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HUMAN GENETICS

The Change in the Population Structure of the Kursk and Voronezh Guberniya in the First Half of the 20th Century. Malecot's Isolation by Distance

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Abstract—The article presents the results of assessing the variability of parameters of Malecot's isolation by distance model among the population of Kursk and Voronezh governate from 1890–1910 to 1951–1953. Over 60 years, there was an increase in the level of local inbreeding (2.8 times) and root-mean-square distances between the places of birth of spouses taking into account long-distance migrations (3.7 times) and without them (5.44 times) and a decrease in the effective population size (2.8 times) and the coefficient of linear systematic pressure (4.5 times).

Keywords: Malecot's isolation by distance model, local inbreeding

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INTRODUCTION

When describing the population structure of the population and its dynamics, it is important to quantify marriage and migration parameters, which can be indicators of Malecot's isolation by distance model [1–3]. This model of isolation by distance is widely used in population genetic studies and makes it possible to establish the dependence of the degree of consanguinity of spouses on the distance between their places of birth. The advantage of this approach is the ability to assess both inter- and intrapopulation relatedness [3]. It should be noted that the local inbreeding values (*a*), obtained using this model correspond to the indicator of population subdivision (Wright F_{st}) calculated by surnames [3–6].

Using Malecot's isolation by distance model, the population was studied of both various foreign populations (Bar, Australia, Switzerland, Iceland, etc.) [2, 7–11] and populations in Russia (Kostroma, Kirov, Arkhangelsk, Tver, and Kursk oblasts, Krasnodar krai, Republic of Adygea, Republic of Mari El, Udmurtia, Tatarstan, etc.) [5, 6, 12–27] and the former CIS (Ukraine, etc.) [28–30].

This communication continues the series of works [31] devoted to the study of the dynamics of a number of population-demographic indicators among the population of the south of Central Russia and presents the results of studying the parameters of the model of isolation by distance among the population of the Kursk and Voronezh provinces, from which Belgorod oblast was formed in 1954, over time 60-year period (from the 1890s to 1951–1953).

MATERIALS AND METHODS

The object of this study is the population of the Central Black Earth Region (Kursk and Voronezh governates) from the late 19th century to the mid-20th century. Detailed characteristics of the studied uezds (later districts) and the criteria for their inclusion are presented in the previously presented work [31]. The study was conducted over two time periods: 1890–1910 and 1951–1953—until the formation of the Belgorod oblast in 1954 from part of the districts of the Kursk and Voronezh governates. The work included Belgorod, Grayvoronsky, Korochansky, Novooskolsky, Starooskolsky uezds (districts), which were part of the Kursk governate, then the Kursk oblast, and after 1954 were transferred to Belgorod oblast. Other uezds (districts), Biryuchansky (later Krasnogvardeysky and partially Alekseevsky) and Valuysky, until 1954 were part of the Voronezh governate, then Voronezh oblast; after 1954, they are districts of Belgorod oblast. The material for the study was data from records of church and parish books from the Civil Registry Office Archive of Belgorod oblast at the end of the 19th century (1890–1910, 4925 records), as well as acts civil status of the regional registry office archive for 1951–1953 (5128 records). Information about the places of birth of brides and grooms was copied from the vital records. Next, we measured the distances between the birthplaces of the spouses in a straight line in kilometers using the Internet resource https://ru.distance.to/Just.... A total of 10053 distances between the birthplaces of spouses were included in the analysis. Calculations of isolation parameters by Malecot distance were carried out in accordance with the works of G. Malecot [1], N.E. Morton [2], G.I. Elchinova, and others [3, 4, 25]. The analysis of the parameters of the Malecot model was carried out at the uezd (district) level.

RESULTS

Parameters of Malecot's Isolation by Distance Model among the Population of Kursk and Voronezh Governates

1. *1890–1910.* Study of the indicators of Malecot's isolation by distance model in the uezds of the Kursk and Voronezh governates in 1890–1910 showed significant variability in such indicators as the root-mean-square distances between the places of birth of spouses taking into account long-distance migrations (2.6 times: from 21.75 to 55.84 km) and without them (2.6 times: from 8.65 to 22.62 km) and the coefficient of linear systematic pressure (2.2 times: from 0.01942 to 0.04168) (Table 1).

In general, in the Voronezh governate, the root-mean-square distances between the places of birth of spouses, taking into account long-distance migrations (1.4 times) and without them (1.6 times), and the effective pressure of migration (1.2 times) were higher than in the Kursk governate. At the same time, the average values of the coefficient of linear systematic pressure (1.5 times) and local inbreeding (1.4 times) in the Voronezh governate are lower than in the Kursk governate owing to the fact that the effective population size in the Voronezh province exceeded the effective population size in the Kursk governate by 1.2 times (Table 1).

Among the urban population, compared to the rural population, the values of local inbreeding are higher (by 19.5 times), the mean square distances between the places of birth of spouses, taking into account long-distance migrations (by 1.9 times) and without them (by 2.7 times), and the effective population size and the coefficient of linear systematic pressure lower by 13.8 times and 2 times, respectively. Also, urban populations were characterized by higher variability of most calculated indicators. It should be noted that the rural population of all seven counties experienced an equally low (0.00006–0.00014) inbreeding load.

2. *1951–1953.* In 1951–1953, among the population of Kursk and Voronezh oblasts, the maximum variability was noted for the coefficient of linear systematic pressure (4 times, with variability from 0.00291 to 0.01154), root-mean-square distances between the places of birth of spouses taking into account long-distance migrations (2 times, with variability from 93 to 185.02 km) and without them (3.6 times, with variability from 36.78 to 133.25 km), effective population size (2.7 times, with variability from 13359 to 36485), and local inbreeding (2.2 times, from 0.00010 to 0.00022) (Table 2).

In 1951–1953 districts of Kursk and Voronezh oblasts experienced equally low inbreeding load with insignificant differences in the values of the root-mean-square distances between the places of birth of spouses taking into account long-distance migrations and without them (higher in the Voronezh region—1.3, 1.6 times, respectively), the coefficient of linear systematic pressure, and the effective population size (slightly higher in the Kursk region—1.9 and 1.2 times, respectively) (Table 2).

Among the urban population, the effective population size was smaller (1.6 times), and the level of local inbreeding was significantly higher (4.2 times) compared to the rural population. Also, urban populations were characterized by higher variability in a number of indicators (local inbreeding—18.5 times, effective population size—18.4 times, coefficient of linear systematic pressure of migration—5.2 times, root-mean-square distances between the places of birth of spouses without taking into account long-distance migrations—4.6 times) compared to rural populations (Table 2). It should be noted that the rural population of all seven regions experienced an equally low (0.00016–0.00033) inbreeding load, which increased 3.4 times over the past 60 years (from 1890–1910 to 1951–1953).

Thus, from the end of the 19th century to the middle of the 20th century, the root-mean-square distances between places of birth of spouses increased taking into account long-distance migrations and without them (3.7 times and 5.4 times, respectively), the value of local inbreeding (2.8 times) with a decrease in the effective population size (2.9 times), and the coefficient of linear systematic migration pressure (4.5 times).

DISCUSSION

Analysis of the parameters of Malecot's isolation by distance model among the population of the Central Black Earth Region from 1890–1910 to 1951–1953 showed an increase in the level of local inbreeding (2.8 times) against the background of a decrease in the effective population size (almost 3 times). It should be noted that the period of 1890–1910 was characterized by high values of the effective population size and a minimal level of local inbreeding, which in turn was determined by the large population of the uezds of Kursk and Voronezh governates, from which Belgorod oblast was subsequently formed. Uezds were very large administrative-territorial units.

Table 1. Parameters of Malecot's isolation by distance model among the population of Kursk and Voronezh governates in 1890–1910

	Uezd	*N*	σ	σ'	*m*	*k*	M_e	N_e	*a*	*b*
Uezds of Kursk governate	Belgorodsky	844	36.17	13.21	0.011	0.222	0.070	58100	0.00006	0.02823
	city	253	53.95	18.26	0.020	0.130	0.074	8855	0.00038	0.02114
	village	591	24.95	7.52	0.011	0.253	0.075	49245	0.00007	0.05164
	Stary Oskolsky	795	40.94	12.78	0.013	0.235	0.078	48670	0.00007	0.03087
	city	167	68.88	29.49	0.021	0.165	0.086	5206	0.00056	0.01404
	village	628	29.33	10.18	0.008	0.243	0.063	43464	0.00009	0.03478
	Novooskolsky	727	24.92	8.65	0.010	0.152	0.057	52616	0.00008	0.03900
	city	302	32.40	13.45	0.013	0.094	0.052	999	0.00482	0.02391
	village	425	20.61	5.28	0.006	0.195	0.048	51618	0.00010	0.05889
	Korochansky	364	44.47	14.73	0.012	0.173	0.067	53008	0.00007	0.02478
	city	162	64.57	21.39	0.025	0.086	0.070	3412	0.00105	0.01747
	village	202	14.83	4.88	0.002	0.265	0.036	49596	0.00014	0.05521
	Grayvoronsky	789	21.75	8.98	0.013	0.187	0.070	59160	0.00006	0.04168
	city	321	20.59	9.16	0.008	0.181	0.054	2113	0.00220	0.03573
	village	469	22.48	8.84	0.016	0.191	0.080	57046	0.00006	0.04520
	Average for the governate	**704**	**33.65**	**11.67**	**0.012**	**0.194**	**0.068**	**54311**	**0.00007**	**0.03291**
	city	**241**	**48.08**	**18.35**	**0.017**	**0.131**	**0.067**	**4117**	**0.00180**	**0.02246**
	village	**463**	**22.44**	**7.34**	**0.009**	**0.229**	**0.060**	**50194**	**0.00009**	**0.04915**
Uezds of Voronezh governate	Valuysky	820	55.84	22.62	0.020	0.221	0.097	62704	0.00004	0.01942
	city	190	102.66	72.38	0.021	0.184	0.091	2233	0.00124	0.00588
	village	630	40.11	14.91	0.010	0.224	0.066	60472	0.00006	0.02436
	Biryuchansky district	586	37.68	14.34	0.009	0.258	0.070	66889	0.00005	0.02612
	city	259	32.36	12.22	0.012	0.28	0.081	4360	0.00070	0.03302
	village	327	41.41	14.72	0.009	0.252	0.069	62529	0.00006	0.02517
	Average for the governate	**703**	**46.76**	**18.48**	**0.015**	**0.240**	**0.083**	**64797**	**0.00005**	**0.02277**
	city	**225**	**67.51**	**42.30**	**0.016**	**0.232**	**0.086**	**3297**	**0.00097**	**0.01945**
	village	**479**	**40.76**	**14.82**	**0.009**	**0.238**	**0.067**	**61501**	**0.00006**	**0.02477**
Regional average		**704**	**37.40**	**13.62**	**0.013**	**0.207**	**0.073**	**57307**	**0.00006**	**0.03001**
city		**236**	**53.63**	**25.19**	**0.017**	**0.160**	**0.072**	**3883**	**0.00156**	**0.02160**
village		**467**	**27.67**	**9.48**	**0.009**	**0.232**	**0.062**	**53424**	**0.00008**	**0.04218**

For Tables 1 and 2: σ—root-mean-square distance between the places of birth of spouses taking into account long-distance migrations; σ'—root-mean-square distance between the places of birth of spouses without taking into account long-distance migrations; *m*—half the share of long-distance migrations; *k*—half the share of intermediate migrations; M_e—effective migration pressure; N_e—effective population size; *a*—local inbreeding; *b*—coefficient of linear systematic pressure.

Table 2. Parameters of Malecot's isolation by distance model among the population of Kursk and Voronezh oblasts in 1951–1953

	District	N	σ	σ'	m	k	M_e	N_e	a	b
District Kursk oblast	Belgorodsky	1170	123.40	52.97	0.019	0.113	0.068	36485	0.00010	0.00695
	city	404	159.44	76.08	0.026	0.062	0.062	24093	0.00017	0.00464
	village	766	99.26	47.40	0.012	0.142	0.061	12393	0.00033	0.00735
	Stary Oskolsky	675	93.00	36.85	0.018	0.083	0.057	22730	0.00019	0.00917
	city	197	103.14	34.32	0.018	0.048	0.045	9158	0.00061	0.00875
	village	478	88.49	37.85	0.018	0.097	0.061	13572	0.00030	0.00926
	Novooskolsky	645	185.02	133.25	0.016	0.165	0.075	14889	0.00022	0.00291
	city	102	167.66	76.10	0.025	0.093	0.072	4303	0.00081	0.00498
	village	543	188.11	141.44	0.015	0.174	0.073	10586	0.00032	0.00270
	Korochansky	633	144.91	54.27	0.021	0.212	0.097	16837	0.00015	0.00813
	city	156	190.22	31.05	0.038	0.071	0.083	1309	0.00229	0.01313
	village	477	126.61	52.21	0.019	0.257	0.100	15528	0.00016	0.00858
	Grayvoronsky	643	95.65	36.78	0.023	0.169	0.090	13359	0.00021	0.01154
	city	112	149.18	120.70	0.009	0.116	0.046	1714	0.00314	0.00252
	village	551	78.44	28.22	0.017	0.180	0.081	11645	0.00027	0.01422
	Average for the oblast	**753**	**128.40**	**62.83**	**0.019**	**0.148**	**0.078**	**20860**	**0.00018**	**0.00774**
	city	**194**	**153.93**	**67.65**	**0.023**	**0.078**	**0.062**	**8115**	**0.00140**	**0.00680**
	village	**563**	**116.18**	**61.42**	**0.016**	**0.170**	**0.075**	**12745**	**0.00028**	**0.00842**
Districts of Voronezh oblast	Valuysky	724	148.81	87.40	0.019	0.157	0.080	17228	0.00018	0.00458
	city	193	117.88	45.16	0.026	0.098	0.076	6023	0.00055	0.00863
	village	531	158.57	98.56	0.018	0.186	0.084	11206	0.00027	0.00415
	Alekseevsky	638	184.54	117.25	0.021	0.170	0.087	19004	0.00015	0.00357
	city	295	209.77	141.27	0.020	0.217	0.096	6716	0.00039	0.00310
	village	343	159.68	70.22	0.032	0.128	0.096	12288	0.00021	0.00625
	Average for the oblast	**681**	**166.67**	**102.33**	**0.020**	**0.163**	**0.084**	**18116**	**0.00017**	**0.00407**
	city	**244**	**163.82**	**93.21**	**0.023**	**0.158**	**0.086**	**6370**	**0.00047**	**0.00587**
	village	**437**	**159.12**	**84.39**	**0.025**	**0.157**	**0.090**	**11747**	**0.00024**	**0.00520**
Regional average		**733**	**139.33**	**74.11**	**0.020**	**0.153**	**0.079**	**20076**	**0.00017**	**0.00669**
city		**208**	**156.75**	**74.95**	**0.023**	**0.101**	**0.069**	**7617**	**0.00113**	**0.00654**
village		**527**	**128.45**	**67.98**	**0.019**	**0.166**	**0.079**	**12460**	**0.00027**	**0.00750**

For example, on the territory of the former Grayvoronsky uezd, there are currently five districts [32]. The subsequent sharp decline in the effective population of the Belgorod region by the period of 1951–1953 was a consequence of three catastrophic, from a demographic point of view, crises: (1) World War I, civil war, famine—1915–1922; (2) collectivization, famine—1930–1936; (3) Great Patriotic War, famine—1941–1945. So, for example, according to N.V. Chugunova in the 1930s, the number of residents of the Belgorod oblast within its modern borders decreased from 1.8 to 1.4 million people, or by almost 25% (for 1930–1939) [33]. Demographic losses of the Belgorod region from the famine of 1932–1933 were comparable to the losses of the civilian population of the region from the occupation by troops of Germany and its allies in 1941–1943 [34]. Belgorod land became the scene of severe battles during the Great Patriotic War. Thus, during the Battle of Kursk and the Prokhorovsk tank battle, the city of Belgorod was almost completely destroyed, and out of 34000 inhabitants, only 150 people remained by the day of liberation. A similar situation was observed in other settlements of the Belgorod region.

It should be noted that, from the end of the 19th century to the middle of the 20th century, the range of marriage migrations expanded significantly [31], as evidenced by the increase in the root-mean-square distances between the places of birth of spouses taking into account long-distance migrations and without them. However, the effective migration pressure has not changed over the 60-year period. This is explained by the administrative-territorial transformations of counties and provinces, as a result of which the boundaries of modern districts of the Belgorod region were formed, and this was accompanied by a significant decrease in the effective population size.

It is worth noting that, over a 60-year period, the variability of the main parameters of Malecot's isolation by distance among the urban and rural populations was somewhat different. From the end of the 19th century to the middle of the 20th century, the effective population size among the urban population increased by 2 times, and the level of local inbreeding decreased by 1.4 times compared to the rural population. Among the rural population, there was a decrease in both the effective size by 4.3 times and the level of local inbreeding by 3.4 times.

The connection between the parameters of population isolation (local inbreeding, migration, etc.) and the prevalence of hereditarily determined human diseases has been shown by numerous studies [6, 12, 13, 15, 35–38]. This determines the need to take into account these indicators when planning population genetic and medical genetic studies [39–46].

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ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This work does not contain any studies involving human and animal subjects.

CONFLICT OF INTEREST

The authors of this work declare that they have no conflicts of interest.

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