

The Gene Pool of the Belgorod Oblast Population: Changes in the Endogamy Indices of District Populations with Time

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Abstract—Changes in the endogamy indices of district populations of the Central Chernozem region of Russia during the past 100 years were studied. The size of an elementary population in this region increased from that of a rural municipality in the mid-20th century to that of an administrative district in the late 20th century.

INTRODUCTION

Estimation of the size of an elementary population is an important problem in population genetic studies. The endogamy index is one of parameters that could be used to estimate the elementary population size. Cavalli-Sforza and Bodmer [1] defined the endogamy index as the proportion of husbands and wives that had been born in the same population. The higher the endogamy index, i.e., the higher the frequency of cases where both spouses originate from the same population, the higher is the probability that they are relatives and, hence, share some genes inherited from common ancestors. Endogamy, in contrast to migration, leads to an increase in genetic differences between subpopulations constituting a single population of a higher level. A population may be considered a separate evolutionary unit if the proportion of endogamous marriages in it is no smaller than 50% [2]. The endogamy index makes it possible, to a certain degree, to draw natural boundaries of populations, which is of a great importance for population studies [3].

The endogamy index was widely used in population genetic studies in Kostroma [3, 4], Kirov [3, 4], Rostov [5, 6], and Kursk [7, 8] oblasts; city of Moscow [9, 10]; Marii El [3, 11] and Chuvashia [3] republics; Krasnodar krai [3]; and some other populations [12–15]. The endogamy index proved to vary considerably in different Russian populations. In general, the endogamy indices of rural populations are higher than those of urban populations; however, the index widely varies in all of them.

For our comprehensive study on the gene pool structure in the Belgorod oblast population with the use of a wide spectrum of population genetic markers (biochemical, molecular genetic, and quasi-genetic ones), it is necessary to answer the following questions: (1) At what population level should the gene pool structure of

modern populations be studied to obtain representative data not only on individual population genetic characteristics, but also on genetic relationships between populations?; (2) At what population level should the changes in the population genetic structure during several past decades be estimated, with its considerable migration activity taken into account?; (3) What real population (or what level of a virtual population) will be characterized by the population samples that we have collected for typing various genetic markers (immune and biochemical systems and autosomal DNA, Y-chromosome, and mtDNA markers)? These samples consist of persons three generations of whose ancestors originated from the same population (this approach to sampling allows us to avoid the effects of accidental variations of the migration flow during the past decades and take into account only the steadiest migrations, whose genetic contribution to the population has been preserved in two successive generations); (4) How much have administrative reforms of the 1950s in the Central Chernozem region (in 1954, Belgorod oblast was formed out of several raions (districts) of Kursk and Voronezh oblasts) affected the sizes of elementary populations in this region?

We studied the endogamy index of the Belgorod oblast population and estimated its changes during the past 100 years.

MATERIALS AND METHODS

Characteristics of Populations

The size of an elementary population in Belgorod oblast was estimated for three periods of time: the late 19th to early 20th centuries (1879–1914); the mid-20th century (1947–1953) before Belgorod oblast was formed out of raions of Kursk and Voronezh oblasts in 1954; and the late 20th to early 21st centuries (1987–2001).



Map of raions of Belgorod oblast. The studied raions (Prokhorovka and Krasnoe raions of Belgorod oblast, Pristen' raion of Kursk oblast, and Rep'evka raion of Voronezh oblast) are cross-hatched. The thick line shows the boundary between Kursk and Voronezh oblasts until 1954, when Belgorod oblast was established.

Data on two administrative districts of Belgorod oblast, Prokhorovka and Krasnoe raions (formerly of Kursk and Voronezh oblasts, respectively), for all the three periods were used. In addition, we used population data on two neighboring raions of other oblasts for the last two periods. These were Pristen' raion (which borders on Prokhorovka raion and remained in Kursk oblast after Prokhorovka raion was included into the newly formed Belgorod oblast in 1954) and Rep'evka raion (which borders on Krasnoe raion and remained in Voronezh oblast after Krasnoe raion was included into Belgorod oblast in 1954). The figure shows the locations of the studied districts.

In the early 20th century, the area of the modern Prokhorovka raion was part of the Korocha uezd (district) of Kursk guberniya (province), and parts of the modern Krasnoe raion were included in Korotoyak and Biryuch uezds of Voronezh guberniya.

We selected for the study five "model" rural municipalities located at considerable distances from one another in each of these raions (except for Rep'evka raion, where four municipalities were studied). A rural municipality in the studied districts usually consists of a large village and several small villages or farmsteads. The administrative centers of the studied raions are vil-

lages with the largest populations. This type of administrative organization is typical of the Central Chernozem region (e.g., administrative centers of 29 out of 49 raions of Kursk and Belgorod oblasts are villages, and only 20 administrative centers are towns). Data on the population sizes of the rural municipalities and districts for the analyzed periods were obtained from departments of statistics of Belgorod, Kursk, and Voronezh oblasts. More than 95% of residents of the studied districts are Russians.

When copying data on marriages contracted in the 1900s, we found that parish registers of some volosts (administrative units comparable in size with the modern rural municipality) had been lost. Therefore, we used data on neighboring volosts and villages of the same district.

Population Genetic Study

We analyzed 5849 marriage records from the archives of the regional registry offices of Belgorod, Kursk, and Voronezh oblasts (3745, 1100, and 1004 records, respectively), 1209, 2625, and 2015 of which were made, respectively, in 1879–1914, 1949–1953, and 1987–2001. We copied data on the birthplaces of

Table 1. The endogamy index at the volost populations level (a volost was comparable in size with a modern rural municipality) in Kursk and Voronezh guberniyas (provinces) in the 1900s

Population (former volost)	Population size in 1885	Sample size	Proportion of endogamous marriages at the level of		
			the given volost	the given raion	the given oblast
Prokhorovka raion of former Kursk guberniya					
1. Podol'khi	6490	112	0.45	0.65	1.00
2. Kolomytsevo	565	102	0.67	0.83	1.00
3. Kholodnoe	1626	113	0.65	0.93	1.00
4. Priznachnoe	2659	84	0.61	0.94	0.99
5. Luchki	*	161	0.73	0.83	1.00
<i>Average</i>	2835	114	0.62	0.83	0.99
Krasnoe raion of former Voronezh guberniya					
1. Gorki	*	147	0.71	0.96	0.96
2. Krasnoe	*	104	0.91	0.96	0.98
3. Utochka	*	156	0.80	0.86	0.97
4. Verkhnyaya Pokrovka	*	112	0.90	0.93	0.98
5. Mar'evka	*	118	0.91	0.98	0.99
<i>Average</i>	*	127	0.85	0.94	0.98

Notes: Asterisks indicate an absence of data on the population size.

both spouses and used them for calculating the endogamy indices. We calculated the endogamy index of each population according to Cavalli-Sforza and Bodmer [1], as the proportion of husbands and wives that had been born in this population. The endogamy indices were estimated for different "hierarchical ranks" of the populations (at the rural municipality, raion, and oblast levels). Modern administration subdivision (municipalities, raions, and oblasts) is usually based on historical hierarchical groups of populations (rural parishes, uezds, and guberniyas), their current infrastructure often affecting the structure of marriage migrations. A population in which at least 50% of marriages were endogamous was considered elementary [2].

RESULTS AND DISCUSSION

We studied the sources of marriage migrations in four district populations of the Central Chernozem region of Russia during the past 100 years.

First, we estimated the endogamy indices in ten former volosts (administrative units comparable with the modern rural municipalities) located in the modern Prokhorovka and Krasnoe raions in the late 19th to early 20th centuries (1879–1914) (Table 1). We analyzed data on the volosts for which marriage records were preserved. The proportion of marriages contracted within a volost (Table 1) proved to be rather high (the

value averaged over ten volosts was 0.74). The endogamy index in these ten volosts varied widely (from 0.45 to 0.91). On average, 62% of marriages contracted in the area of the modern Kursk oblast in the 1900s were marriages between persons born in the same volost; 83% of marriages were contracted between persons born in the area corresponding to the modern Prokhorovka raion; and 99% of marriages, between those born in Kursk guberniya. In Voronezh guberniya, the endogamy was higher: 85% of marriages were contracted within a volost. In the area corresponding to the modern Krasnoe raion, 86–98% (on average, 94%) of marriages were contracted between local residents; 96–99% (on average, 98%) of marriages were contracted within Voronezh guberniya. High endogamy levels at the volost level (on average, 0.74, the endogamy index being higher than 0.50 in nine out of ten volosts) (Table 1) indicate that the population of a volost (comparable to the modern rural municipality) was an elementary population in the Central Chernozem region of Russia in the late 19th century, according to the standard criterion of an elementary population, i.e., a proportion of endogamous marriages higher than 50% [2].

Then, we estimated the endogamy indices for the early 1950s, when the raions of the modern Belgorod oblast were parts of Kursk and Voronezh oblasts. Prokhorovka and Pristen' raions of Kursk oblast and Krasnoe and Rep'evka raions of Voronezh oblast were

Table 2. Endogamy index at the rural municipality population level in Kursk and Voronezh oblasts in the 1950s

Population (rural municipality)	Population size in 1953	Sample size	Proportion of endogamous marriages at the level of		
			the given municipality	the given raion	the given oblast
Prokhorovka raion of Kursk oblast (1947–1953) (since 1954, part of Belgorod oblast)					
1. Plota	*	120	0.68	0.98	1.00
2. Podol'khi	2417	156	0.74	0.85	0.89
3. Prelestnoe	3110	173	0.92	0.95	0.96
4. Kolomytsevo	2089	102	0.93	0.93	0.94
5. Kholodnoe	*	104	0.90	0.93	0.94
<i>Average</i>	2539	131	0.83	0.93	0.95
Pristen' raion of Kursk oblast (1947–1953)					
1. Bobryshevo	4206	112	0.96	0.98	0.99
2. Nagol'noe	1632	120	0.95	0.97	0.97
3. Pristen'	2250	126	0.81	0.83	0.97
4. Pselets	2175	135	0.91	0.95	0.96
5. Srednyaya Ol'shanka	2336	140	0.83	0.84	0.87
<i>Average</i>	2520	127	0.89	0.91	0.95
Krasnoe raion of Voronezh oblast (1947–1953) (since 1954, part of Belgorod oblast)					
1. Gorki	2854	108	0.85	0.87	0.87
2. Gotov'e	2284	129	0.84	0.92	0.93
3. Kamyzino	2291	164	0.87	0.92	0.93
4. Krasnoe	6444	137	0.55	0.75	0.76
5. Raskhovets	3941	176	0.83	0.92	0.92
<i>Average</i>	3563	143	0.79	0.88	0.88
Rep'evka raion of Voronezh oblast (1947–1953)					
1. Butyrki	*	156	0.91	0.95	0.97
2. Krasnolip'e	*	130	0.82	0.92	0.99
3. Platava	*	168	0.92	0.98	0.99
4. Rep'evka	*	169	0.48	0.75	0.88
<i>Average</i>	*	156	0.78	0.90	0.96

Note: Asterisks indicate an absence of data on the population size.

studied. Estimation of the sources of marriage migrations averaged over 19 rural municipalities of the four districts showed that the proportion of marriages between indigenous residents of the same municipality was 82% (Table 2). Thus, as in the early 20th century, most marriages in the mid-20th century were contracted within a rural municipality, the proportion of such marriages having increased from 74 to 82% in the period from the 1900s to the 1950s.

The proportion of marriages contracted within rural municipalities in Prokhorovka raion of Kursk oblast varied from 68% in the Plotava municipality to 93% in the Kolomytsevo municipality (on average, 83%). In

Pristen' raion, this proportion varied from 81% in the Pristen' municipality to 96% in the Bobryshevo municipality (on average, 89%). Analysis of a higher organizational level of the population structure (raions or administrative districts) showed that 93 and 91% of marriages contracted in Prokhorovka and Pristen' raions were marriages between residents of the same raion. The mean proportion of marriages between residents of Kursk oblast contracted in municipalities if the studied raions was 95%.

Analysis of the sources of marriage migrations in the 1950s in Voronezh oblast yielded similar results. In Krasnoe raion, 79% of marriages were contracted

within municipalities. The endogamy index varied from 0.55 to 0.87. In the neighboring Rep'evka raion, there were 78% of such endogamous marriages, their proportion varying between 48 and 92% in different municipalities. The mean endogamy index averaged over nine rural municipalities of two raions of Voronezh oblast was 0.79. The mean proportions of marriages contracted by residents of a given rural municipality with residents of the same raion were 88 and 90% in Krasnoe and Rep'evka raions, respectively, and the proportions of marriages contracted with residents of the same (Voronezh) oblast were 88 and 96%, respectively.

These data indicate that the population of a rural municipality was an elementary population in the Central Chernozem region in the mid-20th century, as it was in the early 20th century (the endogamy index averaged over 19 rural municipalities was 0.82, which is considerably higher than the threshold value, 0.50).

Note that, according to our data, about 89% of all marriages in the 1900s and 91% of them in the 1950s were contracted between persons that were born in the same raion. This allows us to conclude that the samples that we collected for studying genetic markers (immune and biochemical systems and autosomal DNA, Y-chromosome, and mtDNA markers) in district populations of southern central Russia, which comprised subjects from the third (at least) generations of residents of the respective districts (i.e., their grandparents were born in the same districts between the 1900a and 1950s), are indeed representative samples from actual populations of southern central Russia of the first half of the 20th century. Analysis of these samples will yield correct data on the gene pool structure of the population of southern central Russia and allow us to estimate the effect of the steadiest and most important migrations, whose genetic trace has been preserved in the population for more than two generations, on the gene pool structure.

At the next stage, we studied the endogamy indices in four district populations from three oblasts (Belgorod, Kursk and Voronezh) of the Central Chernozem region of Russia in the 1990s (Table 3). In 1954, Belgorod oblast was formed out of raions of Kursk and Voronezh oblasts, Prokhorovka and Krasnoe raions (formerly, of Kursk and Voronezh oblasts) being included into the newly formed oblast, and Pristen' and Rep'evka raions being left in Kursk and Voronezh oblasts, respectively.

The proportion of marriages contracted within a rural municipality in the 1990s (Table 3) was very low (the mean value for 19 municipalities was 0.29), the endogamy index not exceeding 0.38 in any one of the 19 municipalities of four raions of three oblasts studied. In rural municipalities of Krasnoe raion of Belgorod oblast, the endogamy index varied from 0.23 to 0.36 (on average, 0.33). In Prokhorovka raion of this oblast, the endogamy index was even lower (it varied from 0.17 to 0.37, with a mean value of 0.28). Similar data

were obtained for rural municipalities of the neighboring raions of Kursk and Voronezh oblast, where this parameters varied from 0.16 to 0.38 (mean value, 0.26) and from 0.13 to 0.38 (mean value, 0.27), respectively. These endogamy indices are too low for a rural municipality to be regarded as an elementary population in neither Belgorod oblast nor the neighboring Kursk and Voronezh oblasts (as noted above, the criterion for an elementary population is a proportion of endogamous marriages of at least 50% [2]).

After that, we considered a higher organization level of the population structure (administrative districts or raions). Table 3 shows the proportions of marriages contracted by residents of a given rural municipality with residents of the same raion. In other words, we considered endogamy at the district level of population organization. The proportion of endogamous marriages contracted within a raion varied from 0.45 to 0.55 in different rural municipalities of Belgorod oblast. In rural populations of Prokhorovka raion, the mean endogamy index at the district organizational level was 0.52 (0.50–0.55). In Krasnoe raion, it was somewhat low (0.49, with variation from 0.45 to 0.53). In the studied populations from Kursk and Voronezh oblasts, the endogamy index at the district level exceeded the critical value of 0.50. In Rep'evka raion of Voronezh oblast, this parameter was, on average, equal to the critical value of 0.50 (varying from 0.44 to 0.58 in different municipalities). In Pristen' raion of Kursk oblast, the endogamy index at the district organizational level was 0.51 (0.45–0.57). The endogamy index calculated for the range of marriage migrations restricted to the oblast varied, in the municipalities studied, from 0.49 to 0.83 (on average, 0.66).

The results demonstrate that a rural district (raion) should be regarded as an elementary population in Belgorod, Kursk, and Voronezh oblasts at the present time, because the endogamy index of a district population in this region is 0.50–0.52. The population of Krasnoe raion of Belgorod oblast almost meets this criterion, though not entirely (0.49).

Since a district (raion) population is an elementary population in the Central Chernozem region at present, we estimated the endogamy index at the level of a district population as a whole (Table 4). The endogamy indices of the populations of Prokhorovka raion (Belgorod oblast) and Pristen' raion (Kursk oblast) were 0.52, and those of the populations of Krasnoe raion (Belgorod oblast) and the neighboring Rep'evka raion (Voronezh oblast) were 0.49. The mean endogamy index in southern central Russia calculated at the district level was 0.51, which met the criterion of an elementary population (higher than 0.50). These data confirm that a district population is now an elementary population in the Central Chernozem region.

Our data entirely agree with the results of population demographic studies performed in Kostroma [3] and Kursk [7, 8] oblasts. In district populations of Kos-

Table 3. Endogamy index at the rural municipality population level in Belgorod, Kursk, and Voronezh oblasts in the 1990s

Population (rural municipality)	Population size in 1998	Sample size	Proportion of endogamous marriages at the level of		
			the given municipality	the given raion	the given oblast
Prokhorovka raion of Belgorod oblast (1978–1995)					
1. Plota	770	101	0.17	0.50	0.69
2. Podol'khi	2303	127	0.36	0.55	0.72
3. Prelestnoe	1232	76	0.20	0.50	0.63
4. Kolomytsevo	1501	109	0.37	0.55	0.83
5. Kholodnoe	1503	114	0.30	0.50	0.74
<i>Average</i>	1462	105	0.28	0.52	0.72
Krasnoe raion of Belgorod oblast (1987–1999)					
1. Gorki	1255	104	0.36	0.50	0.60
2. Gotov'e	1165	101	0.36	0.47	0.59
3. Kamyzino	2547	205	0.33	0.53	0.79
4. Krasnoe	2976	138	0.23	0.45	0.54
5. Raskhovets	1481	92	0.35	0.49	0.70
<i>Average</i>	1885	128	0.33	0.49	0.64
Pristen' raion of Kursk oblast (1991–2001)					
1. Bobryshevo	2036	89	0.28	0.50	0.59
2. Nagol'noe	572	100	0.16	0.49	0.54
3. Pristen'	509	102	0.17	0.57	0.61
4. Pselets	803	96	0.38	0.56	0.69
5. Srednyaya Ol'shanka	667	80	0.30	0.45	0.49
<i>Average</i>	917	93	0.26	0.51	0.58
Rep'evka raion of Voronezh oblast (1994–2001)					
1. Butyrki	1583	54	0.28	0.54	0.70
2. Krasnolip'e	1626	88	0.38	0.58	0.78
3. Platava	1182	82	0.29	0.44	0.67
4. Rep'evka	6409	157	0.13	0.44	0.62
<i>Average</i>	2700	95	0.27	0.50	0.69

troma oblast, the endogamy index was 0.48–0.64 [3]. The endogamy index of rural district populations of Kursk oblast in 1987–1990 was shown [7] to be 0.46. There is evidence [8] that 96–97% of marriages in the rural population were contracted between residents of the same uezd, including 50% of marriages between residents of the same village.

Population genetic study of the Rostov oblast population yielded somewhat different results [5, 6]. They demonstrated that the weighted mean value of the endogamy index of the rural population of Rostov oblast was 0.34. From 41 to 69% of marriages were contracted within Rostov oblast, and from 78 to 85%, within Russia. The authors conclude that an almost

entire population of Rostov oblast is one elementary rural population [6].

In summary, the size of an elementary population in the Central Chernozem region of Russia has changed during the past century from that of a rural municipality population in the early and middle 20th century to that of a district population by the end of the 20th century. Our data allow us to answer the questions that we set in this study. First, population genetic studies on the modern population of southern central Russia should be performed at the level of an administrative district, which currently corresponds to an elementary population. Second, the changes in the genetic structure of the Central Chernozem region during the past 100 years

Table 4. Endogamy index at the raion (district) population level in Belgorod, Voronezh, and Kursk oblasts in the 1990s

Raion	Population size	Sample size	Proportion of endogamous marriages at the level of	
			the given raion	the given oblast
Krasnoe raion of Belgorod oblast	16070	640	0.49	0.66
Prokhorovka raion of Belgorod oblast	32576	525	0.52	0.73
Rep'evka raion of Voronezh oblast	18672	380	0.49	0.68
Pristen' raion of Kursk oblast	21368	465	0.52	0.59
<i>Average</i>	22171	502	0.51	0.67

should be studied at both the district (a modern elementary population) and rural municipality (an elementary population of the early and middle 20th century) levels. Third, samples from populations of southern central Russia comprising persons three generations of whose ancestors were residents of the same district are representative for the given population and adequately reflect the characteristics of the district population during the 20th century (about 90% of marriages in the early and middle 20th century and about 50% of marriages in the late 20th century were contracted between the persons that were born in the given district). Note that, although only 50% of marriages were endogamous (contracted within a district) in the late 20th century because of a high immigration rate, it will not be possible to estimate the actual contribution of migrants to the gene pools of district populations until after a generation, when it is clear whether the immigrants have settled in the given district or, after contracting marriages with local residents (or with other migrants), have migrated to another region. Statistical data show that Belgorod oblast is characterized by high rates of both immigration and emigration. For example, in 1999, 45 467 people migrated to Belgorod oblast and 28 556, from it. Fourth, the administrative reforms of the 1950s in the Central Chernozem region related to the establishment of Belgorod oblast have not significantly affected the elementary population size in any of the three administrative regions involved in the reform (Belgorod, Kursk, or Voronezh oblasts) during the past 50 years: the elementary population sizes were the same in all the three oblasts both in the 1950s (a rural municipality) and in the 1990 (a raion).

ACKNOWLEDGMENTS

This study was supported by the Russian Foundation for Humanities and Russian Foundation for Basic Research.

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