing a role in the marital behaviour of the area.

In conclusion, this study demonstrates the influence of geographical (altitude) and social factors (pastoralism) on the marital structures of the investigated populations, pointing out the importance of further research using genetic polymorphisms (Pálsson, 2008; Destro Bisol and Paine, 2011). Taking advantage of the greater availability of DNA data for the construction of large datasets (Congiu et al., 2012), approaches based on comparisons among biodemographic and genetic results, together with direct estimates of demographic parameters and coalescent simulations (Tofanelli et al., 2011; Hoban et al., 2012), may allow to better understand the micro-evolutionary patterns that

shape the genetic structure of human isolated populations.

Acknowledgements

The authors acknowledge the staff of the State Archive of L'Aquila for historical information, the Parish Priests for providing access to the Marriage Registers and Doctor Elisa Amicone for technical assistance in data management. We wish to thank the anonymous reviewers whose comments and suggestions improved this work.

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Tables

Table 1. Population dataset and chronological periods analysed

Population	Acr	N (1841)	N (1881)	N (1936)	Alt	P1	P2	P3
Celano	**CEL**	4,944	7,370	11,653	800	1840-1850	1851-1900	1901-1940
Lecce dei Marsi	**LEC**	1,310	1,693	2,235	740	1825-1850	1851-1900	1901-1940
Ortucchio	**ORT**	1,102	1,975	2,055	680	1802-1845	1887-1900	1901-1940
Roio	**ROI**	1,292	1,636	n.a.	830	1802-1850	1851-1900	1901-1965
Villavallelonga	**VVL**	1,559	2,189	1,838	1,005	1802-1850	1851-1900	1901-1940

Abbreviations: Acr = Acronym; N = Population size; Alt = Metres of altitude;
P = Period

Population sources: State Archive of L'Aquila (A.S.Aq.); De Matteis, 1993; ISTAT, 1985; 2001

Table 2. Isonymy and inbreeding coefficients estimates

Population	Marriage Cohorts	Marriages	Isonymous Marriages	P	Fr	Fn	F
Celano	1840-1850	347	3	0.00860	0.00227	-0.00011	0.00216
	1851-1900	2,457	21	0.00850	0.00211	0.00002	0.00213
	1901-1940	2,284	25	0.01090	0.00193	0.00090	0.00274
	Total	5,088	49	0.00933	0.00210	0.00027	0.00234
Lecce dei Marsi	1825-1850	258	20	0.07750	0.00800	0.01175	0.01966
	1851-1900	691	33	0.04780	0.00853	0.00352	0.01202
	1901-1940	690	43	0.06230	0.00862	0.00720	0.01576
	Total	1,639	96	0.06253	0.00838	0.00749	0.01581
Ortucchio	1802-1845	340	3	0.00880	0.00611	-0.00401	0.00213
	1887-1900	292	7	0.02400	0.00511	0.00090	0.00600
	1901-1940	571	7	0.01230	0.00300	0.00006	0.00306
	Total	1,203	17	0.01503	0.00474	-0.00102	0.00373
Roio	1802-1850	339	10	0.02950	0.00671	0.00067	0.00738
	1851-1900	505	35	0.06930	0.00949	0.00814	0.01755
	1901-1965	624	62	0.09940	0.01127	0.01420	0.02532
	Total	1,468	107	0.06607	0.00916	0.00767	0.01675
Villavallelonga	1802-1850	346	22	0.06360	0.01827	-0.00257	0.01575
	1851-1900	744	57	0.07660	0.02103	-0.00205	0.01902
	1901-1940	521	41	0.07870	0.02221	-0.00279	0.01948
	Total	1,611	120	0.07297	0.02050	-0.00247	0.01808

Abbreviations: P = frequency of marital isonymy; Fr = random component of inbreeding coefficient; Fn = non random component of inbreeding coefficient; F = total inbreeding coefficient.

Table 3. Repeated pairs of surnames in married couples and random expectation of repetition including and excluding isonymous marriages

		including isonymous marriages						excluding isonymous marriages					
Population	**Marriage Cohorts**	**RP**	**Rpr**	**RP-RPr**	**SE(RPr)**	**%**	**Z value**	**RP**	**Rpr**	**RP-RPr**	**SE(RPr)**	**%**	**Z value**
	1840-1850	0.0001499	0.0000865	0.0000634	0.000014	73.29	0.27	0.0001525	0.0000847	0.0000678	0.000014	80.05	0.29
Celano	1851-1900	0.0001087	0.0000726	0.0000361	0.000003	49.72	2.26	0.0001095	0.0000716	0.0000379	0.000003	52.93	2.37
	1901-1940	0.0000774	0.0000534	0.0000240	0.000003	44.94	1.50	0.0000752	0.0000521	0.0000231	0.000002	44.34	1.44
	1825-1850	0.0015684	0.0011165	0.0004519	0.000182	40.47	0.84	0.0011346	0.0008628	0.0002718	0.000148	31.50	0.52
Lecce dei Marsi	1851-1900	0.0015100	0.0012166	0.0002934	0.000125	24.12	1.30	0.0013832	0.0010639	0.0003193	0.000112	30.01	1.43
	1901-1940	0.0015228	0.0011666	0.0003562	0.000124	30.53	1.32	0.0011197	0.0009472	0.0001725	0.000103	18.21	0.83
	1802-1845	0.0009370	0.0006013	0.0003357	0.000079	55.83	1.00	0.0009537	0.0005939	0.0003598	0.000079	60.58	1.05
Ortucchio	1887-1900	0.0005413	0.0004069	0.0001344	0.000076	33.03	0.39	0.0005436	0.0003656	0.0001780	0.000069	48.69	0.50
	1901-1940	0.0002335	0.0001336	0.0000999	0.000016	74.78	0.81	0.0002330	0.0001299	0.0001031	0.000016	79.37	0.82
	1802-1850	0.0011520	0.0007421	0.0004099	0.000114	55.24	1.13	0.0010749	0.0006353	0.0004396	0.000095	69.20	1.20
Roio	1851-1900	0.0020666	0.0013939	0.0006727	0.000181	48.26	1.63	0.0014244	0.0010530	0.0003714	0.000135	35.27	1.37
	1901-1965	0.0033028	0.0020255	0.0012773	0.000217	63.06	2.72	0.0024993	0.0014914	0.0010079	0.000170	67.58	2.49
	1802-1850	0.0050598	0.0052827	-0.0002229	0.000657	-4.22	-0.26	0.0041470	0.0042086	-0.0000616	0.000501	-1.46	-0.09
Villavallelonga	1851-1900	0.0071563	0.0071386	0.0000177	0.000622	0.25	0.02	0.0061237	0.0055637	0.0005600	0.000475	10.07	0.94
	1901-1940	0.0073674	0.0078199	-0.0004525	0.000784	-5.79	-0.52	0.0068458	0.0062417	0.0006041	0.000652	9.68	0.67

Abbreviations: RP = repeated pair of surnames; RPr = random expectation of repetition; SE(RPr) = standard error of RPr; % = percentages of excess RP above that expected at random; Z = measure of the significance of the RP results

Table 4. Matrix of local kinship (rii, bolded diagonal), between population kinship (rij, below the diagonal) and of genetic distances (D^2, above the diagonal). Reported values were multiplied by 10,000. The names of populations are abbreviated as in Table 1

	CEL	LEC	ORT	ROI	VVL
CEL	**19.582**	101.180	54.736	108.968	222.512
LEC	1.901	**85.400**	116.580	177.562	288.050
ORT	2.408	4.395	**39.970**	131.406	244.158
ROI	1.617	0.229	0.592	**92.620**	297.930
VVL	1.332	1.472	0.703	0.142	**205.594**

Table 5. Matrices of geographic road distance values in kilometres. The names of populations are abbreviated as in Table 1

	CEL	LEC	ORT	ROI	VVL
CEL	0				
LEC	26	0			
ORT	21	5	0		
ROI	53	79	74	0	
VVL	30	30	25	83	0

Figures

Figure 1

Figure 1. Geographical location of the five investigated communities (Abruzzo region, Central Italy).

Figure 2

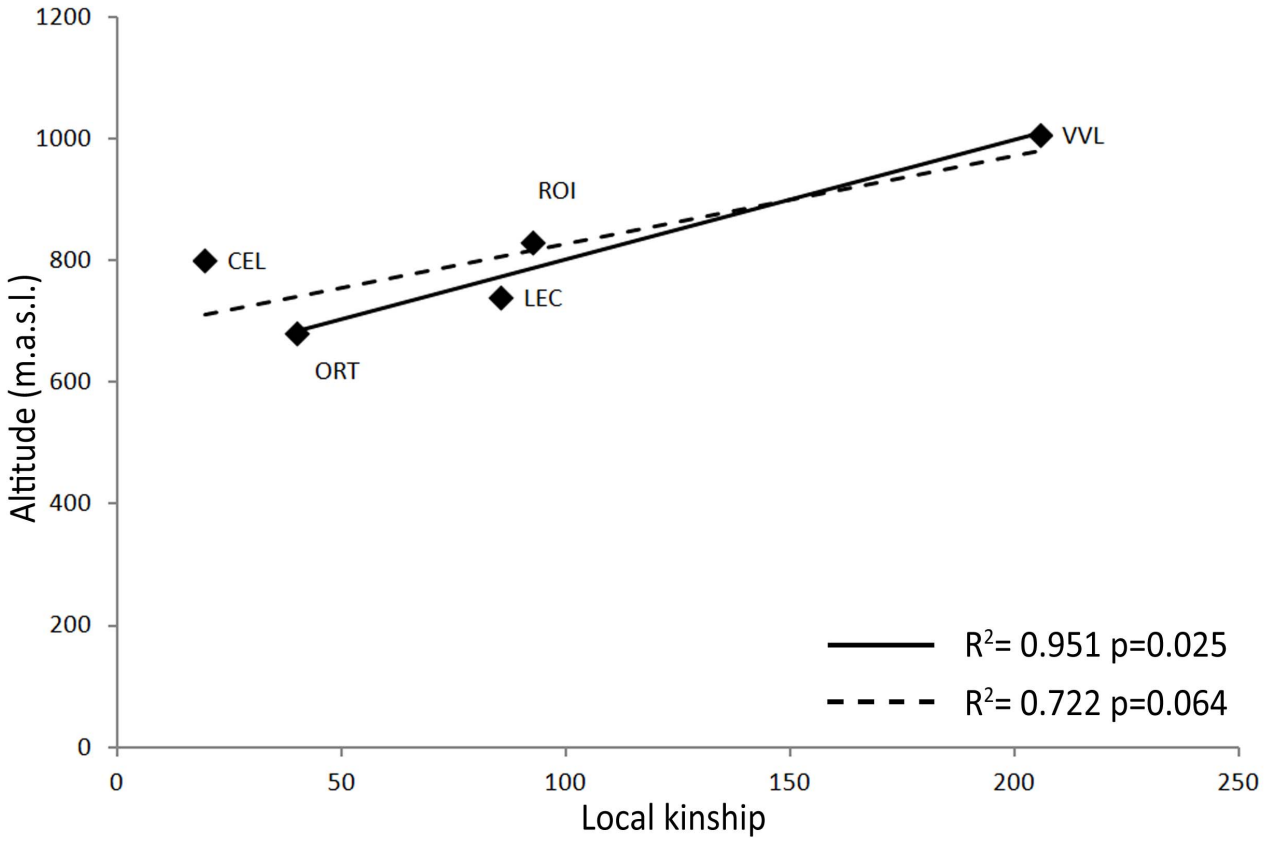

Figure 2. Linear regressions: (a) between local kinship values and altitude (5 populations); (b) between local kinship values and altitude (4 populations).

Figure 3

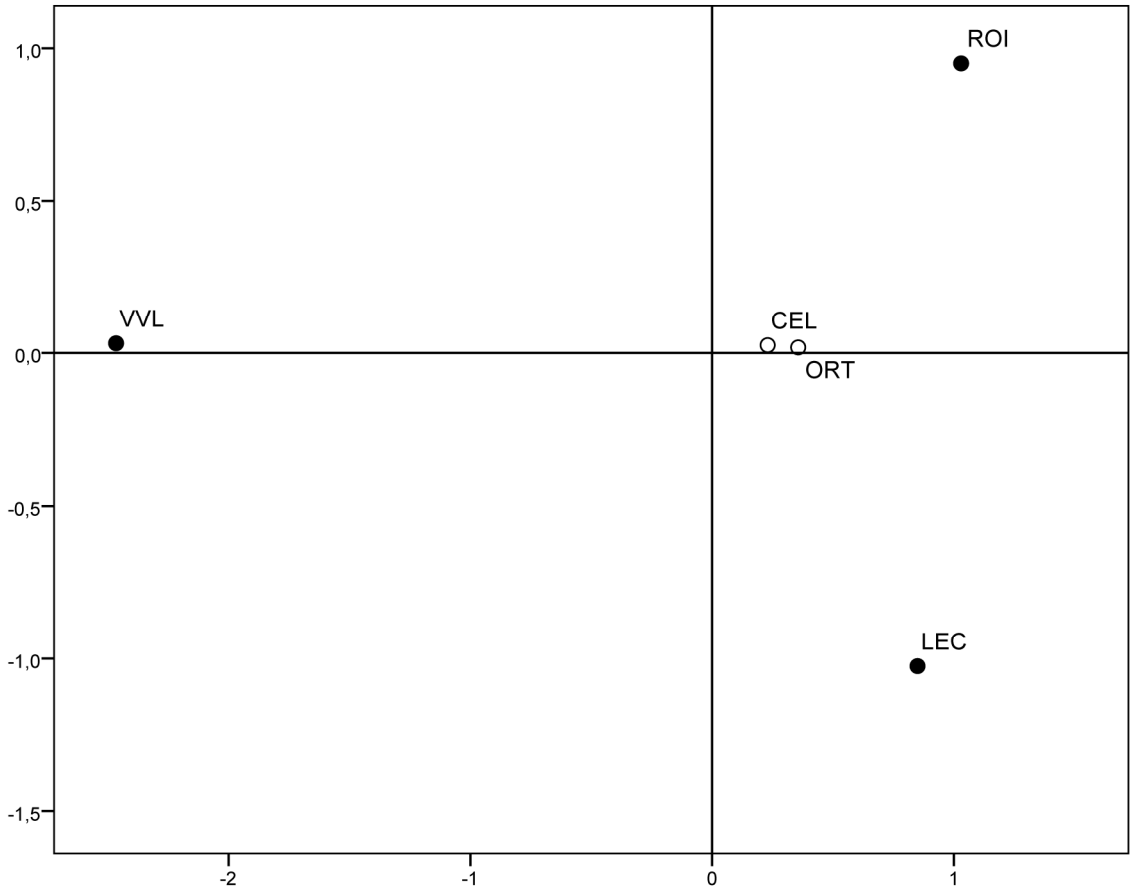

Figure 3. Multi-Dimensional Scaling plot of genetic distances among the five populations analysed (stress value = 0.0098). Pastoral population are marked in black.