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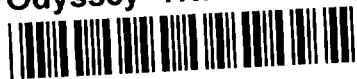
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The effects of a new political border on the migration patterns and predicted kinship (PHI) in a subdivided Hungarian agricultural population: Tiszahat

Die Wirkung einer neuen politischen Grenze auf das Migrationsmuster und die geschätzte Verwandtschaft (PHI) in einer unterteilten ungarischen Landbevölkerung: Tiszahat

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Summary

Tiszahat, an agricultural region of northeastern Hungary, is highly stable and culturally homogeneous, with settlements that can be traced to the 12th c. AD. This swampy, malarial region has been geographically isolated by the Tisza River and the Russian border. In 1945, the border with the Soviet Union was shifted, bisecting Tiszahat and markedly reducing matrimonial migration. – This research focused on church marital migration records of the Calvinist parishes of Tiszahat for two time periods, 1875 to 1899 and 1950 to 1974. A migration matrix was constructed (male and female places of birth – rows and columns) and predicted kinship was computed for the 20 subdivisions of Tiszahat. The average predicted kinship ($\times 10^4$) for the two periods decreased from 67 to 36. The relationship between geography and predicted kinship closely paralleled MALECOT'S isolation-by-distance model. An increased linear effect was observed in the predicted kinship of the northern villages of Tiszahat.

Introduction

The underlying assumptions of Hardy-Weinberg equilibrium include such population characteristics as panmixis and infinite size. However, most human aggregates are in fact subdivided hierarchically, mate non-randomly and are of finite or small size. Studies of human population structure, made possible by the existence and maintenance of extensive church and civil records, have revealed that factors such as geography, unique historical events and an assortment of cultural variables (such as religion, economics, and language affiliation) subdivided seemingly large populations into smaller units (JORDE, 1980). The structure of hierarchically subdivided populations has been examined in the Åland Islands (MIELKE et al. 1982), Oxfordshire (HARRISON et al. 1970), and Newfoundland (CRAWFORD et al. 1995). Methods of analysis included genetics, migration patterns and surname distributions.

To date, several publications stemming from the Tiszahat Project (a joint US-Hungarian field research program) have focused on villages located within the Tiszahat population. For example, KOERTVELYESSY et al. (1992) applied the repeated pair (RP) method to three villages of Tiszahat and uncovered recurring

mating patterns between lineages. Similarly, DUGGIRALA et al. (1992) have documented temporal changes in RP in one of the Tiszahat villages (Tarpa) from 1780–1979. An excess of observed RP over random RP was noted, suggesting the significant presence of lineage-related matings, i.e. population structure.

This paper considers the relationship between geography, migration patterns, the presence or absence of political borders, and predicted kinship (Φ) in the North-eastern sector of Hungary, Tiszahat. Prior to World War II, the Tiszahat region was territorially larger because the USSR-Hungarian border was located further East. The new political border, created in 1945, bisected Tiszahat and prevented matrimonial migration into or from the villages that were incorporated into the Soviet Union. The primary concerns of this manuscript are the demographic and genetic consequences of the imposition of a new political barrier and its effects on the population structure of Tiszahat.

Population

What distinguishes the Tiszahat population from other human aggregates studied for genetic structure is: 1) Tiszahat is highly stable numerically and is made up of a series of settlements whose existence can be traced to the 12th century A.D. 2) Geographic isolation is imposed by an elbow of the Tisza river and the Soviet (now

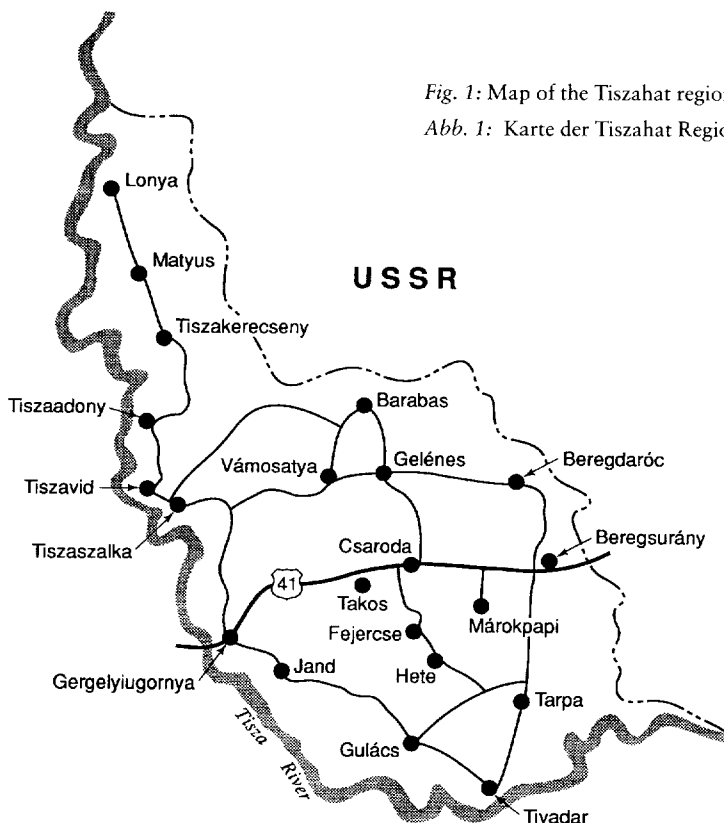


Fig. 1: Map of the Tiszahat region, northeastern Hungary.

Abb. 1: Karte der Tiszahat Region, Nordost-Ungarn.

Ukrainian) border (Figure 1). Until the 1930s, when a bridge was built, the primary transport across the Tisza River was by ferry. 3) Until recently, Tiszahat, was a swampy, back-water region of Hungary that was periodically inundated and usually infested with mosquitos and malaria. As a result, this region was avoided by conquering armies and as a result has remained culturally and genetically homogeneous. The primary exception to this cultural homogeneity is the division of some villages into Catholic and Calvinist congregations. The demographic effects of this religious dichotomy is considered in another paper (KOERTVELYESSY et al., 1992). 4) Tiszahat experienced a unique series of historical events that apparently altered the migration direction and pattern. In 1945, the establishment of a new Hungarian-Soviet border resulted in the partitioning of Tiszahat. Migration across the Soviet border was difficult, if not impossible for the Tiszahat residents of the former USSR. 5) Since the Tiszahat economy is primarily horticulture, coupled with animal husbandry, the impact of industrialization (prevalent throughout most of Europe) has had minimal impact on Tiszahat.

Methods

Calvinist matrimonial church records were transcribed for all 24 of the Tiszahat villages for a period of roughly from the end of the 18th century to 1986. However, in some cases villages in close geographic proximity merged because of their numerical growth, while in larger communities one or two parishes were closed and the records of the two congregations were combined. As a result, matrimonial migration patterns were compared for only 20 villages. This comparison was made for two time periods in order to observe the effects of the creation of a new political border on the migration patterns between the subdivisions and its evolutionary implications. One time period (1875–1899) was chosen because it predated many of the demographic disturbances associated with the two World Wars and the creation of the more easterly USSR-Hungarian border. The second period, 1950–1974, was five years after the establishment of a new border and the political subdivision of Tiszahat.

A 20×20 marital migration matrix was constructed with male and female villages of birth constituting the rows and columns. Predicted kinship (θ_{ij}) was computed utilizing the method of MORTON (1973). This migration predicted kinship provides a measure of the genetic similarity between populations. The diagonal elements, θ_{ii} , of the matrix provides the probability that two random genes in a population were identical by descent and denoted local kinship. The off-diagonal elements, θ_{ij} , are measures of the genetic relationship between any two populations, i and j . High values denote population affinity, while low values suggest the existence of little genetic resemblance.

Matrices of predicted kinship for the two time periods were compared to each other, to geographic trail distance matrices, and to surname kinship (R_i) matrices by Mantel tests of matrix correlation, which compute product-moment correlations between the elements of the various matrices. The significance is tested by a matrix permutation procedure. To make these computations, RELETFORD's (1990) Mantel computer program was utilized.

Results and discussion

Endogamous marriages

The proportion of endogamous marriages in the 20 Tiszahat subdivisions for the two time periods (1875–1899 and 1950–1974) are compared in Table 1. For the earlier time period, 1875–1899, village endogamy in Tiszahat ranges from a high of 98% to a low of 61%. Tarpa, a relatively large village in the southeastern corner of Tiszahat, with an effective population size (N_e) of 925, is the most endogamous (98%), while Beregsurany is least endogamous with only 61% of the marriages being contracted within the village. During the later period (1950–1974), Tarpa continues to be the most endogamous, with 96% of the marriages are between residents of the same village. There has been a decrease in endogamy over the two time periods with an average 83% of marriages in the 20 subdivisions being endogamous in 1875–1899 and only 66% endogamy in 1950–1974. The greatest observed change in endogamy took place in Marok-papi, which had no endogamous unions during 1950–1974. Most likely this reduction in endogamy resulted from a further diminution in the size of the population and the construction of a nearby connecting highway. Similarly, Tividar, Hete/Fejercse, and Takos experienced a marked diminution of endogamy and an increase in migration.

Table 1: A comparison of the proportion of endogamous marriages in the subdivisions of Tiszahat between the two time periods (1875–1899 and 1950–1974).

Tabelle 1: Ein Vergleich des Verhältnisses endogamer Heiraten in den Unterteilungen von Tiszahat zwischen den beiden Zeitperioden.

Subdivision	1875–1899	1950–1974
Lonya	94%	93%
Matyus	80	51
Tiszaadony	79	68
Tiszavid	88	72
Tiszaszalka	84	82
Barabas	86	62
Gelenes	73	86
Bregdaroc	74	58
Marok-papi	72	0
Vamosatya	79	77
Csaroda	76	85
Beregsurany	61	74
Takos	82	32
Hete/Fejercse	68	25
Gergelyugornya	90	89
Tarpa	98	96
Jand	94	88
Gulacs	97	85
Tividar	93	17
Tisza-kerecseny	89	82
Tiszakerecseny	89	82

In-migration

In addition to the exchange of mates between the villages of Tiszahat, some systematic pressure (in the form of migration from outside Tiszahat) entered the subdivided population. However, when the two time periods are compared, there is no statistically significant increase in migration from outside of Tiszahat. Although the average systematic pressure between the two time periods remained unchanged, some fluctuations in migration was noted within the subdivisions (Table 2). For example, both Hete/Fejercse and Tivadar experienced no outside migration during the 1950–1974 time period, even though the earlier period had 12.6% and 3.2% migration respectively. Beregsurany (a small border village located on a major highway that cuts through the region) has the highest migration rate from outside Tiszahat. This significant difference is most likely due to the unavailability of unrelated and eligible mates in such small communities. Residents of villages such as Beregsurany have to obtain mates from surrounding villages in order to circumvent church prohibitions against consanguineous unions.

Predicted kinship (Phi)

A comparison of predicted kinship ($\Phi \times 10^4$) between the two time periods reveals a significant reduction in Phi from 1875 to 1979. The average Phi per village in 1875–1899 was 67×10^{-4} versus 35.5×10^{-4} in 1950–1979 (Table 3). Both Tivadar

Table 2: Systematic pressure and effective sizes of Tiszahat subdivisions.

Table 2: Systematischer Druck und tatsächliche Größen der Untereinheiten von Tiszahat.

Village	N _e	Migration	
		1875–1899	1950–1974
Lonya	398	0.126	0.114
Matyus	83	0.196	0.109
T-adony	158	0.149	0.108
T-vid	161	0.095	0.087
T-szal	226	0.155	0.104
Barabas	276	0.088	0.059
Gelenes	190	0.056	0.077
Beregdaroc	148	0.074	0.194
Marokpapi	155	0.099	0.066
Vamosatya	197	0.085	0.080
Csaroda	205	0.074	0.076
Beregsurany	81	0.150	0.239
Takos	132	0.060	0.074
Hete/Fej.	194	0.126	0.000
Gerg./U.	226	0.167	0.090
Tarpa	925	0.033	0.131
Jand	214	0.063	0.107
Gulacs	313	0.082	0.147
Tivadar	72	0.032	0.000
Tisza-kerec.	252	0.117	0.017

Average		0.097	0.094

Table 3: Predicted kinship (θ_{ij}) $\times 10^4$ by village in TiszahatTabelle 3: Geschätzte Verwandtschaft (θ_{ij}) $\times 10^4$ nach Dörfern in Tiszahat.

Village	Period	
	1875–1899	1950–1979
Lonya	33	24
Maryus	66	51
T-adony	42	39
T-vid	82	45
T-szalka	34	35
Barabas	44	23
Gelenes	64	54
Beregdaroc	70	25
Marokpapi	47	22
Vamosatya	52	41
Csaroda	50	51
Beregsurany	44	49
Takos	107	25
Hete/Fejercse	33	21
Gergelyugornya	40	44
Tarpa	37	10
Jand	88	42
Gulacs	59	23
Tivadar	300	36
Tisza-kerecseny	50	50

Table 4: Mantel tests to examine associations between geography, as measured by trail distances (TD), Relationship by Isonymy (R_i), and Predicted Kinship (θ).Tabelle 4: Mantel Tests zur Prüfung des Zusammenhangs zwischen Geografie, gemessen durch Pfadentfernungen (TD), Verwandtschaft nach Isonymie (R_i) und geschätzter Verwandtschaft (θ).

R_i	θ	θ	TD	
			(1875–1899)	(1950–1974)
TD	–	–		
R_i	–0.14 (NS)	–		
θ (1875–1899)		–0.58 (NS)	0.18*	–
θ (1950–1974)		–0.52 (NS)	0.20*	0.56** –

NS = not significant; * = $p < 0.05$; ** = $p < 0.001$

and Takos exhibit a lower probability of a common origin of two randomly selected alleles, as predicted by a reduction in Φ . Three of the villages, namely Tiszaszalka, Csaroda and Tisza-kerecseny, show no change in Φ over the two time periods. However, these villages had exhibited low kinship (Φ) during the earlier period and experienced no significant change. Only two communities, Gergelyugornya and Beregsurany had slight elevations in predicted kinship. Given the increases in migration and the relative breakdown of isolation, it is not surprising that there is a decrease in the likelihood of random genes being of common descent.

As measured by Mantel permutations (Table 4), the correlation between the Phi values for the two time periods (1875–1899 vs 1950–1974) is 0.56, which is highly significant ($p < 0.001$). These results also suggest unique changes in marital migration patterns that occurred during the intervening years. The slight decline of « r » (i.e. Phi vs geography) from -0.58 (1875–1899) to -0.52 (1950–1974) helps explain the observed decreasing geographic effects on kinship. MIELKE et al. (1982) and JORDE et al. (1982) found similar patterns for the Aland Islands. In the period 1875–1899, 33.5% (R^2) of variation in Phi is explained by geography, while in the latter period, geography explains 27.5% variation in Phi. This again indicates the changing effects of geography on mate selection.

Several other studies have revealed the existence of a negative relationship between the coefficient of relationship (R_i) and geographic distance (LASKER 1985; FUSTER 1986). LASKER (1985: 61) states:

«The coefficient of relationship by isonymy is positively correlated with migration if the latter is summed over many generations, and R_i is negatively correlated with distance between and also within villages, which reflects a pattern of past migrations in which short distances were common, but no longer ones also occurred.»

The mean predicted kinship (F_{st}) for the 20 subdivisions of Tiszahat declined from the 1875–1899 to the 1950–1974 time periods. During the earlier period the F_{st} was 0.0049 versus 0.0028 for the latter period. The F_{st} value for the earlier period compares favorably with the value observed in an isolated fishing population, Fogo Island, Newfoundland, 0.0054, (CRAWFORD et al. 1995) and is considerably higher than the published values for the 16 parishes of the Aland Islands, $F_{st} = 0.0018$ (MIELKE et al. 1982).

A matrix correlation between Phi of both time periods and geography, as measured by trail distances (TD), exhibits a moderate negative association (r) with distance (Phi 1875–1899 vs distance = -0.58 , not significant) and Phi 1950–1975 vs distance = -0.52 (NS). These results suggest low to moderate levels of migration paralleling MALECOT's isolation by distance model (1969). The insignificant relationships, suggest that the effects of factors other than geographic distance influence mate selection. As shown in Figure 2, the relationship between Phi and geography is essentially curvilinear for both time periods, resulting in a pseudo-leptokurtic curve. However, only the plot for earliest of the two time periods is shown in Figure 2 since these curves closely resemble each other. These two correlations fall within the range of 0.2 and 0.6 as noted by JORDE (1980), and FUSTER (1986).

JORDE et al. (1982) cites the WORKMAN et al. (1973) suggestion that if kinship (Φ_{ij}) is related to geographic distance in a negative exponential form than its two-dimensional fit can be improved by using the log of Phi. Table 5 shows various transformations and the values of R-squared derived from the related regression models. The improved fit between geography and Phi (i.e. both periods) is evident from Table 5. Figure 2 shows the change in the transformed plot of the log of predicted kinship against the trail distances between the villages of Tiszahat.

Two major observations are warranted from these correlation data: 1) that a moderate negative relationship exists between geography and predicted kinship in the Tiszahat subdivided population. 2) the creation of the new Soviet-Hungarian

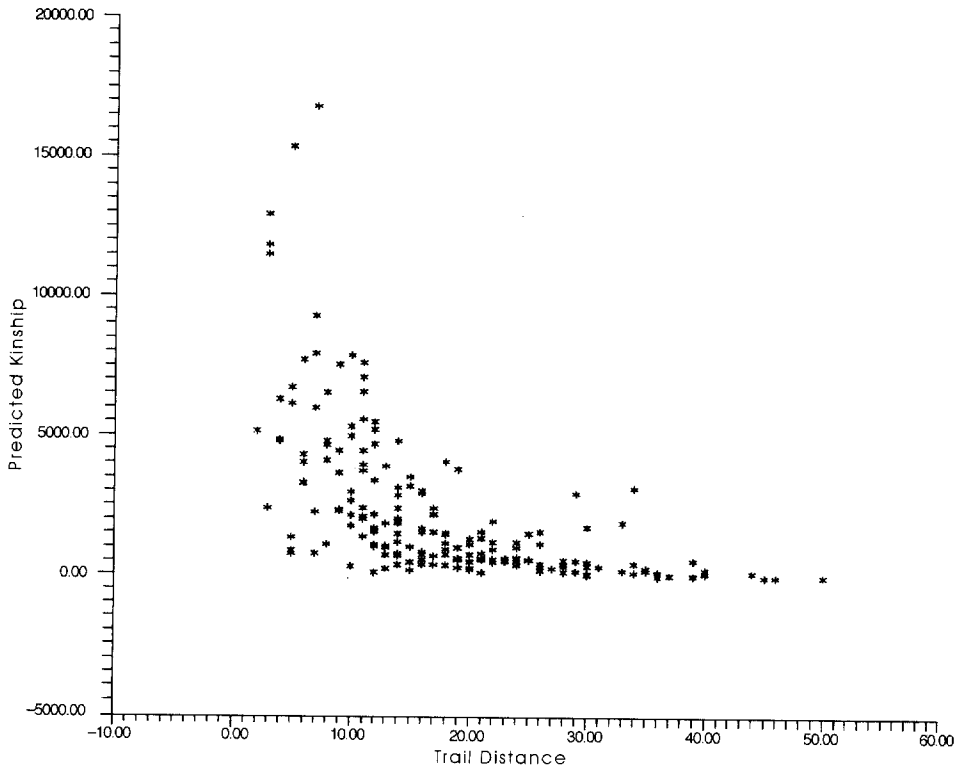


Fig. 2: Predicted kinship vs geography for 1875–1899.

Abb. 2: Geschätzte Verwandtschaft vs Geographie für 1875–1899.

Table 5: Regression analyses that examine the effect of geographic distance (Trail Distance) on predicted kinship (θ).

Tabelle 5: Regressionsanalyse zur Prüfung der Auswirkung geographischer Entfernung (Pfadentfernung) auf geschätzte Verwandtschaft (θ).

Data	θ (1875–1899) against TD R ² (%)	θ (1950–1974) against TD R ² (%)
Original data θ * TD	33.5	27.5
Transformed data 1. log θ vs TD (cubic polynomial)	60.1	58.3
2. log θ vs sq.rt TD	59.1	57.7
3. log θ vs TD	59.4	55.6

border in 1945 and its closure to migration from Hungary, has improved the relationship between geography and kinship. With the cessation of gene flow from the East, there is a more linear kinship effect between the northern villages Lonya-Matyus-Tizsakerecseny-Tiszaadony-Tiszavid-Tiszaszalka. This interpretation is supported by the R-matrix that indicates in the later time period greater affinities between these adjoining villages. The surname kinship R_i provides a better fit to the kinship (Phi) matrix during the later period.

The effects of the imposition of a new border between Hungary and the USSR in 1945 are inter-mingled with numerous other demographic trends that are observed in European agricultural villages during the same time. Generally, the rate of village endogamy was reduced with improvements in roads and modes of transport. For example, in the Aland Islands the development of motor boats altered migration distances in a single generation (MIELKE et al. 1982). Similarly, predicted kinship decreased throughout Tiszahat, with few exceptions. Surprisingly, the systematic pressure (M) appears to be unchanged over the two time periods, with the average M for the earlier period being 0.097 versus 0.094 for the new post-border Tiszahat. These systematic pressures appear to be the result of increased migration from the West balanced by the elimination of population movement across the Soviet border.

Finally, the closing of the border in 1945 has not improved the fit between geography and kinship, despite the creation of a linear effect resulting from greater gene exchanges between adjacent villages and the elimination of gene flow from the easterly direction. It appears that Tiszahat population structure has been affected in a single generation by a unique historical event.

Zusammenfassung

Tiszahat, eine ländliche Region in Nordost-Ungarn, ist ausgesprochen stabil und kulturell homogen, mit Siedlungen, die bis ins 12. Jh. zurück verfolgt werden können. Diese sumpfige Malariagegend ist durch die Theiss (Tisza) und die russische Grenze geografisch isoliert. 1945 verlagerte sich die Grenze zur Sowjetunion, wodurch Tiszahat geteilt und die Heiratswanderung deutlich reduziert wurde. – Diese Forschung konzentriert sich auf kirchliche Heiratswanderungsregister der calvinistischen Gemeinden von Tiszahat aus zwei Perioden, 1875 bis 1899 und 1950 bis 1974. Es wurde eine Wandermatrix erstellt (Geburtsorte der Männer und Frauen als Reihen und Spalten) und die geschätzte Verwandtschaft wurde für die 20 Untergebiete von Tiszahat berechnet. Die allgemeine geschätzte Verwandtschaft ($\times 10^4$) in den beiden Perioden nahm von 67 auf 36 ab. Das Verhältnis zwischen Geografie und geschätzter Verwandtschaft lag eng bei MALECOT's Modell der Entfernungsisolation. Ein erhöhter Lineareffekt wurde bei der geschätzten Verwandtschaft in den nördlichen Dörfern von Tiszahat beobachtet.

Résumé

Tiszahat, une région rurale au nord-est de l'Hongrie est nettement stable et culturellement homogène, avec des habitats qui remontent jusqu'au 12^{ème} siècle. Cette région paludéenne marécageuse était géographiquement isolée par la rivière Tisza et la frontière russe. En 1945, la frontière avec l'Union soviétique était transférée, par quoi la région de Tiszahat était coupée en deux et la migration matrimoniale était nettement réduite. Cette étude se concentre aux registres de migration matrimoniale de l'église d'une paroisse calviniste de Tiszahat comprenant deux périodes, 1875 jusqu'à 1899 et 1950 jusqu'à 1974. On a établi une matrice de migration (lieu de naissance des hommes et des femmes rangs et colonnes) et la parenté supposée était calculée pour les 20 subdivisions de Tiszahat. Le nombre pour la

parenté supposée moyenne ($\times 10^4$) pour les deux périodes diminuait de 67 à 36. La relation entre la géographie et la parenté supposée correspondait strictement avec le modèle de l'isolation de distance (isolation-by-distance) de MALECOT. Concernant la parenté supposée on pouvait observer un effet linéaire élevé dans les villages septentrionalux de Tiszahat.

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