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## ***Genetic Structure of the Ards Peninsula, Northern Ireland: Evidence from Civil Registers of Marriage 1840–1911***

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*Abstract* This paper uses marital migration data transcribed from the Civil Registers of Marriage 1840–1911 to estimate kinship from migration matrices and isonymy in the Ards Peninsula, Northern Ireland. The distribution of religious denominations (Presbyterian, Episcopalian, and Roman Catholic) varies systematically throughout the region, with up to 77% Roman Catholic in the south and 81% Presbyterian in the north. Portavogie, a fishing village on the east coast, is exclusively Protestant, with a population 93% Presbyterian. Comparison of migration and isonymy with geographical distance by multidimensional scaling and the MATFIT procedure show Portavogie to be an outlier, more distantly related to other areas than its geographical position would predict. We suggest that this discrepancy is due to settlement history and occupational and religious isolation. Mantel tests show that marital migration is significantly related to geographical distance ( $r_{MG} = 0.4257$ ), as is the distribution of religious denominations ( $r_{RG} = 0.5548$ ) through settlement history. Migration is dependent on religion ( $r_{MR} = 0.3674$ ), and isonymy is dependent on migration ( $r_{IM} = 0.2531$ ) but not on geography or religion. With Portavogie omitted from the analysis, the dependence of migration on geography and on religion increases ( $r_{MG} = 0.5583$ ,  $r_{MR} = 0.5646$ ), as does the correlation between religion and geography ( $r_{RG} = 0.7213$ ). The dependence of isonymy on migration increases ( $r_{IM} = 0.5103$ ), and significant correlations between isonymy and religion ( $r_{IR} = 0.4135$ ) and isonymy and geography ( $r_{IG} = 0.4660$ ) appear. We argue that a full explanation of population structure requires geographical distance, settlement history, and the influence of religion and occupation to be taken into account.

Studies of the genetic structure of human populations at the local, national, and even continental level often use geographical distance and isolation-by-distance as the default explanatory variable, to the extent that Fix (1999) has remarked that explanations of genetic structure are generally exercises in fitting isolation-by-distance equations. It has long been recognized, however, that genetic structure may also be correlated with a number of other physical parameters, such as pop-

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*Human Biology*, August 2002, v. 74, no. 4, pp. 507–524.

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ulation density and altitude (Cavalli-Sforza and Bodmer 1971), as well as with sociocultural parameters that produce some effect of population subdivision, including caste (Bamshad et al. 1996, 1998), occupation (Smith et al. 1984), social class (Harrison et al. 1970, 1971), ethnicity (Jorde and Pitkänen 1991), linguistic affiliation (Barbujani and Sokal 1990), and recent admixture (Biondi et al. 1996).

Religious affiliation has also been studied as a correlate of genetic structure (Crawford et al. 1995; Koertvelyessy et al. 1992) and found to be important in situations where religion may be associated with settlement history, and especially where religion continues to be an important cultural or socioeconomic identifier (Bittles and Smith 1994; Smith et al. 1990; Relethford and Crawford 1998). Northern Ireland offers a classic example of a population where sectarian allegiance has long been an important component of demographic and social structure, and thus presents an opportunity to investigate the influence of religion, among other factors, contributing to population structure.

Demographic and genealogical research on the 19th-century population of Ireland is hampered by the lack of surviving census enumerators' books (CEBs) comparable to those still available for the 19th-century censuses of England and Wales. In England and Wales, CEBs contain information about each household surveyed in the census, including details of name, age, marital status, occupation, and relationships of all individuals to the head of household. From 1851 onward, birthplace was also recorded, furnishing evidence of lifetime migration for all individuals (Higgs 1989, 1996). The census of England and Wales, instituted in 1801, was taken at 10-year intervals throughout the 19th century. The CEBs, from which official statistical summaries were compiled and published, survive from 1841 onwards, those from earlier decades having been destroyed in 1931 (Drake 1972). The first census of Ireland was taken in 1813, and from 1821 onwards censuses were taken every 10 years. The census covered the whole island of Ireland, which was then linked to Great Britain by the Act of Union of 1801, with partition into the Irish Free State and Northern Ireland not established until 1921. However, almost all of the CEBs relating to the censuses of 1813 and 1821–1851 perished in the destruction of the Four Courts in Dublin in 1922, while those from the period 1861–1891 were pulped during the First World War. The few surviving records for these periods have been carefully documented (Royle 1978), and some analysis has been undertaken (Royle 1983), but for most of Ireland there are simply no extant 19th-century CEBs.

In an earlier study of the Ards Peninsula, County Down, we used the distribution of surnames of the heads of households enumerated in the Griffiths Household Valuation of 1859–1863 to describe and interpret the genetic structure of the peninsula. The analysis demonstrated close correspondence between geography and the pattern of genetic structure based on isonymy (Smith et al. 1990). Some distortion of the pattern of surname distributions was observed, which we suggested might plausibly be explained in terms of settlement history and its legacy in the distribution of religious affiliation.

While the Griffiths Valuation is recognized by genealogists and historians

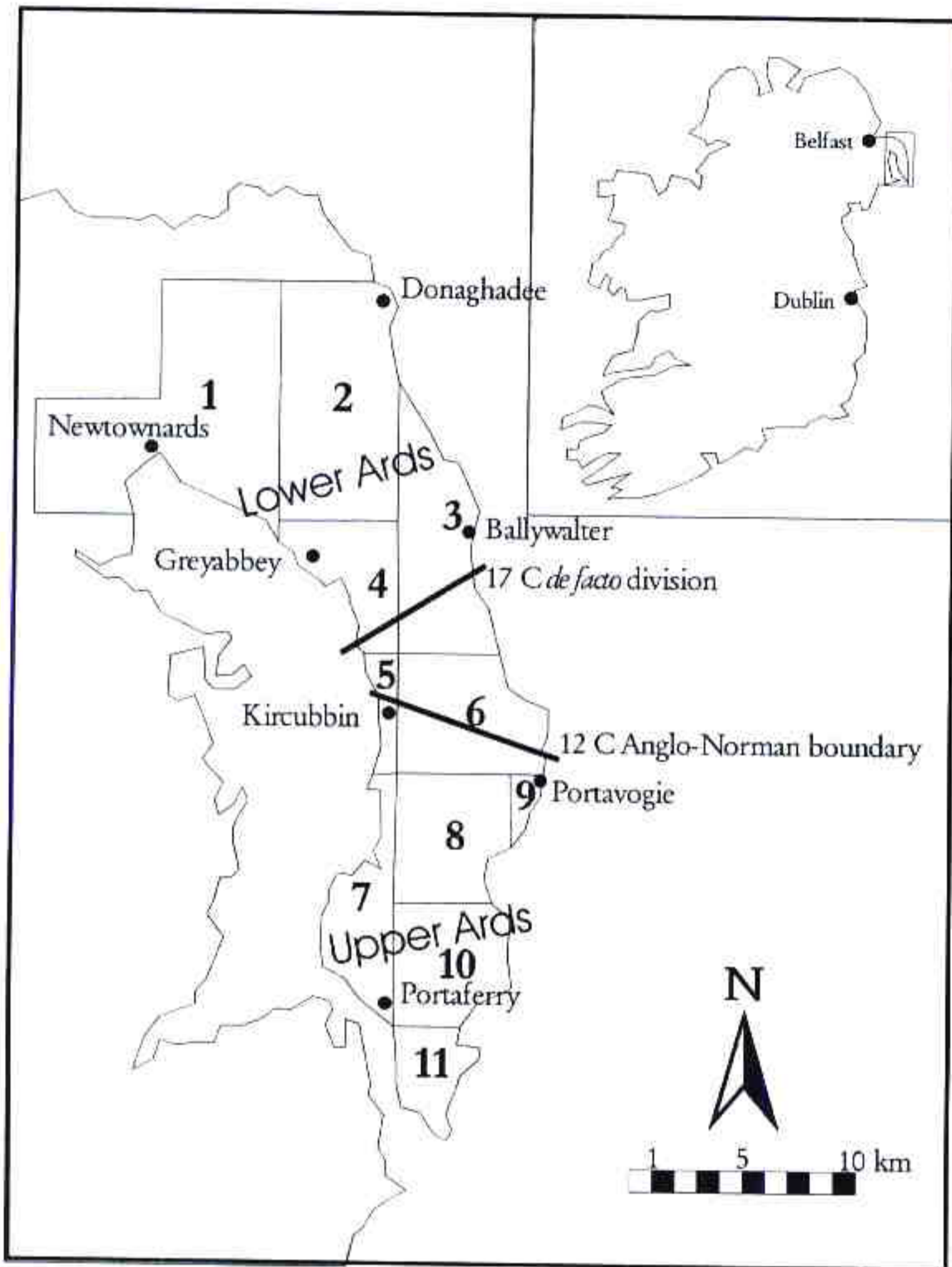
as an important census substitute, in that it enumerates householders and thus permits the identification of a great many individuals, it does not provide information about birthplace or, by inference, migration. Analysis of migration in the post-Famine period cannot therefore be addressed using either CEBs (destroyed) or the Griffiths Valuation (inadequate).

The purpose of this study is to extend the analysis of the factors shaping the genetic structure of the Ards Peninsula to include a study of migration, by using an alternative data source, the Civil Registers of Marriage from 1840–1911. Marriage registers are particularly appropriate for the study of genetic structure, since they focus on that component of population most likely to have genetic representation in the next generation. We use them here to estimate kinship from surnames and migration matrices, and to test hypotheses predicting the relationship between these variables and their causation in terms of the geographical distribution, religious composition, and settlement history of the population. Additional aspects of the 19th-century population history of the Ards, including the patterns of employment, occupation, and the effects of the Great Irish Famine of 1846–1851, also are considered.

## Study Area

The Ards Peninsula in County Down, Northern Ireland, is a fertile, low-lying region of approximately 27,000 hectares, bounded to the east by the Irish Sea and to the west by the tidal waters of Strangford Lough (Figure 1). It was subject to Scandinavian incursions from the 9th to the 11th centuries, followed by colonization by the Anglo-Normans under Sir Richard de Courcy in 1177 (Bittles and Smith 1994). During this latter period a boundary between the Baronies of Upper Ards and Lower Ards was established (Figure 1). The northern part of the Peninsula was heavily settled by Scots Presbyterians during the early 17th century. This polarization of settlement from medieval times through to the 17th century resulted in a Presbyterian majority in the north and a Roman Catholic majority in the south, with other Protestant denominations represented in both areas. A resultant cultural boundary, evidenced in religion, dialect, and family names, lies close to the medieval baronial boundary, and is also reflected in the present-day distribution of genetic markers (Bittles and Smith 1991).

In the first half of the 19th century this region of County Down had a relatively prosperous economy, with mixed agriculture including a considerable export trade in early potatoes to Britain, and, centered on the market town of Newtownards in the north, an extensive textile industry employing both men and women in the weaving and embroidering of muslin for manufacturers in Glasgow (McCavery 1993). In the 1830s and 1840s there was a rapid decline in the domestic linen trade in County Down as a whole, which left large numbers of men and women unemployed (Graham 1971). With the advent of the Great Irish Famine of 1846–1851, which followed repeated destruction of the staple potato crop by



**Figure 1.** Ards Peninsula, showing major towns and division of the study region into areas 1–11.

*Phytophthora infestans*, the economy of the Ards, as elsewhere in Ireland, was severely affected. Although County Down was considered among the most prosperous counties of Ireland, local accounts reported by McCavery (1997) testify that the hardship caused by the Famine was scarcely less acute than elsewhere:

It would be impossible to find more distressing cases, short of the horrors of Skibbereen, in any part of Ireland than those narrated by our reporter from the eastern divisions of Down.

(*The Banner of Ulster*, February 1847)

The revolution in agriculture consequent on the Famine brought in turn a change in relations between landlords and tenants, with consequent evictions and emigration. In Ireland as a whole these events resulted in an estimated 1 million excess deaths, the emigration of 1.3 million persons, and 0.3–0.4 million averted births (Ó'Gráda 1989).

## **Materials and Methods**

The records used in this study are transcriptions of the civil registers of marriage held at Newtownards in the Civil Registry of Births, Deaths and Marriages, commencing in 1840 for Episcopalian and Presbyterian congregations, and in 1861 for Roman Catholic parishes. The data comprise 2976 marriages solemnized between 1840 and 1915. Ordnance Survey map coordinates of the birthplaces of brides and grooms were located (Kovler et al. 1993), and on the basis of these coordinates brides and grooms were allocated to a 5-kilometer grid square of birthplace (Ordnance Survey Northern Ireland, 1989). To maintain adequate sample sizes, some of the grid squares covering the Ards Peninsula were amalgamated as required, resulting in the 11 areas shown in Figure 1. Our intention in using this approach was to incorporate the considerably dispersed rural settlement along with the small towns and villages into spatial units small enough for any geographical and religious variation within the peninsula to be revealed. The order of size of the divisions was based on the geographical scale of genetic and surname variation at the parish level observed in previous studies (Bittles and Smith 1991; Smith et al. 1990). Brides and grooms were allocated by birthplace to one of the 11 geographical subdivisions of the study region, with individuals born outside the Ards being designated as "immigrants."

To corroborate the earlier analysis using the Griffith's Valuation, and for comparison with predictions of kinship from migration, a comparison of surname distributions among the marriage partners was made by measuring genetic distance from random isonymy (Morton et al. 1971). The migration matrix predicts conditional kinship between the population subdivisions on the basis of: (1) observed intermarriage between the subdivisions, (2) systematic pressure, and (3) effective population size. The standard Malécot migration matrix model (Morton 1973), converted to an  $R$  matrix by means of Harpending's transformation (Workman et al. 1973) was used, a procedure employed by Swedlund et al. (1984) and others. In addition to the migration data themselves, the parameters of the model include population sizes estimated from the 1851 census reports (British Parliamentary Papers, 1970), and systematic pressure. In theory, systematic pressure could include selection, migration, or any other deterministic pressure on the entire study region. As is common practice in a study of a small geographical region, we take account only of migration, in this case estimated from the proportion of marriage partners whose birthplace was outside the Ards Peninsula.

To evaluate the interrelationship of surnames, migration, and geography,

the matrices of kinship from isonymy and migration were compared with the geographical distribution of population. The matrices based on isonymy and migration were displayed as two-dimensional maps by multidimensional scaling (MDS), implemented using the SPSS Alscal procedure. Data points in the MDS plots (Figures 2 and 3) are pie charts representing the proportion of marriages within each subdivision of the three principal religious denominations, Episcopalian, Presbyterian, and Roman Catholic. This permits the use of religious affiliation as an additional variable for visual interpretation of the MDS plots.

Matrix comparisons were performed by the MATFIT procedure (Lalouel 1973), which rotates two matrices to maximum congruence and allows a visual identification of mismatch between pairs of points as an aid to the interpretation of results (Roberts et al. 1981). Correlation between matrices, coefficients of determination ( $R^2$ ) and their significance, were calculated by Mantel tests (Mantel 1967; Smouse and Long 1992) using the program Phylogeographer-1 (Buckler 1999). The permutation tests used 1000 replications. For the MATFIT and Mantel tests the matrices used were: (1) genetic distance from isonymy (Morton 1971), referred to below as *Isonymy*; (2) a transformation of Harpending's  $R$  (Harpending and Jenkins 1973) to produce a migration "distance" measure, referred to below as *Migration*; (3) straight-line geographical distances between the physical or population center of each area, referred to below as *Geography*; and (4) a distance measure based on the frequency of affiliation to each of the three main religious denominations. This latter measure was calculated by Nei's genetic distance statistic, implemented in the Arlequin program (Schneider et al. 1997) as though the frequencies of the three affiliations were the frequencies of three alleles at a locus, and referred to below as *Religion* (Smith et al. 1990).

The kinship measures based on migration and isonymy used in this study may each be regarded as outcomes dependent on the geographical distribution of population and settlement history (which in turn includes a geographical and religious component). Thus, observed migration should be predicted by geography through isolation-by-distance effects, and we should expect migration to be predicted by religious distribution, because (1) there is a geographical component in the distribution of religious affiliation as a result of settlement history, and (2) religious affiliation continued to constrain marital migration and gene flow throughout the 19th and early 20th centuries. We might also expect migration to be a predictor of isonymy, although there may be discrepancies between migration and isonymy due to earlier population movement, including settlement (which in this area has a strong geographical and religious component). In this study migration is observed over the period 1840–1910, and so is of relatively short duration compared to the period of approximately 600 years during which surnames have been hereditary.

The hypotheses to be tested by Mantel tests are that through isolation-by-distance we expect Migration to be dependent on Geography. Through sectarian constraint on marriage we expect Migration to be dependent on Religion.

Through settlement effects we expect Religion to be dependent on Geography. Through subsuming the above processes, we expect Isonymy to be dependent upon Geography, Religion, and Migration.

## Results

Table 1 shows the distribution of marriage partners' birthplace by region, including marriages where one partner was from outside the Ards Peninsula, together with the proportion of marriages among the three main religious denominations in each region. These proportions were used in drawing the data-point pie charts in Figures 2 and 3, and in calculating religious distance in the matrix correlation analyses. The final column shows the sex ratio calculated from the marriage registers as the ratio of men to women born within each region. This last attribute will be referred to later when the economic circumstances of the Ards Peninsula are considered.

Table 2 shows the raw migration matrix of endogamous and exogamous marriages where both partners were born within the Ards Peninsula, with estimates of population size from the 1851 census, and systematic pressure calculated from marital migration from beyond the Ards.

Figure 2 is a multidimensional scaling (MDS) plot of Morton's measure of genetic distance from isonymy ( $R^2 = 0.997$ ). With one marked exception (area 9), the overall pattern displayed in this diagram matches the geographical disposition of the regions, as seen by visual comparison of Figure 2 with the geographical map in Figure 1. The migration matrix predicts conditional kinship within the Peninsula on the basis of the birthplaces of the brides and grooms married during the period 1840–1911. These results are shown as an MDS plot in Figure 3 ( $R^2 = 0.920$ ). There is a greater spread of points within the northern and southern clus-

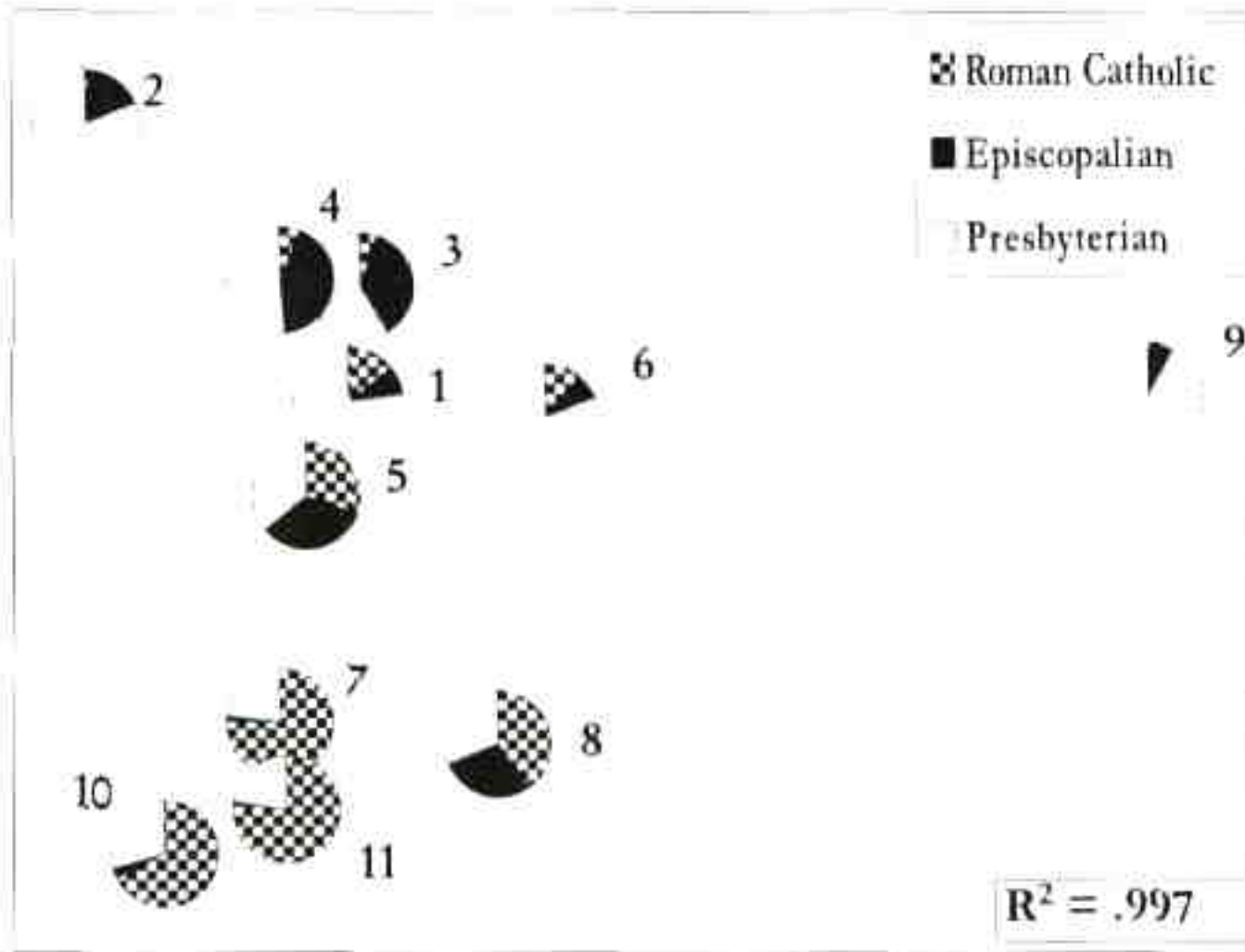
**Table 1.** Birthplace of Marriage Partners and Distribution of Religious Affiliation by Area, Ards Peninsula, 1840–1911

<i>Area</i>	<i>Brides</i>	<i>Grooms</i>	<i>Roman Catholic</i>	<i>Episcopalian</i>	<i>Presbyterian</i>	<i>Sex Ratio</i>
1	79	108	0.14	0.09	0.77	1.37
2	98	99	0.01	0.18	0.81	1.01
3	208	218	0.06	0.43	0.52	1.05
4	204	196	0.05	0.37	0.58	0.86
5	290	236	0.30	0.34	0.36	0.81
6	467	434	0.12	0.08	0.81	0.93
7	497	485	0.75	0.02	0.23	0.98
8	501	455	0.40	0.29	0.31	0.91
9	194	214	0.00	0.07	0.93	1.10
10	281	280	0.68	0.03	0.30	1.00
11	97	81	0.77	0.01	0.23	0.84

Table 2. Marriages between Geographical Divisions, Ards Peninsula

Groom's Birth Area	Bride's Birth Area											Total	Population size	Systematic pressure
	1	2	3	4	5	6	7	8	9	10	11			
1	41	12	8	9	7	6	3	10	3	4	2	105	9336	0.043
2	11	53	5	13	4	8	2	1	1	1	0	99	8600	0.041
3	3	8	134	19	10	25	2	10	2	1	1	215	1820	0.049
4	4	13	13	131	16	13	0	0	1	1	3	195	2502	0.038
5	4	0	5	8	152	31	9	20	1	4	0	234	888	0.044
6	4	2	20	6	54	265	6	27	34	6	1	425	3944	0.038
7	2	1	1	3	6	6	367	26	2	41	20	475	2922	0.039
8	5	1	4	1	12	32	25	309	31	28	3	451	2643	0.021
9	0	0	0	0	5	50	2	38	114	4	0	213	550	0.010
10	0	0	2	0	3	5	38	42	2	163	12	267	1848	0.055
11	0	0	0	0	0	1	15	2	0	10	49	77	965	0.056
Total	74	90	192	190	269	442	469	485	191	263	91	2756		



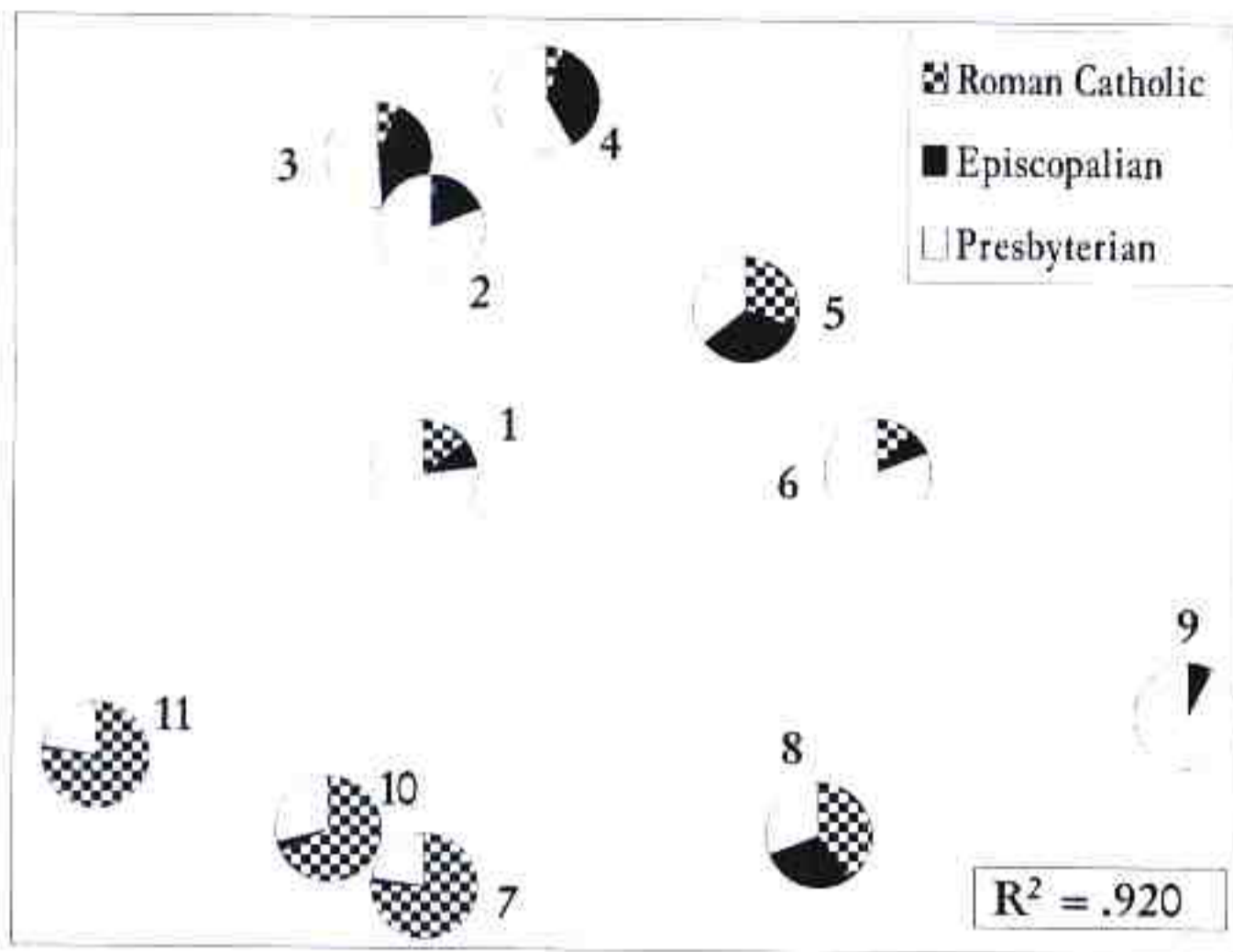


**Figure 2.** Ards Peninsula: bioassay of kinship from isonymy, marriage registers 1840–1911.

ters, with area 9 again the principal outlier, although more closely related to areas 6 and 8 than the isonymy suggested. The data points indicate a concentration of Roman Catholics in the south of the Peninsula (Upper Ards), with higher frequencies of both Episcopalian and Presbyterian to the north.

**Matrix Correlation Analysis.** Figure 4 shows the congruence of matrices of Isonymy and Geography demonstrated by the MATFIT procedure. There are two areas with a marked discrepancy between isonymy and geography, as indicated by the length of line between the geographical position of the area (circle) and kinship from isonymy (triangle). Area 1 has greater kinship with areas 3, 4, 5, and 6 than its geographical position would suggest, and area 9 has much lower kinship with its nearest neighbors (areas 5, 6, and 8) than we should predict from its physical position. Figure 5 shows the MATFIT plot for matrices of Migration and Geography. Again, the two populations with major discrepancies are 1 and 9, with 1 sharing greater kinship than expected with its neighbors and 9 showing less. To summarize these tests, area 1 shows a discrepancy between Geography and both Migration and Isonymy, with closer relationships to its neighbors than geographical distance would predict. Area 9 also shows a discrepancy from Geography in its values for both Migration and Isonymy, with lower kinship to its geographical neighbors than expected.

The results of Mantel tests of matrix correlation are shown in Table 3. In view of the consistent outlier status of area 9, these tests were first performed on the entire data set and were then repeated with area 9 omitted. Our prediction is that the correlations between Migration and Geography and Isonymy and Geography will both be stronger with area 9 omitted.



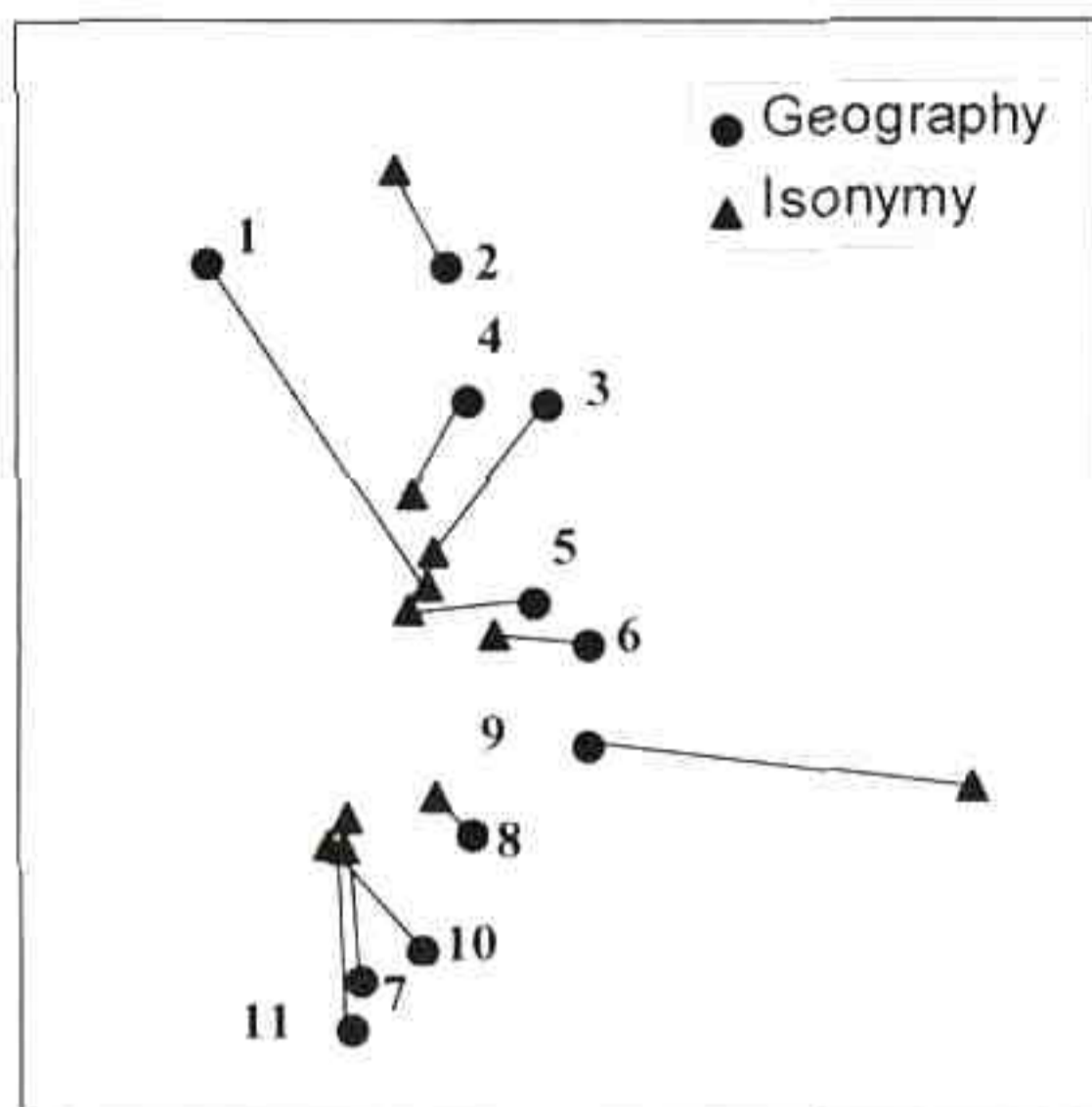
**Figure 3.** Ards Peninsula: conditional kinship predicted from marital migration 1840–1911.

According to our hypotheses of causation, the results for the entire data set can be interpreted as showing that Religion is dependent on Geography ( $r_{RG} = 0.5548$ ), Migration is dependent on Geography ( $r_{MG} = 0.4257$ ), Migration is dependent on Religion ( $r_{MR} = 0.3674$ ), and Isonymy is dependent on Migration ( $r_{IM} = 0.2531$ ) but not on Geography or Religion. With area 9 omitted, the correlation between Religion and Geography increases ( $r_{RG} = 0.7213$ ), as does the dependence of Migration on Geography ( $r_{MG} = 0.5583$ ) and on Religion ( $r_{MR} = 0.5646$ ). The dependence of Isonymy on Migration increases ( $r_{IM} = 0.5103$ ), and significant correlations between Isonymy and Religion ( $r_{IR} = 0.4135$ ) and Isonymy and Geography ( $r_{IG} = 0.4660$ ) appear.

Following Smouse and Long (1992) we use partial correlation coefficients to investigate the independent influence of Religion and Geography on Migration. Holding Religion constant, we find that  $r_{MG.R} = 0.2867$ , and holding Geography constant  $r_{MR.G} = 0.1743$ . The coefficient of multiple determination is  $R^2 = 0.2061$ , and its square root  $R_{M(GR)} = 0.4540$ . This offers little improvement over the correlation of Migration with Geography ( $r_{MG} = 0.4257$ ). With area 9 omitted,  $R_{M(GR)} = 0.6050$ , again a little higher than the correlation of Migration with Geography ( $r_{MG} = 0.5583$ ).

## Discussion

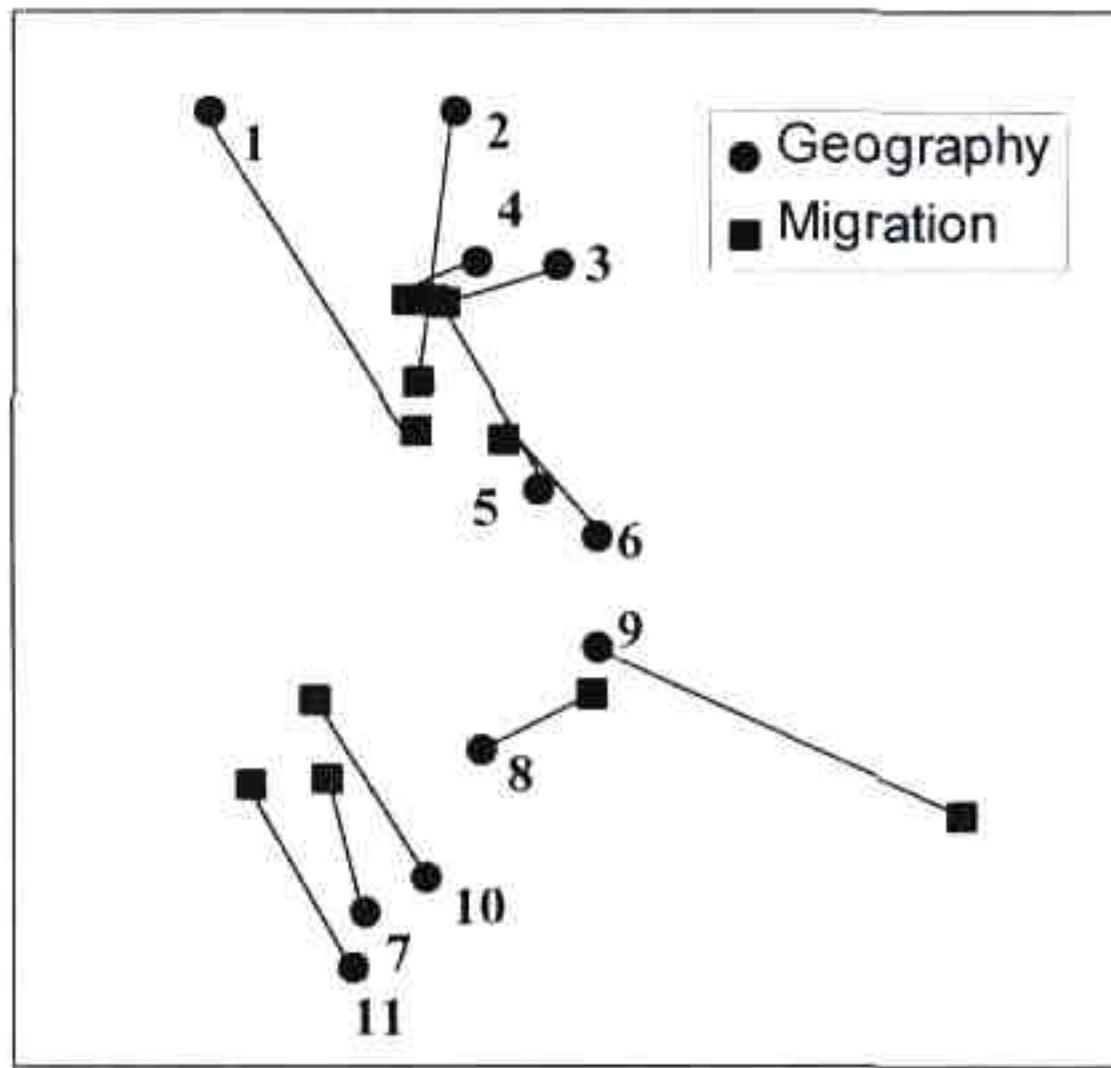
The MDS plots of genetic structure shown in Figures 2 and 3 confirm a close overall correspondence between genetic structure and the geographical positions of the 11 areas (Figure 1). Some distortion of the pattern of kinship distri-



**Figure 4.** MATFIT: Geography versus Isonymy.

butions was however observed, exaggerating the geographical separation between northern and southern areas. We see this effect in the present study both in the kinship map based on the surname distribution of marriage partners (Figure 2), and in that based on marital migration (Figure 3). It is essentially the same pattern that we have previously encountered in isonymic relationships based on the Griffiths Valuation (Smith et al. 1990), and on the pattern of late 20th-century gene frequencies among blood donors (Bittles and Smith 1991). Figures 2 and 3 also show area 9 to be an outlier, which will be discussed below. By examining the pie-charts of religious denomination in Figures 2 and 3, it is apparent that the hiatus in distribution of data points between northern (areas 1–6) and southern locations (areas 7–11) occurs where adjacent populations have strongly contrasting religious compositions.

Figure 2 shows some displacement of area 1, which contains the locally important town of Newtownards, towards the center of the northern cluster of areas. This may be due to the preeminence of Newtownards as a focus of markets, trade, and employment. The displacement of area 2 towards the top of the plot may be accounted for by the fact that the principal settlement in area 2 is Donaghadee, situated in the extreme northeast of that area. As previously noted, the gap between areas 5 and 7 separates the cluster of northern areas from the cluster of southern areas. In this analysis the most obvious exception from conformity with geographical distance is the position of area 9, which is displaced from all the other data points, indicating a surname array considerably different from the



**Figure 5.** MATFIT: Geography versus Migration.

**Table 3.** Mantel Tests with and without Outlier Population 9 (Upper Half Omits Area 9, Lower Half Includes Area 9)

	<i>Geography</i>	<i>Religion</i>	<i>Isonymy</i>	<i>Migration</i>
Geography		$r = 0.7213$ $R^2 = 0.5203^{***}$	$r = 0.4660$ $R^2 = 0.2172^*$	$r = 0.5583$ $R^2 = 0.3117^{**}$
Religion	$r = 0.5548$ $R^2 = 0.3078^{***}$		$r = 0.4135$ $R^2 = 0.1710^{**}$	$r = 0.5646$ $R^2 = 0.3188^{***}$
Isonymy	$r = 0.1055$ $R^2 = 0.0111$	$r = 0.1969$ $R^2 = 0.0388$		$r = 0.5103$ $R^2 = 0.2604^{***}$
Migration	$r = 0.4257$ $R^2 = 0.1812^{***}$	$r = 0.3674$ $R^2 = 0.1350^{**}$	$r = 0.2531$ $R^2 = 0.0641^{***}$	

\*\*\* $p \leq 0.001$ , \*\* $p \leq 0.01$ , \* $p \leq 0.05$

other areas of the Ards Peninsula. Area 9 represents the village of Portavogie, situated just below the boundary between Lower and Upper Ards. Portavogie was not specifically identified as an individual settlement in our previous work owing to the differences in survey catchment areas employed. In Figure 3, area 9 is again an outlier, though less remote from other areas than in the analysis based on surnames, on account of its proximity to areas 8 and 6.

The identification in this study of the population of Portavogie (area 9) as an outlier in the plots of genetic structure (Figures 2 and 3) and the MATFIT analyses (Figures 4 and 5) merits further explanation. A striking feature of the

Ards Peninsula is that while Portavogie is staunchly Protestant, 93% Presbyterian and 7% Episcopalian, the areas to its west and south contain the highest proportion of Roman Catholics in the Peninsula. Portavogie is renowned as a tight-knit coastal fishing community. Local history suggests a founding population independent in origin from the other Presbyterian settlements in the Ards. Some accounts suggest settlement from coastal fishing communities further north in County Down or from Kilkeel to the south, one of the historic centers of the Down fishing fleet (Pollock 1992). However, other local sources posit the direct sea-borne settlement of Portavogie by Scottish families from The Maidens in Ayrshire (Gallagher 1979) and a continuing tradition of social and economic contact with the Scottish coast. This may explain the apparent social separation of the inhabitants from their coreligionists in Areas 6 and 3 (the town of Ballywalter) to the north, as well as from their Roman Catholic neighbors to the south and east. A newspaper report from 1885, when the population was nearly three hundred strong, records:

Little or no emigration or immigration has taken place. . . . Surnames are scarce; "Palmer's" can be counted by the score; Adairs, Mahoods, Cullys, Hughes, and Coffeys by the dozen; a fact to some extent accounted for by the tendency to intermarry. The young men seldom venture outside the limits of the village in their search for a wife; hence a strong family likeness prevails. . . .

*(Belfast News Letter 26 October 1885,  
Portavogie and Its Fishermen)*

It is significant that both isonymy and migration analyses show Portavogie as remote, for while the distribution of surnames reflects the outcome of long-term population movements—both settlement and subsequent migration—the migration matrix is based solely on activity observed during the survey period 1840–1911. This indicates a continuity of behavior over the centuries, though the closer kinship between areas 8 and 9 in the migration analysis (Figure 3) suggests some breakdown of isolation through marital exchange between them. Given their contiguity and their shared Presbyterian component of population, greater marital exchange between areas 8 and 9 might have been expected. It may be that the isolated position of Portavogie in part reflects the influence of occupation on population structure, since studies elsewhere in the British Isles have shown fishing communities often to be isolated from their geographical neighbors (Baillie 1984; Pollitzer et al. 1988; Smith and Sherren 1989; Smith et al. 1984). The anomalous position of Portavogie may therefore be the result of founder effect, sustained by the cultural isolation of both occupation and religious affiliation (Bittles and Smith 1994).

We have not previously considered occupation as a component of population structure in this research, but we note that in addition to the religious dimension of settlement in the Ards, there was considerable geographical variation in the subsis-

tence base and economic activity. Newtownards, in the north of the peninsula (area 1), was a prosperous market town with a weekly market and hiring fairs three times a year (McCavery 1997). Although the economic effects of the Famine were harsh throughout the Peninsula (Bittles et al. 1986; McCavery 1993, 1997), Newtownards and its neighbors did not suffer as much as the Upper Ards, thanks to its mixed economy, which included cotton weaving and embroidery. It also had a more varied agricultural sector, which, besides the ubiquitous potato, included cereals such as wheat, oats, and barley. This focal role in the agricultural and manufacturing economy is likely to account for the unexpectedly close kinship shared by area 1 with its neighbors to the south, demonstrated both in the MDS plots (Figures 2 and 3) and the matrix correlation analysis (Figures 4 and 5). The differential economic success is also reflected in the sex ratio of brides and grooms born in each area (Table 1). The marriage registers show an excess of males from the north of the Peninsula (areas 1, 2, and 3), and a surplus of females from the rural agricultural south (areas 4, 5, 6, 7, and 11), suggesting that the greater diversity of economic opportunity in the north gave males a greater chance to stay on after the Famine (Table 1). Increased opportunities of male employment would also have been available in the rapidly developing industrial center of Belfast, situated some 10 miles from Newtownards. The only area of the Upper Ards with an excess of males is once again Portavogie, where local economic activity in the fishing industry may have supported a higher tertiary sex ratio.

The Mantel tests provide statistical confirmation of the predicted relationships between migration and geography (the isolation-by-distance effect), and migration and religion (through constraint on choice of marriage partners). Religion was also shown to be dependent on geographical distance (through settlement effects). Isonymy was correlated with the pattern of observed marital migration, but the predictions that isonymy would be dependent on geography (through settlement) and religion (through settlement and the influence of religion on subsequent migration) were not confirmed. However, when the anomalous population of area 9 was removed from the analysis the correlations in the entire sample increased, and the correlations of isonymy with geography and religion attained statistical significance. Partial correlation provided no evidence of the independent effect of religion on migration, and we suggest that this is due to the high correlation between religion and geography. Thus, the Mantel tests were unable to confirm the independent influence of religion on genetic structure that seems apparent from the MDS analysis.

**The Ards Peninsula in the Irish Context.** The population genetic structure of Ireland has been the subject of a number of studies using genetic markers, anthropometrics, surnames, and demography. An emerging consensus suggests that while at a local level isolation-by-distance has an important explanatory role, on an island-wide scale genetic structure exhibits more complex relationships explained principally by settlement history (North et al. 1999). One identifiable component of that history seems to be Viking settlement, evidenced through an-

thropometric analysis (Relethford and Crawford 1995), blood group genetics (North et al. 2000), and the distribution of disease haplotypes, such as phenylketonuria (Zschocke et al. 1997). Furthermore, while an analysis of Y-chromosome haplogroups in European populations (Wilson et al. 2001) has identified Welsh and Irish populations as similar to each other and distinct from Norwegian samples, the haplogroup 2.47 (which is present in Norway at 38%, Orkney at 7%, and Ireland at 5%, but absent from Wales) is argued by the authors to be “diagnostic of Viking invaders in [regions] where the only candidate parental populations are Celtic and Scandinavian.”

At the level of the Ards Peninsula, isolation-by-distance is confirmed as an important predictor of genetic variation, but our findings suggest a complex overlay of other variables affecting population structure of the Ards. There is ample documentary evidence of Scandinavian influence in the area (O’Corrain 1972). However, other components of historical settlement—including the Anglo-Norman incursions and settlement, the pattern of Lowland Scots Presbyterian settlement, and the subsequent development of the Ulster Scots-Irish population (Johnston-Liik 1997)—appear to have influenced the 19th-century pattern of kinship measured by isonymy, and to have extended a genetic legacy to the present day (Bittles and Smith 1991). The distribution of religious denominations resulting from the settlement process appears to have constrained marital migration within the Ards Peninsula, and this too has impacted on the distribution of 19th-century isonymy and contemporary genetics. The nature of the local economy also appears to have affected population relationships. Through its central role in the economy of the Lower Ards, the prosperous market town of Newtownards in the far north of the Peninsula shared greater than predicted levels of kinship with its neighbors. By comparison, the fishing port of Portavogie was much more remote from its neighbors in terms of kinship and marital exchange than its geographical position and religious composition would suggest.

By utilizing the Civil Registers of Marriage, a data source that permits the analysis of migration as well as isonymy, the present study has confirmed and extended earlier work suggesting the influence of geographical distance, settlement history, and religion on the genetic structure of the Ards Peninsula. It has further suggested that economy and occupation may have been significant additional determinants. The work is consistent with other research suggesting the influence of isolation-by-distance and religion on the population structure of Ireland (Relethford and Crawford 1998). But it also argues that, even within a small geographical area, a full explanation of population structure requires that the complex interrelationship of a number of additional determinants be taken into account.

*Acknowledgments* Access to the marriage records of the Ards Peninsula was granted by kind permission of the Registrar-General of Northern Ireland. Generous financial assistance was provided by the Economic and Social Research Council under grant G 002300116 to A.H. Bittles. The excellent research assistance of John J. McHugh is grate-

fully acknowledged. A number of people helped us pursue Portavogie's history, including Daryl Birkett (Upper Ards Historical Society), Joan Magee (South Eastern Education and Library Board), Trevor Parkhill and Vivienne Pollock (Ulster Museum), Stephen Royle (Queen's University, Belfast), and Chris Warnock (Northern Ireland Fishery Harbour Authority), and we thank them warmly for their help.

*Received 4 February 2002; revision received 11 April 2002.*

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