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# SOME FACTORS AFFECTING MARITAL DISTANCES IN THE OUTER HEBRIDES

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**Summary.** Some factors affecting marital distances have been studied in two Outer Hebridean islands, Harris (843 marriages) and Barra (444 marriages), over the period 1855–1990. In each island marital distances fell before 1900, but then rose to their greatest values after the 1950s. Fishermen generally married at the shortest distances and men in land-based occupations at the longest. The depression in the fishing industry during the 1880s and early 1890s was associated with reductions in marital distances, especially among fishermen. In the different regions of Harris, marital distances were least in the south-east, where settlement was most dense, and greatest in the south-west where it was most sparse.

When the association between marital frequencies and inter-settlement distances was studied, it was found that for Harris there was, overall, a trend to endogamous and short-distance marriage. However, this trend was only slight during 1955–90. For Barra a similar trend was found before 1955, but thereafter there appeared to be virtually no connection between marital frequency and inter-settlement distance. Thus the only constraint on marriage was the spatial distribution of settlements. In this situation the chances of random mating with respect to distance are maximised.

Application of 'Central Place' theory suggested that only since 1946 can any tendency be detected to regard Tarbert in Harris or Castlebay in Barra as Central Places, at least as far as marriage is concerned. In each island the tendency appears to be limited to the settlements closest to the Central Place.

## Introduction

Within any identifiable human population, marriage does not occur at random. Many factors determine the likelihood of particular individuals meeting and marrying. These include the ages of potential spouses (Dyke, 1971; Coleman, 1980), the degree of correlation between spouse ages (Hajnal, 1963; Leslie, 1983), their biological and social characteristics (Mascie-Taylor, 1986; Rao, Morton & Cloninger, 1979), cultural attitudes to the marriage of related individuals (Darr & Modell, 1988) and their geographical separation (Boyce, Küchemann & Harrison, 1967; Boyce, 1984; Brennan,



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1981; Cavalli-Sforza & Bodmer, 1971; Swedlund, 1988). These factors (and others) act both independently and together and have important effects on the structure of the population in its widest sense. Many of them vary with time so that over comparatively short periods there may be such alterations in measurable human behaviour as to lead to significant changes in population structure.

The extent to which these changes lead to variation in selection pressures in populations remains controversial. *Prima facie* they should be expected to, but, as Coleman (1984) has pointed out, the enormous variety of human mating behaviours in different societies suggests that most, if not all of them, are compatible with evolutionary success. Nevertheless, in so far as they all result in deviation from panmixis, they need to be studied.

As a general rule, the greatest frequency of marriage is between spouses living in the same community or in communities short distances apart. As the distance between spouses' residences increases, so the frequencies of marriage decrease.

Many models have been proposed to explain these findings (Malecot, 1969). Often they use the concept of 'neighbourhood knowledge'—the likelihood that individuals will know their own local environment better than one far away (Boyce *et al.*, 1967), and thus be in a better position to know about, and meet, potential spouses. The extreme is 'the boy or girl next door'. On the assumption of (i) uniformly distributed population and (ii) no hindrances to migration, the size of the 'neighbourhood' of a place increases as the square of the distance from it, and hence an inverse square law might be thought to apply to the level of neighbourhood knowledge, with the likelihood of finding a mate decreasing with the square of the distance from the place of residence (Boyce *et al.*, 1967; Harrison & Boyce, 1972).

But uniformity of population distribution and unfettered migration cannot be assumed. Individuals are aggregated into settlements of varying sizes and positions and there might be expected to be reciprocal 'gravitational' effects between them, their magnitudes depending on their sizes (Ravenstein, 1889; Zipf, 1949; Stouffer, 1940) as well as their distances apart. In addition, some settlements are more important than others in terms of communications, administrative level, commerce, etc. Christaller (1966) introduced the idea of 'Central Place' theory into geography, in which settlements were size-ranked into hierarchies, those of a given rank including neighbouring ones of lower rank in their 'urban field'. Such Central Places might be expected to attract migrants by virtue of their importance and Coleman (1977) tentatively introduced the idea of applying Central Place theory to the study of patterns of marriages.

The second confounding factor, the non-random reality of migration, has been studied less often. Migration implies movement between settlements and there may be constraints on the route which that migration takes (Boyce, Küchemann & Harrison, 1967, 1971). Many workers have taken marital distance to mean the straight-line distance between two communities, but as Coleman (1977) pointed out, except in the case of long-distance migration this is unlikely to represent the actual distance travelled by an individual moving between these two points. Cavalli-Sforza & Bodmer (1971) recommended the use of road distances or travel time as being more in keeping with actual human behaviour, and road distances will be followed in this paper. Further, given that in most geographical areas human settlements are not uniformly distributed,

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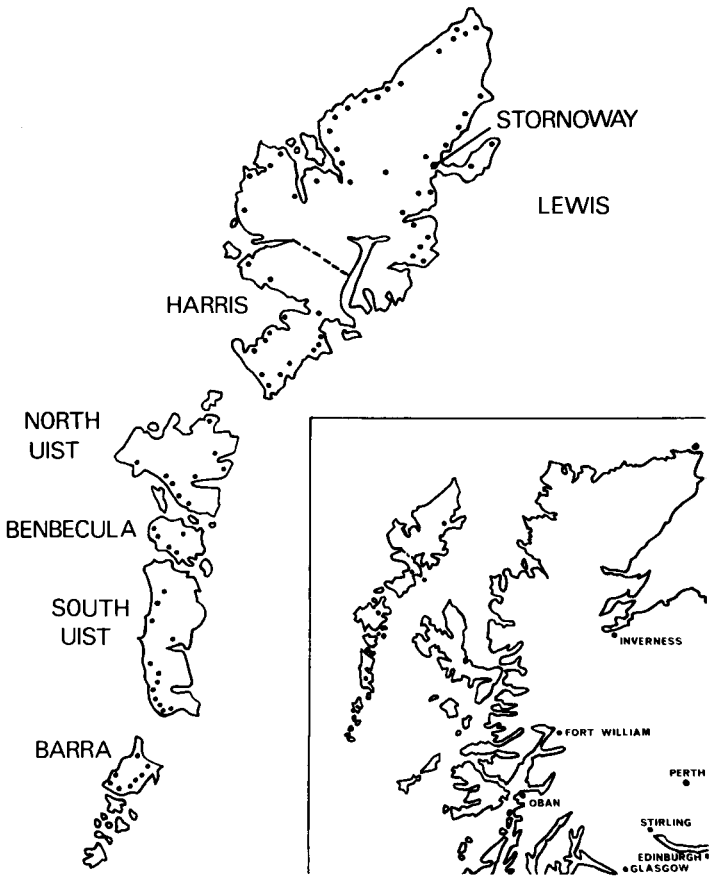



**Fig. 1.** The Outer Hebrides, showing their relationship to the Scottish mainland, and the positions of Harris and Barra.

it seems inevitable that the nature of such distributions would affect the distributions of marital distance, either directly or through the factors described above.

The influence of the various factors described above, together with those of groom's age and occupation will be examined in the context of two Outer Hebridean islands, Harris and Barra (Figs 1–3). They were chosen because of their sizes and their relative isolation from other Hebridean populations. Harris (Fig. 2) is much larger than Barra (Fig. 3) and its settlements can be somewhat arbitrarily divided into several regions: north-east, south-east, south, south-west and north-west. The region of residence of the groom was included as an additional factor in the analysis of Harris marriages.

Each island has a Central Place—Tarbert in Harris and Castlebay in Barra—which has developed as the main commercial and administrative centre and where communication links with other islands and with the Scottish mainland are centred, but which, in spatial terms, are not centrally placed (Figs 2 and 3). In addition, the distribution of settlements in the two islands is clearly non-uniform. All are situated

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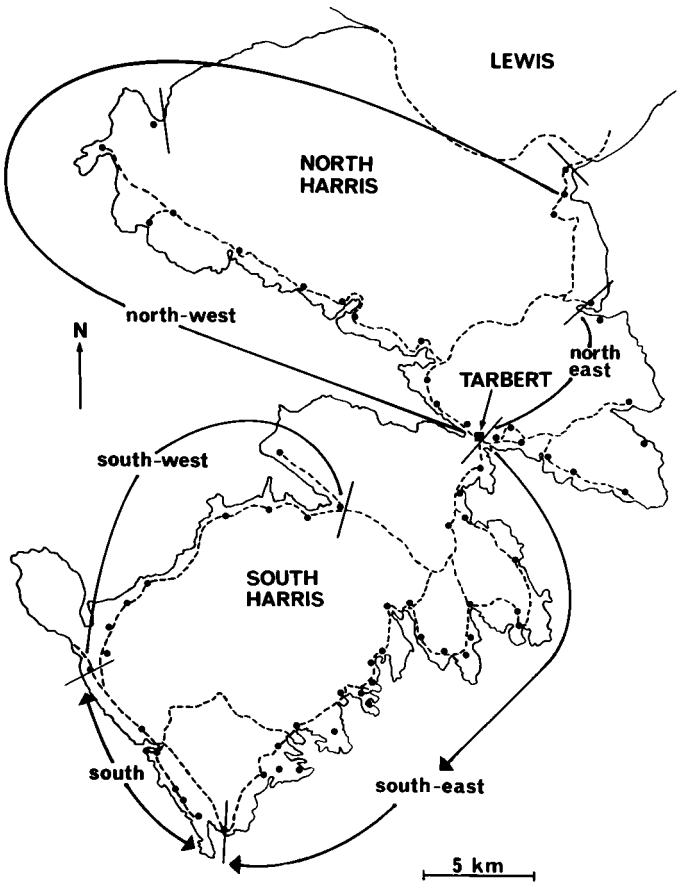



**Fig. 2.** The Isle of Harris.

on or near to the coast, as the central part of each island is composed of inhospitable mountain and moor. Previous work on the population of Harris (Clegg, 1995) suggested a trend to non-endogamous marriage among mainland residents. Fishermen showed a greater propensity to marry locally, while the more affluent members of the population were significantly more exogamous.

## Materials and methods

Data on marriages within Harris and Barra were ascertained from 1855 (when statutory vital records were first collected in Scotland) to 1990. For the purposes of this paper the relevant information comprised the places of residence of the two spouses, the date of the marriage and the groom's age and occupation. Only first marriages of both partners were considered and, to reduce the error inherent in allowing for sea crossings between islands, only marriages occurring on the mainland of each island were taken into account. Occupations were described in five categories:

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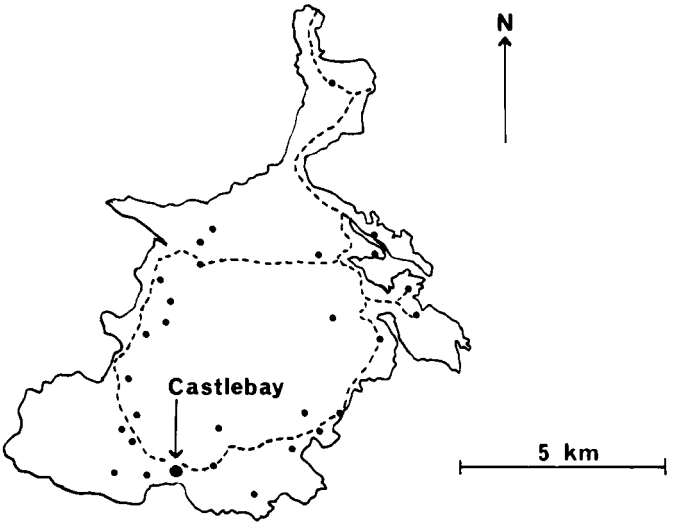



**Fig. 3.** The Isle of Barra.

fisherman, crofter, seaman, lower status land-based and upper status land-based. The shortest road distances between the places of residence of the spouses were measured on 1/25000 Ordnance Survey maps, using a computer-controlled digitiser. Eight hundred and forty-three marriages were ascertained in Harris, and 444 in Barra. The number of named settlements for Harris was 70 and for Barra, 29.

Preliminary analysis of distributions of marital distances showed that the variances of subgroups—whether determined by time, groom's occupation or groom's age—were generally proportional to their means, and positively skewed. Empirically, logarithmic transformation of these distances rendered variances independent of means and reduced skewness considerably, generally to non-significant levels. Statistical examination of marital distances was performed, therefore, on logarithmically transformed data, using only exogamous marriages.

Problems of analysis were considerably greater when the relationships between marital distances and inter-settlement distances were considered. While each marriage—and hence marital distance—can be considered independent of all others, this does not hold for inter-settlement distances. For example, if two settlements, A and B, are close together, their distances from a third settlement C will be similar. Hence direct comparisons of the distributions of marital and inter-settlement distances would be invalid.

Simply comparing mean marital distances over time is potentially misleading because changes can be caused by differences over time in settlement size and location as well as by changes in behaviour. If settlement A is three times the size of settlements B and C, and all are equidistant, then one would expect three times as many marriages between people from A and B, and between people from A and C, as between people from B and C. If relative settlement sizes change over time, then ignoring this could seriously bias the results. For example, if in time period 1 the two largest settlements

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are A and B, which are fairly close, then a fairly small mean marital distance would be expected, due to a large number of the exogamous marriages being between people from A and B. If in time period 2 the two largest settlements are A and C, which are much further away, then a larger mean marital distance would be expected, due to a large number of the exogamous marriages being between people from A and C. This would be true even if the behaviour of individual people had not changed at all.

Hence it is necessary, for each time period, to compute the expected distribution of marital distances, given the above. Comparison of this to the observed numbers will indicate changes in behaviour. The approach adopted here is as follows.

For each time period on each island, the expected number of marriages between each pair of settlements is proportional to the product of the sizes of the settlements. In other words this expected value assumes random mating. Settlement sizes were not available so that the total observed number of marriages, both endogamous and exogamous, undertaken by members of a particular settlement was taken as an indication of its size. Hence the expected number of marriages between A and B is just the number of marriages for A times the number of marriages for B, divided by the total number of marriages for that time period on that island. This calculation is exactly analogous to that of the expected numbers in the chi-squared test of association in a contingency table.

Next, the distance (in km) between each pair of settlements was noted and, to aid interpretability, these were grouped into approximately 5-km (Harris) and 2-km (Barra) bands. By analogy with the chi-squared test, sometimes the last two or three bands were amalgamated so that (almost) all of the expected values were above 5. For each band the expected number of marriages is the sum of those calculated as above. Endogamous marriages were treated as a separate band with zero distance. The observed and expected values will sum to the same value in each time period.

The observed number of marriages was then modelled as the expected number times a function of the time period and the average distance for that band. A single model was used to fit all times and distance bands on an island, but separate models were fitted for each island. The details of this modelling are in the Appendix.

As far as the application of Central Place theory to the data was concerned, it was hypothesised that the development of a Central Place would result in an excess over expectation of the observed numbers of journeys, including marital journeys, between rural settlements and Central Places, as compared with those between rural settlements. To aid comparability, settlement distances were banded, and comparisons made within bands.

All the computations were made on the University of Aberdeen's SUN computer, using the Statistical Package for the Social Sciences (SPSS) and GENSTAT.

## Results

### *The effects of time, groom's occupation, and groom's age on marital distances*

Mean back-transformed values at different periods and the 95% confidence intervals (Sokal & Rohlf, 1981) are shown in Table 1. Comparisons over time can only be regarded as approximations due to the problems of differential settlement size noted above.

For Harris there was a considerable fall in marital distances between 1855–75 and

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**Table 1.** Antilogarithms of mean log marital distances, with lower and upper 95% confidence intervals (CI), by time period

| | Harris | | | | Barra | | | |
|---|---|---|---|---|---|---|---|---|
| Period | *n* | Antilog mean log marital distance | Antilog lower CI | Antilog upper CI | *n* | Antilog mean log marital distance | Antilog lower CI | Antilog upper CI |
| 1855–75 | 157 | 6·93 | 5·90 | 8·14 | 88 | 2·86 | 2·35 | 3·48 |
| 1876–95 | 151 | 4·42 | 3·77 | 5·18 | 88 | 2·77 | 2·32 | 3·30 |
| 1896–1915 | 147 | 4·16 | 3·53 | 4·91 | 89 | 2·56 | 2·10 | 3·11 |
| 1916–35 | 117 | 5·18 | 4·25 | 6·32 | 85 | 2·99 | 2·49 | 3·59 |
| 1936–55 | 124 | 6·62 | 5·49 | 7·99 | 39 | 4·30 | 3·39 | 5·45 |
| 1956–75 | 95 | 10·43 | 8·60 | 13·63 | 29 | 5·11 | 3·69 | 7·08 |
| 1976–90 | 52 | 12·93 | 10·72 | 15·49 | 26 | 4·73 | 3·22 | 6·96 |

**Table 2.** Antilogarithms of mean log marital distances, with lower and upper 95% confidence intervals (CI), by groom's occupation

| | Harris | | | | Barra | | | |
|---|---|---|---|---|---|---|---|---|
| Period and groom's occupation | *n* | Antilog mean log marital distance | Antilog lower CI | Antilog upper CI | *n* | Antilog mean log marital distance | Antilog lower CI | Antilog upper CI |
| 1855–1915 | | | | | | | | |
| Fisher | 263 | 4·58 | 4·17 | 5·34 | 124 | 2·41 | 2·08 | 2·79 |
| Crofter | 47 | 4·75 | 3·51 | 6·16 | 21 | 3·12 | 1·96 | 4·97 |
| Seaman | 25 | 6·12 | 3·88 | 9·64 | 13 | 2·57 | 1·60 | 4·13 |
| Lower | 34 | 6·30 | 4·65 | 8·99 | 27 | 3·57 | 2·37 | 5·39 |
| Upper | 83 | 6·48 | 5·27 | 7·98 | 75 | 2·99 | 2·44 | 3·68 |
| 1916–90 | | | | | | | | |
| Fisher | 42 | 6·78 | 5·02 | 9·15 | 17 | 4·10 | 2·60 | 6·45 |
| Crofter | 44 | 4·22 | 3·12 | 5·71 | 14 | 4·02 | 2·22 | 7·25 |
| Seaman | 51 | 6·99 | 5·15 | 9·50 | 85 | 3·62 | 3·06 | 4·29 |
| Lower | 96 | 7·96 | 6·52 | 9·72 | 24 | 3·15 | 2·00 | 4·96 |
| Upper | 158 | 8·72 | 7·38 | 10·30 | 44 | 4·02 | 3·07 | 5·26 |

1876–95. Thereafter distances remained small until they began to rise in the early years of this century, reaching their highest levels after the middle of the century.

For Barra there was a slight decline in mean marital distance during the latter part of the last and early part of the present century, followed by a more marked rise, with maximal values being reached during the period during and after the 1950s.

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**Table 3.** Harris: antilogarithms of mean log marital distances, with lower and upper 95% confidence intervals (CI), by groom's region

| | 1855–1915 | | | | 1916–90 | | | |
|---|---|---|---|---|---|---|---|---|
| Groom's region | *n* | Antilog mean log marital distance | Antilog lower CI | Antilog upper CI | *n* | Antilog mean log marital distance | Antilog lower CI | Antilog upper CI |
| North-east | 71 | 7·66 | 6·12 | 9·59 | 36 | 6·91 | 5·12 | 9·34 |
| South-east | 264 | 4·11 | 3·63 | 4·65 | 163 | 5·47 | 4·64 | 6·44 |
| South | 34 | 5·93 | 4·48 | 7·86 | 47 | 7·93 | 5·62 | 11·15 |
| South-west | 15 | 12·60 | 8·46 | 18·76 | 48 | 12·86 | 10·35 | 15·75 |
| North-west | 68 | 5·83 | 4·54 | 7·40 | 97 | 9·47 | 7·74 | 11·60 |

Back-transformed logarithmic marital distances and 95% confidence limits for different groom's occupation, during two time periods, 1855–1915 and 1916–90 are shown in Table 2. These two periods were chosen because during the earlier one the populations of the two islands were increasing, while during the later one they decreased (Geddes, 1955). Within-time period comparisons between occupations or areas should be valid, although differences in mean marital distance could be due to differences in how the various populations are dispersed rather than differences in the behaviour of individuals in those populations.

In Harris the traditional occupations of crofter and fisherman had the smallest marital distances and unskilled and skilled/professional land-based occupations the highest; seamen were intermediate. In Barra, differences were less marked, but seamen generally married at shorter distances than other groups. In both Harris and Barra the secular trend to greater marital distance with time was seen in most occupations.

Table 3 shows that marital distances in Harris were least in the south-east and greatest in the south-west. Generally, distances during 1916–90 were greater than during 1855–1915.

These data were analysed separately for each island and for the two periods, 1855–1915 and 1916–90, by analysis of covariance, the dependent variable being the logarithm of marital distance, the factors the groom's occupation and region of residence (for Harris), and the two covariates the decimal date of marriage and the age of the groom. The results are indicated in Tables 4, 5 and 6.

Table 4 shows the analyses of covariance. The date of marriage had significant effects in Harris during both periods; the coefficient was negative during 1855–1915, but positive during 1916–90 (Table 5). In Barra the coefficient was significant (and positive) only during 1916–90.

The age of the groom did not appear to influence marital distance in either island during 1855–1915, but subsequently coefficients were highly significant in Harris and almost significant in Barra. Both these coefficients were negative (Table 5), and it seems that older grooms married at shorter distances.

Groom's occupation appeared to have an effect on marital distance only in Harris

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**Table 4.** Analysis of covariance

| Source of variation | 1855–1915 Sum of squares | df | Mean square | F | 1916–90 Sum of squares | df | Mean square | F |
|---|---|---|---|---|---|---|---|---|
| Harris | | | | | | | | |
| Within cells + residual | 76·25 | 442 | 0·17 | | 63·73 | 382 | 0·17 | |
| Marriage date | 2·70 | 1 | 2·70 | 15·66**** | 5·90 | 1 | 5·90 | 35·35**** |
| Groom's age | 0·29 | 1 | 0·29 | 1·68 | 0·84 | 1 | 0·84 | 5·03* |
| Groom's occupation | 0·51 | 4 | 0·13 | 0·73 | 1·20 | 4 | 0·30 | 1·80 |
| Groom's region | 5·44 | 4 | 1·36 | 2·89**** | 4·75 | 4 | 1·19 | 7·12*** |
| Barra | | | | | | | | |
| Within cells + residual | 37·36 | 251 | 0·15 | | 23·57 | 177 | 0·13 | |
| Marriage date | 0·04 | 1 | 0·04 | 0·27 | 1·63 | 1 | 1·63 | 12·54*** |
| Groom's age | 0·12 | 1 | 0·12 | 0·80 | 0·44 | 1 | 0·44 | 3·39⁻* |
| Groom's occupation | 0·70 | 4 | 0·18 | 1·20 | 0·81 | 4 | 0·20 | 1·54 |

Dependent variable is log marital distance. Independent factors are groom's occupation and (for Harris only) groom's region of residence. Covariates are date of marriage and groom's age.
⁻$*p = 0{\cdot}069$; ***$0{\cdot}001 < p < 0{\cdot}01$; ****$p < 0{\cdot}001$.

**Table 5.** Regression coefficients (with standard errors) for the covariates

| Covariate | Regression coefficients 1855–1915 | 1916–50 |
|---|---|---|
| Harris | | |
| Marriage date | −0·00576 (0·00131)**** | 0·00623 (0·00112)**** |
| Groom's age | −0·00504 (0·00420) | −0·00650 (0·00291)* |
| Barra | | |
| Marriage date | −0·00081 (0·00156) | 0·00494 (0·00141)*** |
| Groom's age | 0·00417 (0·00432) | −0·00750 (0·00410)⁻* |

⁻$*p = 0{\cdot}069$; *$0{\cdot}02 < p < 0{\cdot}05$; ***$0{\cdot}001 < p < 0{\cdot}01$; ****$p < 0{\cdot}001$.

during the earlier period, with a clear difference between the traditional occupations of fishing and crofting on the one hand, and the remaining occupations on the other (Table 6).

In Harris the region of residence of the groom had significant effects on marital distance during both periods, with the shortest distances in the south-east and greatest distances in the south-west (Table 7).

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**Table 6.** Antilogarithms of mean log marital distance before and after covariance analysis

| | 1855–1915 | | 1916–90 | |
|---|---|---|---|---|
| Groom's occupation | Antilog observed mean log | Antilog adjusted mean log | Antilog observed mean log | Antilog adjusted mean log |
| Harris | | | | |
| Fisher | 4·72 | 4·54 | 6·29 | 6·70 |
| Crofter | 4·65 | 4·24 | 4·24 | 5·07 |
| Seaman | 6·12 | 6·79 | 7·27 | 7·35 |
| Lower | 6·47 | 6·74 | 8·00 | 7·48 |
| Upper | 6·49 | 6·41 | 8·75 | 7·28 |
| Barra | | | | |
| Fisher | 2·41 | 2·47 | 4·10 | 3·52 |
| Crofter | 3·12 | 2·98 | 4·02 | 5·40 |
| Seaman | 2·57 | 2·64 | 3·62 | 4·12 |
| Lower | 3·57 | 3·64 | 3·15 | 2·71 |
| Upper | 2·99 | 2·89 | 4·02 | 3·55 |

**Table 7.** Antilogarithms of mean log marital distances for Harris before and after covariance analysis

| | 1855–1915 | | 1916–90 | |
|---|---|---|---|---|
| Groom's region | Antilog observed mean log | Antilog adjusted mean log | Antilog observed mean log | Antilog adjusted mean log |
| North-east | 7·66 | 7·44 | 6·91 | 7·37 |
| South-east | 4·11 | 4·02 | 5·47 | 5·89 |
| South | 5·93 | 5·95 | 7·93 | 8·07 |
| South-west | 12·60 | 12·98 | 12·81 | 11·35 |
| North-west | 5·83 | 6·24 | 9·47 | 9·39 |

*Relationship between marital frequency and inter-settlement distance*

Observed and expected numbers of marriages at different inter-settlement distances are shown in Table 8 (Harris; 5-km intervals) and Table 9 (Barra; 2-km intervals). During early time periods there were marked excesses of marriages at shorter distances, and deficiencies at longer distances. Latterly though, and especially after 1955, these trends largely disappeared in Barra, and were markedly reducd in Harris.

For both Harris and Barra it was found, using the procedures described in Appendix 1, that the models could be reduced to fitting separate lines for four

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**Table 8.** Observed and expected numbers of marriages in 5-km inter-settlement distance classes: Harris, all marriages

| | Distance (km) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Period | 0 | <5 | <10 | <15 | <20 | <25 | <30 | <35 | <40 | <45 |
| 1855–75 | | | | | | | | | | |
| Mean distance | 0 | 2·57 | 7·61 | 12·41 | 17·60 | 22·45 | 27·46 | 32·37 | 41·41 | |
| Obs | 129 | 75 | 19 | 18 | 16 | 15 | 9 | 1 | 4 | |
| Exp | 11·92 | 48·62 | 50·28 | 46·05 | 38·90 | 36·48 | 31·48 | 11·50 | 11·04 | |
| 1876–95 | | | | | | | | | | |
| Mean distance | 0 | 2·50 | 7·62 | 12·40 | 17·56 | 22·39 | 27·51 | 32·46 | 41·48 | |
| Obs | 105 | 93 | 26 | 13 | 9 | 6 | 3 | 0 | 1 | |
| Exp | 8·69 | 43·68 | 40·38 | 44·41 | 38·97 | 31·73 | 26·54 | 11·63 | 9·80 | |
| 1896–1915 | | | | | | | | | | |
| Mean distance | 0 | 2·51 | 7·59 | 12·42 | 17·57 | 22·38 | 27·49 | 32·42 | 41·02 | |
| Obs | 107 | 88 | 30 | 14 | 7 | 6 | 2 | 0 | 0 | |
| Exp | 8·63 | 39·81 | 36·98 | 42·31 | 39·78 | 31·12 | 27·93 | 12·75 | 14·50 | |
| 1916–35 | | | | | | | | | | |
| Mean distance | 0 | 2·48 | 7·59 | 12·38 | 17·42 | 22·37 | 27·55 | 32·36 | 37·33 | 46·20 |
| Obs | 78 | 63 | 19 | 16 | 4 | 3 | 8 | 2 | 1 | 1 |
| Exp | 6·30 | 29·94 | 25·90 | 28·93 | 27·52 | 21·68 | 25·68 | 13·48 | 9·23 | 6·34 |
| 1936–55 | | | | | | | | | | |
| Mean distance | 0 | 2·47 | 7·54 | 12·52 | 17·68 | 22·59 | 27·50 | 32·44 | 37·09 | 45·48 |
| Obs | 48 | 56 | 18 | 20 | 9 | 6 | 10 | 3 | 1 | 1 |
| Exp | 5·31 | 23·50 | 21·30 | 25·31 | 23·66 | 21·02 | 27·58 | 12·12 | 5·38 | 6·70 |
| 1956–75 | | | | | | | | | | |
| Mean distance | 0 | 2·43 | 7·68 | 12·39 | 17·57 | 22·56 | 27·49 | 32·38 | 41·67 | |
| Obs | 16 | 23 | 20 | 8 | 10 | 13 | 13 | 5 | 3 | |
| Exp | 4·00 | 12·35 | 13·43 | 14·54 | 17·43 | 15·28 | 17·13 | 8·75 | 7·95 | |
| 1976–90 | | | | | | | | | | |
| Mean distance | 0 | 2·23 | 7·59 | 12·53 | 17·64 | 22·66 | 27·34 | 34·97 | | |
| Obs | 8 | 9 | 9 | 6 | 10 | 7 | 9 | 2 | | |
| Exp | 2·17 | 8·50 | 6·39 | 8·81 | 9·24 | 9·81 | 10·44 | 4·69 | | |

amalgamated time periods. These are the same for each island except that the split between first and second periods comes at 1875 on Harris but 1895 on Barra. The other split points are 1935 and 1955 on each island.

The models can now be used to show how the number of marriages depends on distance and how this changes over time, but without the potentially distorting effect of differential settlement sizes. In addition the full distribution of marital distances is seen, not just its mean. Fitted (predicted) values were produced from the models using an expected value of 10 (an arbitrary figure) in each case, and these are shown in Figs 4 and 5. Here, the aim is to remove the effects of the fact that, even under panmixis, some marital distances are more likely to occur than others because of the sizes and locations of the settlements, and also that this effect may change over time. Hence the

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**Table 9.** Observed and expected numbers of marriages in 2-km inter-settlement distance classes: Barra, all marriages

| | Distance (km) | | | | | | |
|---|---|---|---|---|---|---|---|
| Period | 0 | <2 | <4 | <6 | <8 | <10 | ⩾10 |
| 1855–75 | | | | | | | |
| Mean distance | 0 | 1·24 | 3·05 | 5·04 | 6·94 | 9·02 | 14·26 |
| Obs | 80 | 30 | 24 | 11 | 10 | 10 | 3 |
| Exp | 14·50 | 22·02 | 33·00 | 30·94 | 22·46 | 30·40 | 14·38 |
| 1876–95 | | | | | | | |
| Mean distance | 0 | 1·28 | 3·04 | 5·04 | 6·99 | 9·04 | 11·90 |
| Obs | 73 | 31 | 31 | 8 | 6 | 8 | 4 |
| Exp | 14·19 | 21·98 | 38·64 | 27·71 | 24·47 | 23·71 | 10·21 |
| 1896–1915 | | | | | | | |
| Mean distance | 0 | 1·19 | 3·09 | 5·05 | 6·94 | 8·98 | 10·52 |
| Obs | 55 | 30 | 19 | 20 | 6 | 11 | 2 |
| Exp | 10·39 | 19·33 | 29·48 | 29·86 | 18·72 | 26·83 | 9·24 |
| 1916–35 | | | | | | | |
| Mean distance | 0 | 1·20 | 3·07 | 5·07 | 6·94 | 8·97 | 11·90 |
| Obs | 36 | 28 | 22 | 19 | 6 | 5 | 6 |
| Exp | 6·55 | 11·93 | 16·65 | 24·43 | 18·70 | 31·79 | 11·82 |
| 1936–55 | | | | | | | |
| Mean distance | 0·42 | | 3·04 | 5·05 | 6·90 | 8·97 | 12·77 |
| Obs | 18 | | 12 | 8 | 3 | 4 | 6 |
| Exp | 8·35 | | 6·86 | 9·66 | 7·31 | 10·58 | 8·21 |
| 1956–75 | | | | | | | |
| Mean distance | 0·58 | | 3·21 | 5·85 | | 9·00 | 13·18 |
| Obs | 9 | | 7 | 5 | | 7 | 6 |
| Exp | 6·94 | | 5·41 | 8·61 | | 6·17 | 6·56 |
| 1976–90 | | | | | | | |
| Mean distance | 0·55 | | 3·17 | 5·09 | 7·96 | | |
| Obs | 10 | | 3 | 4 | 9 | | |
| Exp | 7·04 | | 4·39 | 5·62 | 8·39 | | |

features of Figs 4 and 5 should be due only to people's behaviour, not the distribution of settlements.

Endogamous marriages were far more common earlier on: the drastic reduction in these came after 1956 in Harris but after 1936 in Barra. At longer distances there were many more marriages in the post-1956 period, especially on Barra. On Harris the effect of greater distance was minimal above 5–10 km. Thus an individual was much more likely to marry someone from within 5 km than from further afield, especially before 1956. However, they were not much more likely to marry a particular person from 10 km distance than someone from, say 35 km away. The fact that more marriages actually occurred in the 10-km band was due to there being more potential spouses at these distances. On Barra the effect was similar, with the band at about 5 km.

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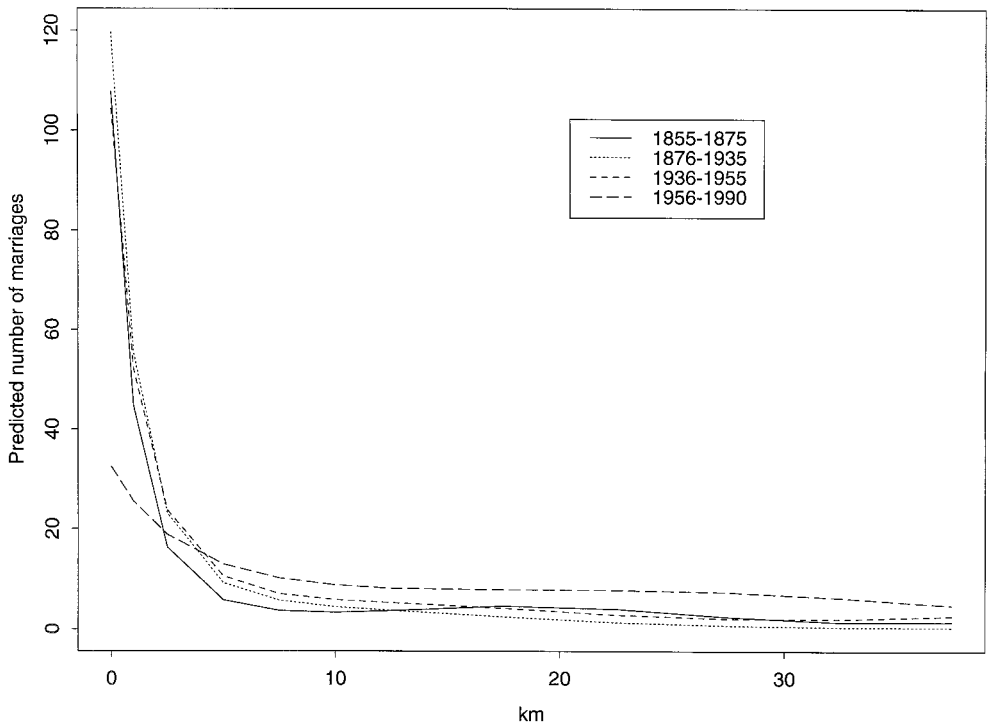



**Fig. 4.** Predicted numbers of marriages versus inter-settlement distance, where 'expected' number is 10 (Harris).

*Spouse residences and Central Place theory*

Tables 10 and 11 comprise contingency tables for Harris and Barra respectively, over successive 30-year periods and for different bands of inter-settlement distances. They show observed and expected numbers of marriages where the spouses were either both from landward (rural) parts of their island or one spouse was from a landward settlement and the other from the Central Place. The contributions of each cell to the total $\chi^2$ value are also shown. The 30-year periods were chosen in order to raise cell totals to reasonable levels.

On Harris significant heterogeneity was found only for short-distance marriages—less than 10 km—but on Barra both distance bands showed heterogeneity. However, while the findings at less than 5 km were highly significant, at greater distances they only just reached the 5% level, and expected numbers were generally just less than 5.

During most of the 30-year intervals, differences between observed and expected numbers of marriages were small, with consequent small contributions to $\chi^2$, but between 1946 and 1990 there were excesses of landward–Central Place marriages at the shortest distances, these single cells contributing more than two-thirds of the total $\chi^2$ statistics.

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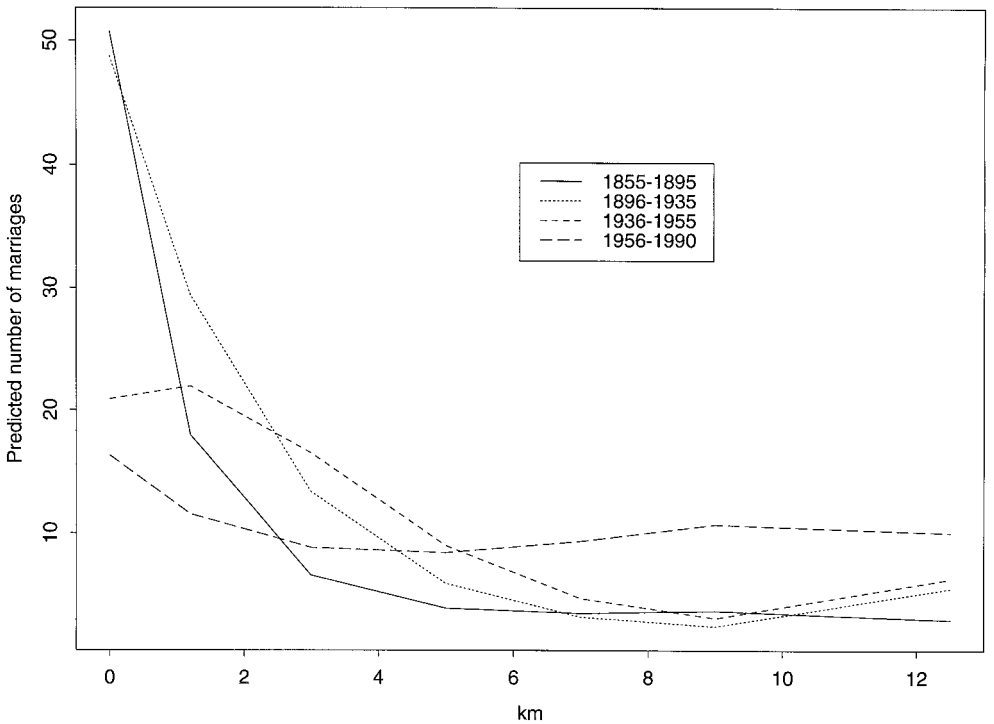



**Fig. 5.** Predicted numbers of marriages versus inter-settlement distance, where 'expected' number is 10 (Barra).

## Discussion

*Effects of time, groom's age and groom's occupation on marital distance*

The impact of time on mean marital distances in these two islands seems to have been complex (Tables 1, 4). In Harris, a highly significant negative regression coefficient during 1855–1915 was replaced by an equally significant positive one subsequently.

Most of the fall in marital distances in Harris during 1855–1915 occurred between 1855 and 1895 (Table 1). This was a time during which the fishing industry suffered a severe and long-term decline, beginning in 1884, due both to over-production and to a fall in the quality of the catch (Gray, 1978; Hunter, 1976). Table 12 shows back-transforms of logarithmic mean marital distances during 1865–84 and 1885–1904 for fishermen and non-fishing occupations. In Harris there was a highly significant fall in marital distances of fishermen between pre- and post-1884; other occupations experienced a smaller, non-significant fall. In Barra, fishermen's marital distances fell, but to a lesser extent, while non-fishermen showed a small rise.

These findings suggest an association, much stronger in Harris and among fishermen themselves, between this collapse of the staple exporting industry of the islands, and change in marital distances. Affluence or high social status have been generally supposed to be associated with increased marital distance (Küchemann *et al.*,

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**Table 10.** Observed and expected numbers of marriages within rural areas and between rural areas and central places: Harris

| Marital distance and type of marriage | | 1855–1885 | 1886–1915 | 1916–1945 | 1946–1990 | $\chi^2$ |
|---|---|---|---|---|---|---|
| 0–9 km | | | | | | |
| Rural | Observed | 122 | 169 | 106 | 60 | 20·795**** |
| | Expected | 118·5 | 161·6 | 105·9 | 70·9 | |
| | Contr. to $\chi^2$ | 0·103 | 0·339 | 0·001 | 1·676 | |
| Rural–Tarbert | Observed | 10 | 11 | 12 | 19 | |
| | Expected | 13·5 | 18·4 | 12·1 | 8·1 | |
| | Contr. to $\chi^2$ | 0·907 | 2·976 | 0·001 | 14·668 | |
| 10–19 km | | | | | | |
| Rural | Observed | 54 | 32 | 36 | 60 | 1·892 |
| | Expected | 52·2 | 30·5 | 37·4 | 61·8 | |
| | Contr. to $\chi^2$ | 0·062 | 0·074 | 0·052 | 0·052 | |
| Rural–Tarbert | Observed | 6 | 3 | 7 | 11 | |
| | Expected | 7·8 | 4·5 | 5·6 | 9·2 | |
| | Contr. to $\chi^2$ | 0·415 | 0·500 | 0·350 | 0·352 | |
| $\geqslant$20 km | | | | | | |
| Rural | Observed | 28 | 9 | 19 | 43 | 2·389 |
| | Expected | 28·9 | 10·7 | 18·2 | 41·3 | |
| | Contr. to $\chi^2$ | 0·028 | 0·270 | 0·035 | 0·070 | |
| Rural–Tarbert | Observed | 7 | 4 | 3 | 7 | |
| | Expected | 6·1 | 2·3 | 3·9 | 8·8 | |
| | Contr. to $\chi^2$ | 0·133 | 1·257 | 0·207 | 0·368 | |

****$p < 0{\cdot}001$.

1974), and their decline could therefore reasonably be expected to be associated with marriages at closer range.

During most of the present century the trend in both islands has been for marital distances to increase (Tables 1 and 4, Figs 4 and 5). Previous authors (e.g. Brennan & Boyce, 1980) have also shown trends to increasing marital distances with time. Such changes have been ascribed to increasing affluence, and also to improved communication, enabling individuals to travel further and more easily (Küchemann, Boyce & Harrison, 1967). It is certainly the case in the Outer Hebrides that land communications were poor until quite recently. In Harris improvements began in the early 1920s with Lord Leverhulme's attempts to develop the area (Nicolson, 1960), and in Barra the ring road linking most of the settlements was not completed until 1930 (Thompson, 1974). These times coincide approximately with the first major increases in marital distances (Table 1).

The finding that after 1915 increasing age was associated with decreasing marital distance (Table 5) is somewhat surprising. It suggests, if it is assumed that non-affluence is associated with reduced marital distance, that older grooms were poorer people—possibly an example of Malthusian 'moral restraint'. Certainly the

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**Table 11.** Observed and expected numbers of marriages within rural ares and between rural areas and central places: Barra

| Marital distance and type of marriage | | 1855–1885 | 1886–1915 | 1916–1945 | 1946–1990 | $\chi^2$ |
|---|---|---|---|---|---|---|
| 0–4 km | | | | | | |
| Rural | Observed | 76 | 83 | 66 | 19 | 17·356**** |
| | Expected | 72·5 | 83·3 | 61·0 | 27·2 | |
| | Contr. to $\chi^2$ | 0·169 | 0·001 | 0·410 | 2·472 | |
| Rural–Tarbert | Observed | 12 | 18 | 8 | 14 | |
| | Expected | 15·5 | 17·7 | 13·0 | 5·8 | |
| | Contr. to $\chi^2$ | 0·790 | 0·028 | 1·923 | 11·593 | |
| ⩾5 km | | | | | | |
| Rural | Observed | 34 | 29 | 37 | 29 | 8·090* |
| | Expected | 30·5 | 31·4 | 34·9 | 32·3 | |
| | Contr. to $\chi^2$ | 0·402 | 0·183 | 0·126 | 0·337 | |
| Rural–Tarbert | Observed | 1 | 7 | 3 | 8 | |
| | Expected | 4·5 | 4·6 | 5·1 | 4·8 | |
| | Contr. to $\chi^2$ | 2·722 | 1·252 | 0·865 | 2·133 | |

*$0{\cdot}02 < p < 0{\cdot}05$; ****$p < 0{\cdot}001$.

**Table 12.** Antilogarithms of mean log marital distances, with lower and upper 95% confidence intervals (CI), before and after 1884

| | | Harris | | | | Barra | | | |
|---|---|---|---|---|---|---|---|---|---|
| Groom's occupation | Period | *n* | Antilog mean log marital distance | Antilog lower CI | Antilog upper CI | *n* | Antilog mean log marital distance | Antilog lower CI | Antilog upper CI |
| Fisher | 1865–84 | 91 | 6·61 | 5·34 | 8·18 | 32 | 3·01 | 2·31 | 3·93 |
| | 1885–1904 | 102 | 3·66**** | 3·06 | 4·37 | 59 | 2·29 | 1·87 | 2·83 |
| Other | 1865–84 | 46 | 6·33 | 4·73 | 8·46 | 43 | 2·73 | 1·99 | 3·75 |
| | 1885–1904 | 52 | 5·04 | 3·91 | 6·49 | 34 | 3·21 | 2·37 | 4·34 |

****Significant difference ($p < 0{\cdot}001$) between means for 1865–84 and 1885–1904.

crofting areas of Scotland during the 19th century contained large pools of celibate people of reproductive age. Anderson & Morse (1993) suggested that, up to 1914 at least, these pools of celibates occupied economic and social niches in their populations which were capable of supporting single individuals, but not families. Hence they may have contributed to the relatively low observed rates of emigration. Clegg & Cross (1995) showed that over the period of this study Coale's (1986) index of proportions

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married ($I_m$) fell in both Harris and Barra until the 1930s and then increased quite rapidly. At all times the indices were lower than for Scotland as a whole. Thus there seem to have been significant pools of celibates in both islands until comparatively recently. Whether Anderson & Morse's (1993) hypothesis applies to the post-1914 period seems doubtful, however, as in both islands it was characterised by massive emigration leading to severe decline in population size.

Groom's occupation (Tables 2, 4 and 6) seems to have had only a small effect on marital distance; only in Harris during 1855–1915 was there significant heterogeneity (Table 4) which seems to have been due to the small distances where grooms were fishermen or crofters (Table 6). If, as suggested above, the impact of the collapse of the fishing industry was felt largely by fishermen—and fishing and small-scale agriculture (crofting) are complementary to one another in the 'crofting economy' (Hunter, 1976)—it is understandable that marital distance in these two groups might be depressed during this time.

The consistently significant effect of groom's region of residence on marital distances in Harris (Tables 3, 4 and 7) seems to be due principally to large distances in the south-west. Figure 2 shows this to be the most sparsely settled region; while the south-east, with the lowest distances, has the greatest number of settlements.

### *Marital frequencies and inter-settlement distances*

The findings shown in Tables 8 and 9 and Figs 4 and 5 suggest that the period 1855–1990 was one of significant changes in the relationships between these two variables. During the latter part of the 19th century and early part of the 20th there was a predominant preference for endogamous and short-range marriage, but these trends subsequently declined and were replaced in the last time period (1955–90) by only a small propensity to marry locally and a pronounced trend (especially in Barra) to marry at greater distances. Indeed, in this island there appears to be little or no relationship between inter-settlement distance and the expected number of marriages at this time, and for Harris the relationship is much less strong than over previous periods. Thus it seems permissible to argue that for Barra after 1955 the only constraint on inter-settlement marital frequency was the spatial distribution of settlements. In Harris, although this distribution became more important, there was still an attenuated tendency to marry locally. It seems reasonable to ascribe the difference between the two islands to the much greater size of Harris.

The biological significance of these findings is that they indicate in both islands, but especially in Barra, a secular trend to random mating with respect to distance. This end seems to be achieved in Barra, but has a little way to go in Harris.

### *Spouse residences and Central Place theory*

According to Central Place theory it might be expected that journeys between the urban field and Central Place would be more frequent than the number derived from random expectation. In so far as neighbourhood knowledge plays a part in determining mate choice it could further be expected that those journeys would include marital journeys.

Table 12 suggests that irrespective of inter-settlement distance, for a great deal of

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the 1855–1990 period there was no clear evidence of excesses of journeys between the landward parts of the islands and the Central Places. Only after 1946 and for short inter-settlement distances were there large differences between observed and expected numbers and these cells contributed disproportionately to the significant $\chi^2$ values for each island. This suggests that up to the 1940s, despite the fact that Central Places could be identified in both islands, journeys to them from landward areas were no more frequent than random expectation. It is possible, of course that marital journeys do not sample randomly all journeys—they occur in a much more restricted age group than the population as a whole, for example. But the evidence does suggest that since the mid-20th century Tarbert in Harris and Castlebay in Barra have become much more firmly established as Central Places. However, it also appears that this recognition is largely confined to settlements relatively close to Central Places: at greater distances, no evidence of more frequent journeys is apparent.

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## Appendix

Let $O_{ij}$ be the observed number of marriages in time period $i$ and distance band $j$ for the island and let $E_{ij}$ be the equivalent 'expected' number. Clearly it is sensible to model $O_{ij}$ as being, apart from the error term to allow for random variation, equal to $E_{ij}$ times a function of the time period and the distance (km). Inspection of the data shows that in most time periods $O_{ij}$ is much larger than $E_{ij}$ for endogamous and short range marriages, but lower for longer range marriages, with further increases in distance having less effect. This immediately suggests an exponential function. Hence let

$$O_{ij} = E_{ij} \times constant \times e^{f(time,km)}$$

where f(.) is some function, so that, taking logs

$$\log(O_{ij}) = \log(E_{ij}) + constant + f(time,km)$$

This is a generalised linear model (McCullagh & Nelder, 1989) with response variable $O_{ij}$, log link, an offset of log ($E_{ij}$) and, since the responses are counts, Poisson error structure. Treating time period as a factor and km as a covariate, f(*time*,*km*) is just $time + time.km + time.km^2 + \ldots$ where the dot denotes interaction in standard statistical notation. In plain terms, this means that a separate regression line, a polynomial in km, is fitted for each time period, with the order of the polynomial the same for each period.

A forward selection procedure found that, rather surprisingly, a polynomial of order 5 was necessary to fit the Harris data adequately while one of order 3 was sufficient for Barra. Each model was then simplified by testing whether adjacent time periods could be amalgamated, that is fitted with the same regression line. The procedure was simply to fit the models with each pair of time periods amalgamated in turn and to join the pair which gave the smallest rise in deviance (equivalent to the residual sum of squares in normal regression). This was repeated until all amalgamations produced significant deterioration in fit.

The structure of this model is similar to that of Relethford (1986, pp. 803–809). However, in comparison, $E_{ij}$ is calculated using the population sizes not raised to any power, while the function of distance is much more general and is allowed to vary over time.

Using generalised linear modelling allows the model to be fitted without the unrealistic assumption of normality, and without zero observed values causing problems. The presentation and interpretation of the results differ from those of Relethford (1986) because of the differing objectives of the present work.

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