

The Contribution of Irish Immigrants to the Quebec (Canada) Gene Pool: An Estimation Using Data from Deep-Rooted Genealogies

La contribution des immigrants irlandais au pool génique du Québec (Canada) : une estimation à partir de données généalogiques

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Abstract European settlement in Quebec (Canada) began in the early 17th century, with the arrival of French pioneers. After the British Conquest in 1760, immigrants from the British Isles began to settle in some parts of Quebec. Many of these immigrants were Irish Catholics. Historians and genealogists have identified several names of Irish origin in the French Canadian population, and many scholars have wondered about the importance of the integration of Irish migrants and their descendants within this population. The purposes of this study are to identify and characterize the founders of Irish origin to estimate the importance of their genetic contribution to the contemporary Quebec population, and to measure the variability of this contribution according to the founders' period of arrival and county of origin in Ireland. Data was obtained from a set of 2,223 ascending genealogies going back as far as the early 17th century. The average genealogical depth is a little more than 9 generations, with many branches reaching 16 or 17 generations. Although Irish founders explain less than 1% of the total Quebec gene pool, results show that nearly 21% of the genealogies contain at least one Irish founder. These founders contributed to the peopling of all regions of Quebec, but there are some important

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variations from one region to another. A majority of the Irish founders immigrated during the 19th century, and most of them came from the counties of Southern Ireland.

Keywords Irish immigrants · Quebec population · Genealogies · Genetic contribution · Founders

Résumé Le peuplement d'origine européenne au Québec (Canada) a commencé au début du 17^e siècle avec l'arrivée de pionniers venus de France. Suite à la conquête anglaise de 1760, des immigrants en provenance des îles britanniques se sont installés sur le territoire québécois. Plusieurs de ces immigrants étaient des Irlandais catholiques. Des historiens et généalogistes ont identifié de nombreux patronymes d'origine irlandaise parmi la population canadienne-française et certains chercheurs se sont interrogés à propos de l'intégration des immigrants irlandais et de leurs descendants au sein de cette population. L'objectif de cette étude est d'identifier les fondateurs d'origine irlandaise et de caractériser leur contribution génétique à la population contemporaine du Québec, ainsi que de mesurer la variabilité de cette contribution selon la période d'arrivée et le comté d'origine en Irlande. Les données proviennent d'un corpus de 2223 généalogies ascendantes remontant jusqu'au début du 17^e siècle. La profondeur moyenne des généalogies est d'un peu plus de 9 générations, plusieurs branches atteignant 16 ou 17 générations. Les fondateurs irlandais expliquent moins de 1% du pool génétique québécois, mais près de 21% des généalogies contiennent au moins un fondateur irlandais. Ces fondateurs ont contribué au peuplement de toutes les régions du Québec, avec toutefois quelques variations importantes d'une région à l'autre. La majorité des fondateurs irlandais identifiés ont immigré au 19^e siècle et provenaient principalement des comtés du sud de l'Irlande.

Mots-clés Immigrants irlandais · Population du Québec · Généalogies · Contribution génétique · Fondateurs

1 Introduction

The European colonization of Canada began in the 17th century with the arrival of settlers coming mostly from France. A few migrants from other parts of Europe also came during the French Regime (Charbonneau et al. 1993, 2000). Following the taking over of the colony by the British authorities in 1760, subsequent immigration brought thousands of migrants from Great Britain and Ireland (McInnis 2000). Many of these immigrants settled in the province of Quebec. Although some studies have been published about the importance and the context of Irish immigration to Canada, little is known of the integration and the genetic impact of Irish immigrants and their descendants within the Quebec population. Using data from extended ascending genealogies, the present study aims at a better understanding of the Irish contribution to the Quebec gene pool. The main purposes of the study were to identify and characterize the immigrant founders of Irish origin in the Quebec

population, to estimate the importance of the genetic contribution of these Irish immigrants to Quebec's total and regional populations, and to measure the variability of this contribution according to the founders' period of arrival and county of origin in Ireland.

2 The Quebec Population and Irish Immigration

The year 2008 marks the 400th anniversary of European settlement in Quebec, which began with the founding of Quebec City by Samuel de Champlain in 1608. During the 150 years of the French Regime, approximately 10,000 Europeans settled along the banks of the St-Lawrence river, in what was then called Nouvelle-France (Charbonneau et al. 2000). Most of these pioneers (90%) originated from France, were Roman Catholics and were either employees of the *Compagnie des Cent Associés*, colonists, *Filles du Roy* or soldiers of the French Army (Charbonneau et al. 1993). Their descendants constitute most of the contemporary French-Canadian population of Quebec, which numbers approximately 5.5 million (Vézina et al. 2006). Although their exact number is unknown, a few Irish immigrants were among the pioneers who settled during the French Regime. It seems that these early Irish immigrants were quickly assimilated into the French-Canadian population (Guérin 1946; Vaillancourt 1976; McGowan 1999).

After the British Conquest in 1760, the French-Canadian population became somewhat isolated as no further demographic contribution came from France. Apart from the arrival of Acadians who emigrated to Quebec after their deportation in 1755, some Loyalists fleeing the United States during the war of Independence and a German contingent (mostly men) in the 1780s, the bulk of the immigration came from the British Isles (Wilhelmy 1984; Dickinson 1994; McInnis 2000). Thousands of migrants from England, Ireland and Scotland settled mainly in the urban areas of the province, especially in the cities of Montreal and Quebec (Houston and Smyth 1990; Willis 1990; Grace 2003). The massive emigration movement from Ireland which began during the second quarter of the 19th century¹ brought more than half a million Irish immigrants to the Canadian shores, making them the most important immigrant group during this period (Houston and Smyth 1990). Among the Irish immigrants who settled in Quebec (number not known), those who were Catholics could intermarry more easily with French Canadians, in comparison with British or Irish Protestants (O'Gallagher 1988; Olson and Thornton 1992; Beaudoin 1998).

After 1870, Irish immigration to Canada became less important, representing between 2% and 8% of all migrants (Wilson 1989; Elliott 1999). According to census data, nearly 25% of Canadians were of Irish origin in 1871 (Statistics Canada 2008). In Quebec, however, this proportion was much lower (10%). Following the slowing down of Irish immigration, the proportion of Canadians of Irish origin

¹ This massive emigration from Ireland was caused by the conjunction of several socioeconomic, demographic and political factors (Kennedy 1973; Willis 1990; Elliott 1999; McGowan 1999). It is estimated that by 1891, 39% of Irish-born people were living outside Ireland (Kennedy 1973).

gradually decreased during the 20th century. In 2001, this proportion was less than 12% (3% in Quebec).

3 The Genetic Profile of the Quebec Population

Population history in Quebec is characterized by what has been called *founder effects*. These effects can be described as consequences of settlement and subsequent reproduction, in a new territory, of a relatively limited number of migrants originating from a mother population (Mayr 1963). Over time, the genetic structure of the population gradually becomes distinct from other populations (including the mother population). In Quebec, such a founder effect was caused by the arrival of the French pioneers in the 17th century (Bouchard et al. 1995a). With the growth of the population and its geographic expansion across the Quebec territory, other regional and local founder effects took place (Bouchard and De Braekeleer 1991; Gagnon and Heyer 2001; Gagnon et al. 2001). One of the consequences of the founder effects is that some inherited disorders are found at an elevated frequency in the population, while others are almost absent (Bouchard and De Braekeleer 1992; Vézina 1996; Scriver 2001; Laberge et al. 2005).

Founder effects have been described in other populations. One interesting case is that of Iceland, which was initially settled by some 12,000 immigrants during the 9th and 10th centuries (Helgason et al. 2005). These pioneers came mainly from the Scandinavian countries and from the British Isles (Helgason et al. 2000). After that initial settlement, the Icelandic population remained somewhat isolated, which caused a certain genetic homogenization (Árnason 2003; Helgason et al. 2003). Strong founder effects have also been observed in Finland. Although the number of founders is not known, it seems that the southern part of the Finnish territory was initially settled some 2,000 years ago by migrants coming from the south and east (Kere 2001). The northern part of the country was colonized later by Finnish migrants from the south, with little input from abroad. Several founding events took place, subsequently leading to regional homogeneities and a specific pattern of inherited disorders within the Finnish population (Peltonen et al. 1995; Kittles et al. 1999; O'Brien et al. 1988).

One of the mechanisms by which founder effects are expressed is through the variability of the founders' genetic contribution to the population. Indeed, due to differential demographic behaviours, founders of a population do not contribute equally to the gene pool of each generation (O'Brien et al. 1994; Helgason et al. 2000). In Quebec, it has been shown that some of the early founders are present in a very high proportion of the genealogies of contemporary individuals, while most others appear at low frequencies (Heyer and Tremblay 1995; Tremblay et al. 2003; Vézina et al. 2006; Tremblay et al. 2008). In-depth analysis of this differential genetic contribution and its characteristics is crucial for a better understanding of the genetic structure of the contemporary population. The present study will focus on the contribution of a specific group of Quebec founders: the Irish immigrants.

4 Material and Methods

4.1 RPQA and BALSAC Databases

The Quebec population is among the few sizeable populations for which high quality genealogical information is available for such a long period. Indeed, two large databases containing rich material on the demographic history of the Quebec population are available for research. The first one, called the *Registre de Population du Québec Ancien* (RPQA), contains linked information based upon 700,000 records of marriages, births and deaths which occurred in Quebec during the 17th and 18th centuries (Légaré 1988; Desjardins 1998; Programme de recherche en démographie historique 2008). The second database is the BALSAC Population Register. It contains 2.4 million records (mostly marriages) and covers the 19th century and part of the 20th century (Bouchard et al. 1995b; Bouchard 2007; Projet BALSAC 2008). Together, these databases span nearly four centuries of demographic events. Most of the material used for this study comes from these two databases.

4.2 Genealogical Data

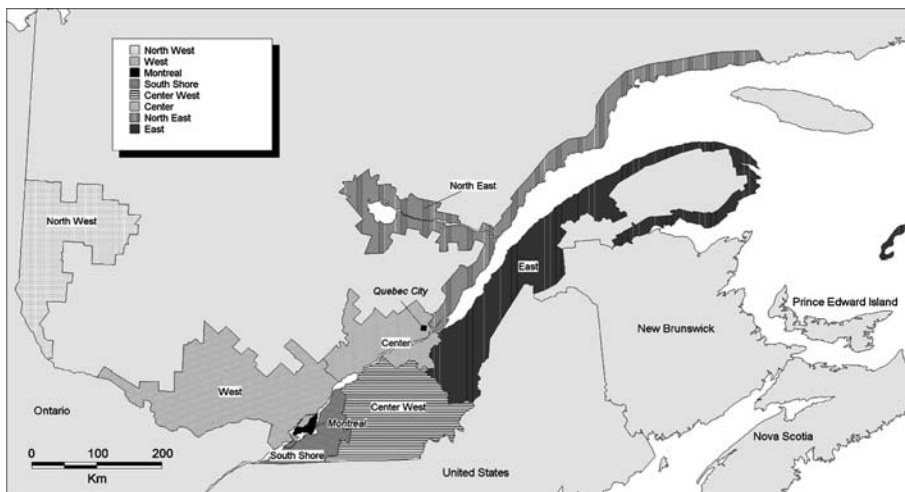
Data was retrieved from a sample of 2,223 ascending genealogies of individuals who married in Quebec between 1945 and 1965. All these subjects were married in the Catholic church. They were selected randomly among the available data in the BALSAC register. The subjects' period of marriage was chosen so as to maximize the sample size and, at the same time, to be as close as possible to the contemporary population of Quebec (the BALSAC register is not completed yet for the 20th century). The distribution of the subjects according to their region of marriage reflects the geographical distribution of the population of Quebec in 1956 (mid-point of the subjects' period of marriage).

The genealogies were reconstructed using the available information in the BALSAC and RPQA registers. Hence, the genealogical branches go back as far as the first immigrants encountered in each branch (the databases include only marriages that have taken place within Quebec). Most genealogies go back to the early 17th century, but since some branches are shorter, the mean genealogical depth varies from one genealogy to another. Still, the average completeness of the genealogies (proportion of known ancestors at each generation level) remains over 90% up to the 7th generation. After the 9th generation, the completeness decreases more rapidly. On average, the genealogical depth of the sample is 9.3 generations, with some branches reaching up to 17 generations. More than 5 million mentions of ancestors were counted in these genealogies, but many ancestors appear several times, either in more than one genealogy or more than once in a single genealogy. The mean number of appearances per ancestor is 33. All known genealogical links between these ancestors were established.

Places of marriage of the 2,223 subjects (the starting points of the ascending genealogies) were grouped in 8 different regions (Table 1 and Fig. 1) based on geographical, historical and genetic characteristics identified in previous studies on

Table 1 Distribution of the 2,223 genealogies according to the subject's region of marriage

Quebec regions	Number	Percentage	Average genealogical depth (number of generations)
West	273	12.3	9.2
North-west	87	3.9	9.6
Montreal	691	31.1	9.0
South shore	179	8.1	9.2
Centre-west	237	10.7	9.4
Centre	316	14.2	9.4
North-east	174	7.8	9.8
East	266	12.0	9.1
All regions	2,223	100.0	9.3

**Fig. 1** Regional groupings of the Quebec territory

the Quebec population (Tremblay et al. 2001; Vézina et al. 2005). Regional groups contain from 87 to 691 genealogies, with an average depth varying between 9.0 and 9.8 generations.

For the purpose of this study, an Irish founder was defined as an ancestor presumably born in Ireland who immigrated, married and/or died in Quebec. Information on places of marriage available in the RPQA and BALSAC databases was used to identify these founders. Additional material was used in cases where no information on place of origin was given in the genealogies. These include data from the Canadian decennial censuses (1851 through 1901), immigrants and orphans lists (Robert and Thibault 1988; Dompierre and O’Gallagher 1995; Dobson 1997, 1998, 2000a, b, 2004; Library and Archives Canada 2008) and various other sources available on the Web (Canadian Genealogy 2008; Fédération québécoise des sociétés de généalogie 2008; RootsWeb 2008; The Ship List 2008).

Place of origin, time of arrival and religious affiliation of the Irish founders were identified or estimated using information from the Canadian censuses, the migrants shipping lists and the available marriage and death records. The geographical levels used for determining the place of origin of the Irish migrants are the county or the province where these immigrants were born, married or from where they emigrated. For the purpose of this study, four periods of arrival were used: the French Regime (1608–1759), the British Regime (1760–1814), the period of Massive Immigration (1815–1860) and the Recent period (after 1860). Religious affiliations were grouped in two categories: Catholics and Protestants.

4.3 Demogenetic Analyses

Analysis of the contribution of Irish founders to the population of Quebec relied on the use of various measures aiming to characterize their presence within the genealogical sample. These measures are:

- 1) proportion of genealogies containing at least one Irish founder
- 2) number of occurrences of Irish founders in the genealogical branches
- 3) genetic contribution of Irish founders to the genealogical sample.

Each measure was calculated for the whole sample and for each regional subsample. The proportion of genealogies containing at least one founder of Irish origin is an indicator of the dispersion of genes of Irish origin in the population. Since some founders appear more than once in the genealogies, and sometimes more than once in a single genealogy, measures of the number of occurrences of each founder will show the variability of the presence of Irish founders among the genealogical trees. These occurrences are then used to calculate the genetic contribution of each founder to the subjects' gene pool. The genetic contribution takes into account the number of occurrences of the founder in each genealogical tree and also the distance, in terms of number of generations, between the founder and the subjects. The closer the distance and the higher the number of occurrences, the higher the genetic contribution. The genetic contribution (G) of a founder to a group of subjects is calculated as follows:

$$G = \sum_S \sum_P \left(\frac{1}{2}\right)^g$$

where S is the sample of subjects linked to the founder, P is the number of genealogical paths between a founder and each subject and g is the number of generations in each path connecting the founder and the subject (Roberts 1968; O'Brien et al. 1988; Heyer and Tremblay 1995). Dividing this result by the number of subjects gives the proportion of the subjects' gene pool that comes from that founder.

Measures of kinship links between the sample subjects were also included in the analysis. These measures were used to characterize the genealogical links within the population and to see if those subjects who have at least one Irish ancestor are more related to each other than to the other subjects. The degree of kinship between two subjects depends on the number of common ancestors identified in their genealogies

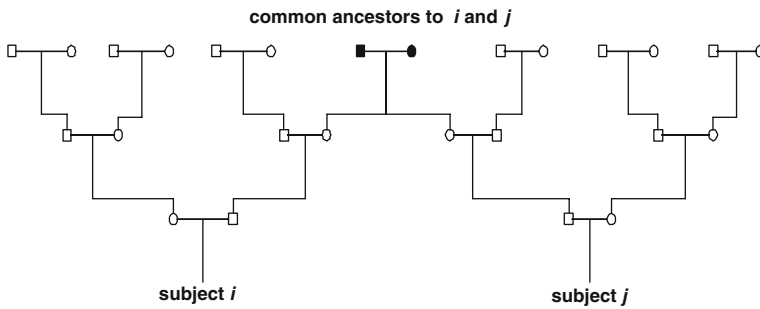


Fig. 2 Kinship links: example with common ancestors at the 3rd generation

and on the genealogical distances between these ancestors and the two subjects. The kinship coefficient (Φ) between two subjects i and j is calculated as follows:

$$\Phi_{i,j} = \sum_A \sum_P \left(\frac{1}{2}\right)^k (1 + F(A))$$

where A is the set of all common ancestors to i and j , P is the set of all genealogical paths between i and j through each common ancestor, k is the number of individuals in each path and $F(A)$ is the inbreeding coefficient for each common ancestor (i.e. the ancestor's parents' kinship coefficient) (Thompson 1986). Figure 2 shows an example of kinship links at the 3rd generation (where i and j have two common great-grandparents).

Since the number of common ancestors grows with the generational depth, kinship coefficients will be higher when a higher number of generations are taken into account. Mean kinship coefficients (sum of all coefficients divided by the total number of coefficients) were thus calculated at various generation levels (up to 13 generations). Differences between the mean coefficients of the two groups of subjects (with or without Irish ancestors) were tested using a permutation test as described in Lavoie et al. (2005). P -values were obtained by the bootstrap method with 5,000 repetitions (Efron and Tibshirani 1993).

All calculations were performed using the S-Plus-based GENLIB software package (Interdisciplinary Research Group on Demography and Genetic Epidemiology 2008).

5 Results

5.1 Characteristics of the Irish Founders

Among the 6,808 founders identified in the 2,223 genealogical trees, 203 (114 men and 89 women), or 3%, are of Irish origin (Table 2). The sex ratio of 1.28 men per woman among these Irish founders is much lower than the sex ratio among all founders which is nearly 3 men for one woman (Vézina et al. 2006). This is explained by the characteristics of the pioneer period of immigration during the French Regime, when immigrant men largely outnumbered immigrant

Table 2 Irish founders and their genetic contribution to the genealogical sample, according to various characteristics

Characteristic	Number	Proportion (%)	Proportion of Irish genetic contribution (%)
Sex			
Males	114	56.2	58.0
Females	89	43.8	42.0
Province of origin			
Connaught	11	5.4	4.5
Leinster	19	9.4	15.0
Munster	22	10.8	10.6
Ulster	11	5.4	3.4
Unknown	140	69.0	66.5
Period of arrival			
French Regime (1608–1759)	15	7.4	8.8
British Regime (1760–1814)	39	19.2	17.2
Massive immigration (1815–1860)	139	68.5	65.0
Recent (after 1860)	10	4.9	9.0
Religious affiliation			
Catholics	158	77.8	81.6
Protestants	22	10.9	11.4
Unknown	23	11.3	7.0
Total	203	100	100

women (Charbonneau et al. 1993). For the most part, Irish founders settled during the 19th century, when sex ratios among immigrants were more balanced (McInnis 2000).

Unfortunately, due to a lack of information among the various sources consulted, the province of origin was known for only 31% of the Irish founders. Results show a slightly higher proportion of migrants coming from the southern counties of Ireland, in the Munster and Leinster provinces (Fig. 3). This is consistent with Grace (2003) who noted that, among Irish immigrants who were residing in Quebec City in the mid-1800s, the most important counties of origin were Wexford, Limerick, Kilkenny and Cork.

Most of the Irish founders (68.5%) arrived during the Massive immigration period (from 1815 to 1860). The earliest settlers immigrated in 1670, while the latest date of immigration is 1887. There are approximately seven Catholics for each Protestant among the Irish founders. According to Houston and Smyth (1988), less than half of the Irish immigrants to Canada were Catholics. However, Grace (2003) mentioned that the majority of Irish immigrants who settled in Quebec were

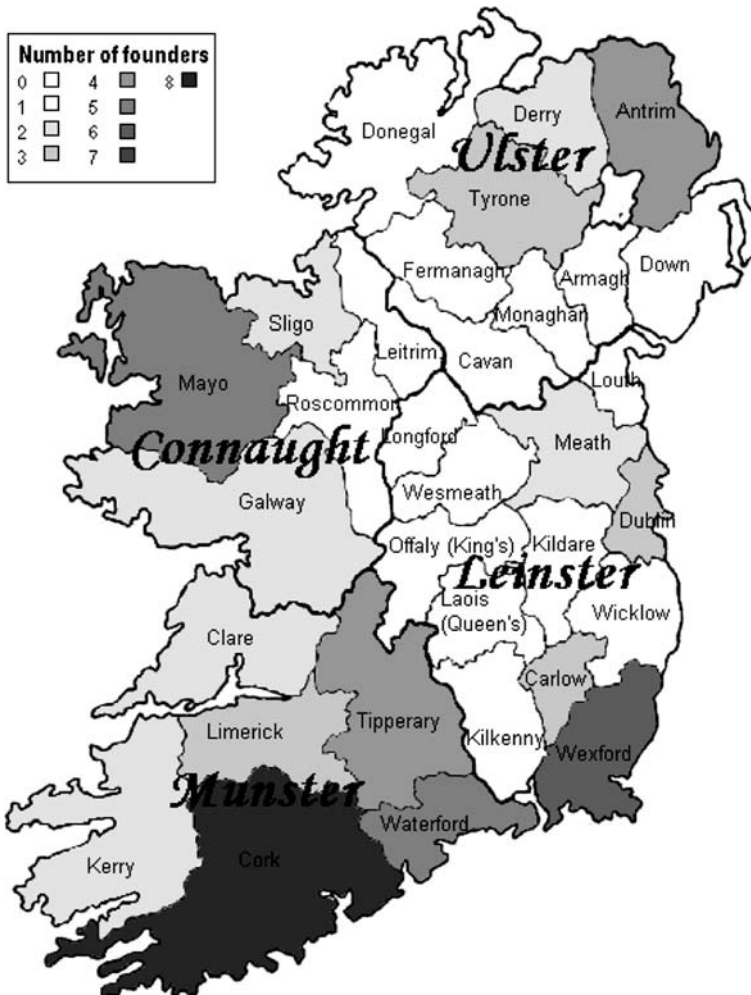


Fig. 3 County of origin of the Irish founders ($n = 62^*$). *The county of origin is unknown for one Irish founder from the Leinster province

Catholics, which is consistent with the present results and also shows that the settling place of Irish immigrants in Canada varied according to their religious affiliation. In Quebec, since the 17th century, the vast majority of the population has been Catholic, which represented an attractive factor for immigrants of Catholic faith. Also, it must be remembered that the subjects of the genealogical sample were all selected using Catholic marriage records.

5.2 Presence and Occurrence of Irish Founders in the Genealogies

Table 3 shows that the presence of Irish founders in Quebec genealogies varies greatly according to the subjects' region of marriage. First, the number of Irish

Table 3 Presence of Irish founders and their genetic contribution to each region

Region	Number of Irish founders in the genealogies	Proportion of genealogies containing at least one Irish founder (%)	Genetic contribution of Irish founders (%)
East	45	16.2	1.31
West	46	41.8	1.22
Centre-west	33	10.1	1.13
South shore	28	28.5	0.89
Montreal	78	26.6	0.73
North-east	12	6.9	0.34
Centre	26	7.0	0.34
North-west	14	17.2	0.21
All regions	203	20.9	0.81

founders in each regional sample varies from 12 (North-east region) to 78 (Montreal), but of course these differences are due in part to the fact that the number of genealogies itself varies from one region to another, with Montreal having the highest number (691). The sum of founders for all regions does not equal 203 (the total number of Irish founders) because some founders appear in more than one region. Indeed, although most founders (72%) appear only once, some are found many times in the genealogies, up to a maximum of 162 for one male founder (Table 4). Founders who immigrated earlier in Quebec have a greater probability of appearing in several genealogies than later immigrants. For example, male founders appear more frequently, on average, than female founders, because more Irish male founders (13 vs. 2 females) immigrated during the French Regime. The two founders with an occurrence over 100 came to Quebec during the 17th century,² while most founders (90%) who appear only once arrived after 1800.

The presence of Irish founders in the genealogies also reflects the differential reproduction and migratory behaviour of the founders and of their descendants. Only those descendants who married in Quebec and who themselves had children who subsequently married in Quebec will have a chance to appear in the genealogies. As a result, the contemporary descendants of Irish founders are relatively more numerous in the Montreal area, which is the largest metropolitan area in Quebec since the middle of the 19th century and which attracted many immigrants and internal migrants. The higher proportions of subjects having at least one Irish ancestor are found in the West (41.8%) and South shore (28.5%) regions and on the island of Montreal itself (26.6%). Conversely, the North-east (6.9%) and Centre (7.0%) regions have the lowest proportions of Irish descendants. This relatively faint trace of Irish ancestry in the Centre genealogies is somewhat

² These two founders are amongst the first Irish settlers in Nouvelle-France. One of them came from *Tullow* in Carlow county and the other one came from *St-Patrice-de-Diasonyden*. Scholars do not agree on whether this parish was located in Kilkenny or Kerry. A problem with the earliest records dating from the French Regime is that they were written in French by French officials who sometimes did not know how to write the Irish names properly. Many names of individuals and places were then recorded on the basis of their pronunciation and got distorted through time.

Table 4 Distribution of Irish founders according to their number of occurrences in the genealogies

Number of occurrences	Male founders	Female founders	Total
1	78	69	147
2	13	12	25
3	4	3	7
4	4	2	6
5–10	6	1	7
11–29	4	2	6
30–99	3	0	3
100 and more	2	0	2
Total	114	89	203

surprising, considering that during the second half of the 19th century, the Irish represented more than 40% of the population in some parts of Quebec city (Grace 2003). Overall, 20.9% of the 2,223 subjects have at least one Irish ancestor somewhere along their family tree.

5.3 Genetic Contribution of Irish Founders

Results in Table 3 also show that Irish founders explain nearly one percent of the Quebec gene pool. Although the two measures are not completely independent, the regions with the highest proportions of genealogies containing at least one Irish founder are not necessarily the ones where the genetic contributions of these founders are the highest. For example, 17.2% of the subjects from the North-west region have at least one Irish founder among their ancestors, which places this region at the 4th rank among the 8 regions, but the Irish genetic contribution in the region is the lowest of all, with only 0.21% of the gene pool. Conversely, the East region shows the highest proportion of the gene pool attributed to the Irish founders (1.31%) even though the proportion of genealogies with an Irish founder is only 16.2%, placing it in 5th rank among the regions. These results clearly show that some founders contribute much more than other founders, depending on the frequency of their occurrences in the genealogies and on the genealogical distance with the subjects to which they are linked. Some founders who immigrated more recently have a lower genealogical distance from their descendants but these descendants are usually not as numerous as those from a more distant ancestor.

The genetic contribution of Irish founders according to their period of arrival is shown in Table 2. For the British Regime and the Massive Immigration periods, the proportion of founders is slightly higher than the proportion of their genetic contribution. Founders who immigrated during the French Regime and the Recent period have a proportionally higher genetic contribution. Since the earliest founders have the longest genealogical paths between them and the subjects, they have to be present in many genealogies or many times in the genealogies, to have a high genetic contribution, which is the case for most founders of the 17th century. Previous studies on the population of Quebec showed that founders who married

before 1700 account for roughly 83% of the contemporary gene pool, even if they represent less than 45% of all founders (Vézina et al. 2006; Tremblay et al. 2008). As for the more recent founders, their relatively high genetic contribution is explained by the short genealogical distance between them and a few subjects.

Male founders and Catholic founders also have a slightly higher genetic contribution than expected. This is due in part to the fact that the earliest Irish founders (i.e. those who came during the French Regime) were nearly all men (13 out of 15) and Catholics (14 out of 15). Also, one can assume that the descendants of Catholic founders mingled more easily with French Canadians than did the descendants of Protestants. As for the founders of unknown religious affiliation, most of them appear only once in the genealogies.

Finally, Table 2 shows a relatively high proportion of the Irish genetic contribution for the founders who came from the province of Leinster. This is explained mainly by the contribution of a single founder from the county of Wexford who immigrated in Quebec in 1790. This founder accounts for nearly 6% of the total Irish genetic contribution, a proportion that is at least three times higher than that of any other Irish founder.

5.4 Kinship Links

Mean kinship coefficients between subjects who have at least one Irish founder among their ancestors are presented in Fig. 4. This figure also shows the mean kinship coefficients among subjects with no Irish ancestors, among all subjects, and between subjects of Irish descent and all other subjects (intergroup coefficients). Kinship coefficients are presented for each generation level, from the 3rd generation (that of the subjects' great-grandparents) to the 13th generation.

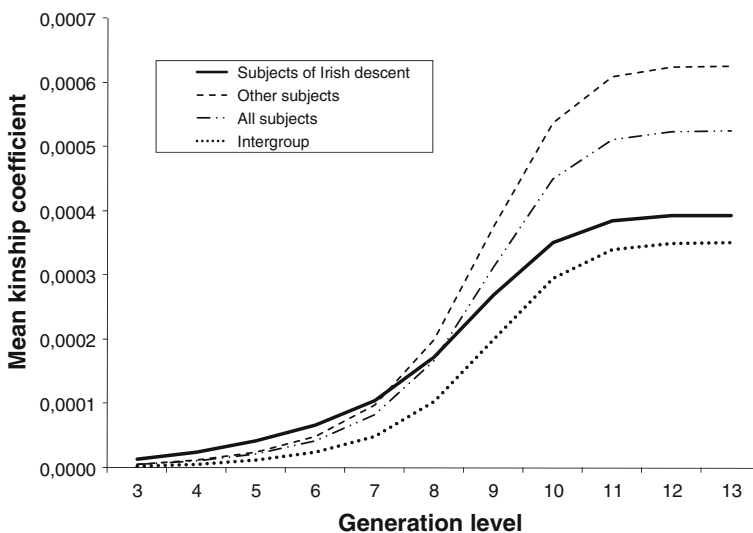


Fig. 4 Mean intragroup and intergroup kinship coefficients for subjects of Irish descent and other subjects, at various generation levels

First of all, these results clearly show that the value of the kinship coefficient does not increase linearly with the number of generations. Before the 6th generation, mean kinship coefficients are relatively small. The coefficients begin to increase more rapidly between the 6th and the 7th generations. After the 11th generation, the values tend to level off: at this point, most of the genealogical branches are interrupted and obviously additional kinship links between the subjects cannot be established.

Before the 7th generation, subjects with Irish descent have a slightly higher kinship coefficient than subjects with no Irish ancestor (all differences are statistically significant, with $p < 0.05$). This can be explained by a selection effect: compared to subjects without Irish ancestors, subjects who have at least one Irish ancestor in their genealogy have a greater probability of sharing common ancestors before the 5th generation, because Irish immigration is much more recent, on average, than French immigration. Half of the ten highest kinship coefficients at the 4th generation between subjects with at least one Irish ancestor are explained by common ancestors linked with an Irish founder.

From the 8th generation onward, kinship links are stronger amongst subjects with no Irish ancestor. These subjects are, for the most part, descendants of the French pioneers of the 17th century. Most of their kinship links are explained by these early founders (Vézina et al. 2006; Tremblay et al. 2008). However, it is important to note that between the 5th and 10th generations, the completeness of the genealogies of the subjects with no Irish ancestor is slightly higher than that of the subjects of Irish descent, thus allowing for a greater probability of finding kinship links between the subjects of the former group.

Finally, at all generation levels, intergroup kinship coefficients between subjects of Irish descent and all other subjects are lower than intragroup coefficients. This means that subjects who have at least one Irish ancestor tend to be more related to each other than to subjects who have no Irish ancestor. This may seem obvious, but since many Irish descendants intermarried with French Canadians, numerous kinship links were established between these two groups over time and the differences between the two sets of coefficients, though significant ($p < 0.05$), are relatively small.

6 Discussion

Although it is difficult to measure precisely the impact of more than two centuries of Irish immigration on the peopling of Quebec and its regions, the findings of this study shed some light on the characteristics of Irish founders and their genetic contribution to the contemporary gene pool of the Quebec population. This was made possible by analysing a large data set of carefully reconstructed ascending genealogies going back several generations. Few populations in the world can benefit from such rich and complete genealogical material, which is crucial for an unbiased interpretation of demogenetic measures such as the founders' genetic contribution and the kinship coefficients. For example, most kinship links between subjects would not have been detected with genealogies reaching fewer than 5 or 6

generations. Also, the measure of the genetic contribution can be quite incomplete if some links between founders and subjects are missing. To our knowledge, the Quebec population is the only one for which a mean generational depth of over 9 generations can be reached. Icelandic and Finnish populations are much older and some of their data go back much further in time than the Quebec data, but they do not benefit from such a high genealogical completeness.

Results indicate that although one out of five subjects has at least one Irish ancestor in its genealogy, less than one percent of the total gene pool of our sample is explained by Irish founders. Previous studies have shown that the greater part of the Quebec gene pool comes from founders of French origin (Vézina et al. 2006; Tremblay et al. 2008). These French founders were the first founders of European origin to colonize the Quebec territory during the 17th century, which gave them a clear advantage in terms of their genetic contribution to the population. The individual genetic contributions of the few Irish founders who came at the end of the 17th century and who appear most frequently in the genealogies are of the same magnitude as that of their contemporary French founders (Vézina et al. 2006; Tremblay et al. 2008).

Unsurprisingly, most of the Irish founders identified in the genealogies immigrated during the 19th century, especially in the 1815–1860 period. These migrants were mostly Catholics and a higher proportion came from the counties and provinces of southern Ireland. Some results appear to be in contradiction with previous studies dealing with Irish immigration to Canada. For instance, Houston and Smyth (1990) mention that Ulster and the north of Leinster were the Irish regions which contributed the most to the peopling of Canada in the 19th century, and according to Elliott (1999) and McGowan (1999), there were more Protestants than Catholics. We found that Irish migrants who settled in Quebec were predominantly Catholics, contrary to those who settled elsewhere in Canada. Grace (2003) had also noted that Irish residents in mid-19th century Quebec City were mostly Catholics. This is not surprising, considering that the population of Quebec as a whole was mainly Catholic.

It is important to remember that the genealogical sample is composed of individuals who married in the Catholic Church between 1945 and 1965. Since the population of Quebec was 88% Catholic in 1961 (Henripin and Péron 1972), about 12% of the population was therefore not represented among the subjects, which explains to a certain extent the relatively small proportion of Protestants among the Irish founders. These founders were all individuals who still have traceable descendants in the contemporary population. Many Irish who immigrated to Quebec did not stay in this province or failed to leave descendants up to the present day. Since the Quebec population has always been mostly francophone and Catholic, it is therefore logical to think that the Irish who did settle in the province mingled with French Canadians, a hypothesis which is borne out by results on kinship links. A previous study on a single Quebec parish also showed that the Irish Catholics married more frequently with French-Canadians than with Anglo-Protestants (Beaudoin 1998).

The demographic impact of Irish immigration varies regionally, some regions showing more genealogies containing at least one Irish founder or a higher genetic

contribution from Irish founders. Historically, the urban areas of Quebec (i.e. Montreal and Quebec City) are the ones where most Irish immigrants settled, especially during the 19th century (Elliott 1999; McGowan 1999). However, the populations of these two regions do not show the highest Irish genetic contribution or the highest proportion of genealogies with one or more Irish ancestors. The Centre-west region also received many Irish colonists and still bears some Irish place names (New Ireland, Armagh, Murray), but only 10% of the genealogies from this region contain at least one Irish founder. The regions with the highest proportion of genealogies containing at least one Irish founder (West: 42%) or where the genetic contribution of the Irish founders is the highest (East: 1.3%) are located on the opposite sides of the Quebec province and have the longest common frontiers with other provinces of Canada (Ontario and the Maritime provinces). This geographical proximity with provinces where the majority of the population is English-speaking could have facilitated the exchange of spouses and the permanent settling of Irish immigrants. Thus, it is clear that differential migration behaviour may have a significant impact on the redistribution of ancestral genes in the population. For example, Helgason et al. (2005) have found that, despite the relative homogeneity of the Icelandic population as a whole, regional populations of Iceland displayed some important differences in their genetic structures, due to various patterns of migration among descendants of moderately distant ancestors (up to 5 generations).

Intermarriage between spouses of Irish and French origins explains the relatively high kinship links between subjects with Irish ancestors and subjects with no Irish ancestors. From the start, many Irish founders and their descendants tended to marry with French-Canadians (Guérin 1946; McGowan 1999). For example, 41 of the 203 founders married a French immigrant or a French-Canadian. Thus, the relative genetic contribution of Irish founders to their descendants progressively decreased from one generation to the next, while the contribution from French founders grew. This form of “assimilation” is clearly illustrated in Fig. 5, which shows the genetic contribution of Irish founders to their first four generations of descendants. Already at the 1st generation (founders’ children), the genetic contribution of Irish founders is on average 30 points below 100%. Among the grandchildren, less than 40% of the gene pool comes from Irish founders. At the 4th generation, this proportion barely reaches 10%. The decrease is somewhat slower for the Irish founders who came during the Massive immigration period. It could be that these founders and their immediate descendants married more easily within the Irish community, being much more numerous than their predecessors or their followers.

On the basis of these new findings, some aspects of Irish immigration in Quebec could be further investigated. For example, the intensity of ethnic exogamy among Irish descendants could be compared according to their type of residency (rural vs. urban). Also, a detailed study of internal mobility among the descendants of Irish founders could contribute to a better understanding of the variability of the founders’ genetic contribution to the contemporary population. Of course, it would be very useful to get genealogical data covering the Irish Protestant community, but this may prove almost impossible based on existing sources. Finally, we intend to pursue similar studies on the contribution of other important ethnic minorities

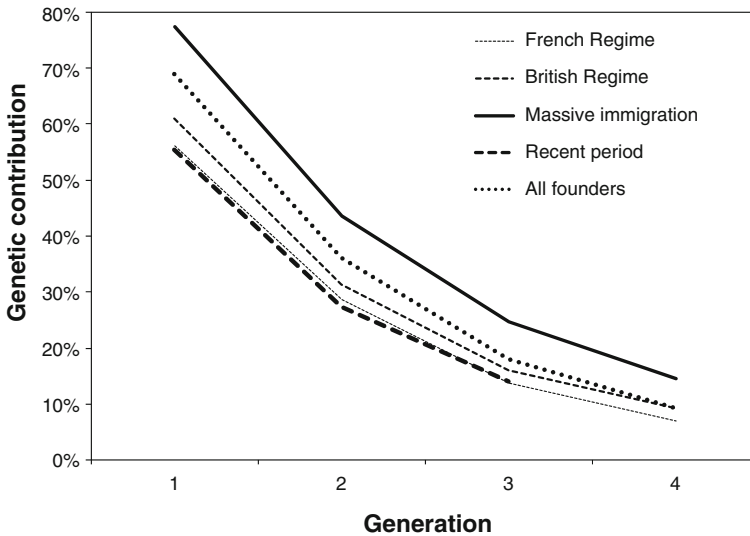


Fig. 5 Genetic contribution of Irish founders to their first four generations of descendants, by period of immigration

(English, Scottish, German) with the goal of improving our knowledge of the demogenetic history of the Quebec population.

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