

# The spring migration and distribution of Common Crane (*Grus grus*) in the Carpathian Basin during the late 19<sup>th</sup> and early 20<sup>th</sup> centuries

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**Abstract** During the early 21<sup>st</sup> century, the Carpathian Basin was recognised as one of the world’s most important migratory area for the Common Crane, but it is not completely clear, what was its status during the late 19<sup>th</sup> and early 20<sup>th</sup> centuries. Between 1897 and 1916, a total of 1487 field observation data were published in the journal *Aquila* from the Carpathian Basin. Our work analysed the timing of the spring migration, how it differed between years and geographical regions, and how the temperature and geographical variables reported above influenced the timing of the migration. The results show that the migration routes of the species have changed significantly over the last century. During the study period, the migration concentrated in the eastern part of the Carpathian Basin, and was particularly rare in the Great Hungarian Plain. There was on average a two-week difference in the timing of migration between the western and eastern parts and between different years. The start and peak of migration were weeks later than today, and this change is mainly due to the effects of climate change. Geographical factors did not influence the migration of the species, whereas higher air temperatures advanced the timing of the migration.

**Keywords:** climate change, *Grus grus*, short-distance migration

**Összefoglalás** A Kárpát-medence a 21. század elején a darvak egyik legfontosabb vonulási útvonala, de nem teljesen világos, hogy mi volt a helyzet a 19. század végén és a 20. század elején. Az *Aquila* című folyóiratban 1897 és 1916 között összesen 1487 terepi megfigyelési adatot közöltek a fajról a Kárpát-medencéből. Munkánkban azt vizsgáltuk, hogy a tavaszi vonulás időzítése hogyan különbözött akkoriban az egyes évek és földrajzi régiók között, és hogy a különböző hőmérsékleti és földrajzi változók hogyan befolyásolták a vonulás időzítését. Az eredmények azt mutatják, hogy a faj vonulási útvonalai jelentősen megváltoztak az elmúlt évszázadban. A vizsgált időszakban a vonuló madarak a Kárpát-medence keleti részén koncentráálódtak, a Tiszántúlon csak ritkán fordultak elő. A nyugati és keleti részek, valamint a különböző évek között átlagosan kéthetes különbség volt a vonulás időzítésében. A vonulás kezdete és csúcsa hetekkel későbbre esett, mint ma. Ez a változás valószínűleg az éghajlatváltozás hatásainak köszönhető. A földrajzi tényezők nem voltak hatással a faj vonulására, míg a magasabb hőmérséklet egyértelműen korábbi vonuláskezdést eredményezett.

**Kulcsszavak:** klímaváltozás, *Grus grus*, rövidtávú vonulás

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## Introduction

The Common Crane (*Grus grus*) is a monotypic bird species. Its isolated populations in Turkey, Georgia and Armenia were previously considered a separate subspecies due to morphological differences (Meine & Archibald 1996), although its taxonomic status is still unclear. Its breeding range extends from Northern and Western Europe, through Eastern Europe, Russia, Northern Kazakhstan and Mongolia, to Lake Baikal and the Far East. The southern limit in 2023 of its breeding range within Europe is reached in Northern France, Hungary, Ukraine (Archibald *et al.* 2020). The Baltic Sea region (Sweden, Finland, the Baltic States) and Russia include the central part of its range within Europe, but Germany and Poland also have significant populations (Prange 2005, Schepers 2020).

It is mainly a nesting species of extensive and undisturbed wetlands (Haraszthy 2019). Due to habitat loss and hunting, its population declined in a large part of its European range by the 19<sup>th</sup> century, and it disappeared as a nesting species from Central Europe (Oláh & Ecsedi 2004, Schepers 2020).

In the Carpathian Basin, it was a regular but rare breeder until the mid-19<sup>th</sup> century (Schenk 1938a), when it declined and then became extinct as a breeder due to river regulation and draining of marshes (Oláh & Ecsedi 2004, Hadarics & Zalai 2008, Bende 2023). Its last nesting sites were found in the 1940s, and its eggs were found in 1952 (Béczy 1974). In the 21<sup>st</sup> century, in parallel with its expansion in Central Europe, it has become a nesting species again in Hungary (Kaufman *et al.* 2017, Végvári 2021).

Until the end of the 20<sup>th</sup> century it was migratory throughout its range, but now wintering areas are shifting further north (Fintha 1993, Végvári 2009, Ojaste *et al.* 2020). Individuals from populations nesting in Western Scandinavia and Central Europe are mostly wintering in Spain and Southern France, while those nesting in Finland, the Baltic and Western Russia migrate through the Carpathian Basin and winter in North Africa and along the Nile (Spina *et al.* 2022).

There is a long tradition of ornithological data collection for scientific purposes in the Carpathian Basin. Between 1894 and 1926, the Hungarian Ornithological Centre set up an extensive observation network covering the whole region. Its task was to record the spring return data of all bird species and send them to the Centre. The raw data were then published annually in the journal *Aquila*. Schenk (1938a, 1938b) published two short summaries of the species' migration. However, these only outlined the migration of the species. This was the first publication dealing with the migration of the species in the Carpathian Basin, no earlier description is available. The database therefore remains unprocessed in several respects. As we have seen so far, the migration of the species varies almost from decade to decade, it is important to analyse the earliest available data. This was the aim of our present work, and we sought to answer the following questions.

1. Was there a difference in the timing of the species' migration between years?
2. In which region of the Carpathian Basin did the species migrate in the greatest numbers, and were there differences in the timing of migration between regions?
3. Did the geographic location, elevation and temperature of the observation site have an effect on the timing of migration?

## Materials and Methods

The original historical data have published in the annual reports of the Hungarian Ornithological Centre (Gaal 1898, Schenk 1899, 1901, 1905, 1906, 1907, 1908, 1909, 1914, 1915, 1916, Vezényi 1902, 1903, 1905, Greschik 1910, Lambrecht 1911, 1912, 1913). The first report was based on data from 1894, while the last one was based on data from 1926 (Bozó 2017). The first three years did not provide enough data, while after 1916 the World War I resulted in the collapse of the observation network, and after 1920, the Carpathian Basin as a geographical unit was divided into several countries. The observers who survived the war sent data in the same way, but the intensity of observation never returned to what it had been before the war. For this reason we decided to process only the data from 1897 to 1916.

Various “identification guides” were prepared for observers to collect data on the more difficult to identify species. Since the Common Crane cannot be confused with any other species, and was known to everyone at the time, there is no uncertainty about the validity of the data. Each observation includes the day of the year, the altitude and coordinates (latitude, longitude) of the observation site. The number of individuals and migration direction were not reported.

We divided the Carpathian Basin into categories of different scales for data processing, so that the 1487 observation data were collected from 11 large regions, 65 smaller administrative units (counties) and 536 settlements (*Table 1, Supplemental material 1*). This

*Table 1.* Geographical distribution of the observation data between 1897 and 1916 within the Carpathian Basin. After the number of small regions, we also gave the number of smaller regions where the species was not observed during the study period

*1. táblázat* Az 1897 és 1916 közötti megfigyelési adatok Kárpát-medencén belüli földrajzi eloszlása. A nagyobb régiókon belüli kisebb régiók esetében zárójelben megadtuk azoknak a kisebb régióknak is a számát, amelyekben nem volt megfigyelése a fajnak

Large region (Recent country)	N. of data	N. of small regions	N. of settlements
Burgenland (Austria)	12	4 (5)	6
S-Transdanubia (Hungary)	9	4 (0)	8
Transylvania (Romania)	635	14 (1)	235
N-Transdanubia (Hungary)	26	6 (0)	13
N-Hungary (Hungary)	8	3 (0)	7
Upper Hungary (Slovakia)	49	6 (3)	28
Croatia	4	2 (12)	3
Transcarpathia (Ukraine)	280	7 (1)	70
Great Hungarian Plain (Hungary)	110	6 (0)	32
Partium (Romania)	272	5 (5)	90
Vojvodina (Serbia)	50	8 (3)	21
unknown	32	–	21

analysis also includes most of the parts of Croatia, as it was also part of the former Kingdom of Hungary. Looking at the data for all species between 1897 and 1916, 26% of the smaller administrative units does not include observations of Common Cranes at all. We have also included these administrative units in *Table 1*. This confirms what we have just said, that it is possible and important to examine the geographical distribution of the data.

We used the median date of the data to describe the start, peak and end of the migration.

Since the species was present in the Carpathian Basin throughout the year at that time, we did not specify a time limit for data collection, but instead used all data from 1 February to 31 May. This allowed us to show the differences between years. Some of the data from May may have overlapped with over-summering and nesting birds, but due to the negligible number of these birds, this did not significantly affect the results.

To analyse the differences in the timing of the migration between years and large regions, we used Kruskal-Wallis test. We tested whether there were any outliers in the number of observations in the regions. The result was, that Transylvania stands out because its sample size is a significant outlier (Mahallanobis distance = 2.57, UCL = 2.12,  $p < 0.05$ ). We found no further outliers after excluding Transylvania. The frequency distribution of the regional sample sizes was significantly different from an exponential distribution before excluding Transylvania and was not significantly different after excluding Transylvania. However, due to insufficient observations in some regions, the timing of migration cannot be compared across regions and years. As there were regions with few observations, we included regions with at least 20 observations (Transylvania, North Transdanubia, Upper Hungary (Slovakia), Transcarpathia, Great Hungarian Plain, Partium, Vojvodina). This threshold was arbitrary, but suitable for calculating a median migration date over the study period. However, all data have been taken into account for comparisons between years, regardless of the region it comes from.

Further, to analyse the effects of year and region on the onset of annual migration waves measured as the median date of the days with reported migrant flocks for each year and region, as the first step we fitted a linear regression on the median migration day as a function of year and region. As the following step, we aimed at investigating the effect of year on the median migration day with a control for regional differences by we fitting a Linear Mixed Model (LMM) on the median migration day as a function of year treating region as random effect term.

We used multiple regression analysis to see if there was a correlation between the geographical location of the smaller geographical units (counties) and the total number of observations over 20 years. We then analysed how different environmental factors (elevation, latitude, longitude) affected the timing of migration. We used general multiple regression analyses to do this. We also investigated the relationship between the mean temperature of the whole period between February and April as well as the mean monthly temperature data and the median date of the migration, using simple linear regression. Elevation data were available for all municipalities, latitude and longitude data were only available at the county scale, and temperature data were only available at the larger regional scale. The source of the temperature data is the annual reports of Kabos Hegyfok (Hegyfok 1903, 1905a, 1905b, 1906a, 1906b, 1907, 1908, 1909, 1910, 1911, 1913, 1914, 1915).

Data analysis was performed using PAST 3.14 (Hammer *et al.* 2001).

## Results

The median date of migration was on 25 March, based on 20 years of data. The median for the first sightings of the year was 28 February and the median for the last sightings was 26 April. The timing differed significantly between years ( $H = 130.8$ ,  $p < 0.001$ ). The earliest median date of the migration was in 1910 (20 March) and the latest was in 1907 (4 April) (Figure 1). The timing of the onset of migration also differed between larger regions ( $H = 67.04$ ,  $p < 0.001$ ). The arrival of birds was as follows: Vojvodina (15 March), Northern Transdanubia (21 March), Partium (24 March), Upper Hungary (Slovakia) and Transcarpathia (26 March), Great Hungarian Plain (27 March), Transylvania (30 March).

The linear regression fitted on the median migration day as a function of year and region showed that i) the year had a non-significant, albeit advancing trend ( $b = -0.1737$ ,  $p = 0.1351$ ) and ii) the only significant level of the region was exhibited by Vojvodina ( $b = -14.3259$ ,  $p \leq 0.0007$ ). If we removed the records from Vojvodina from the dataset, we

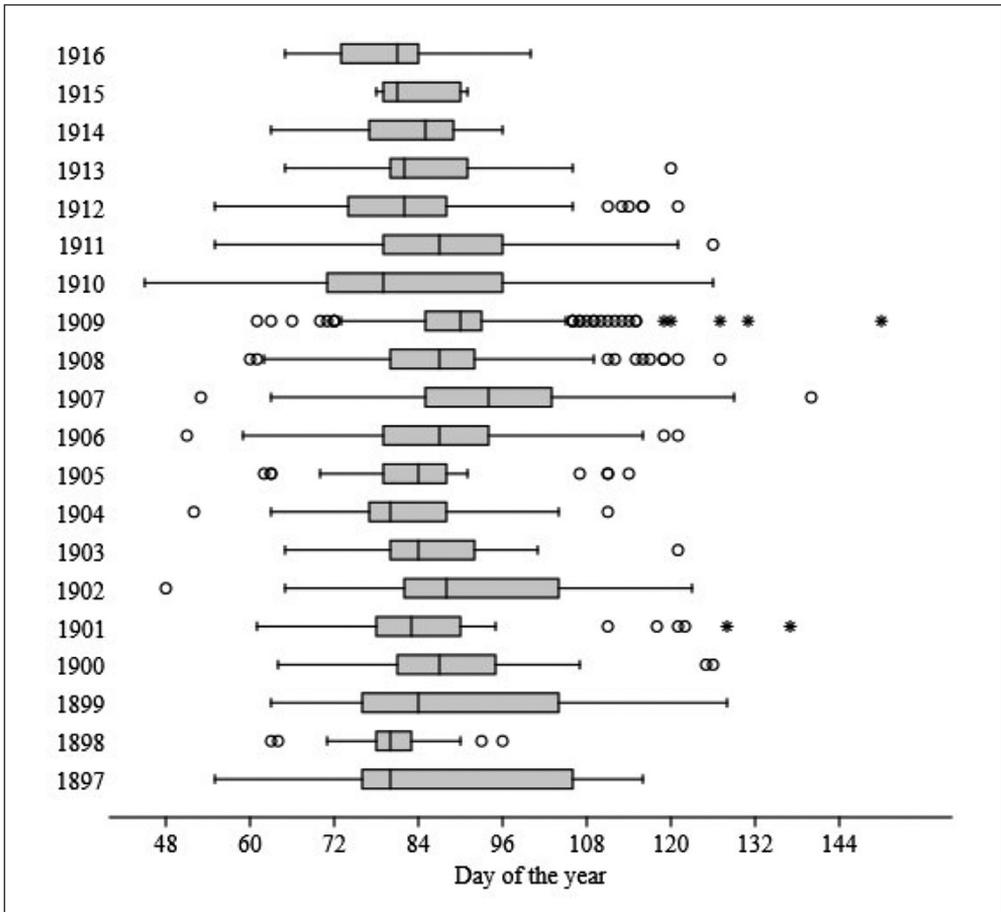


Figure 1. Annual differences in the migration timing of the Common Crane in the Carpathian Basin  
 1. ábra Évenkénti különbségek a daru Kárpát-medencei vonulásának időzítésében

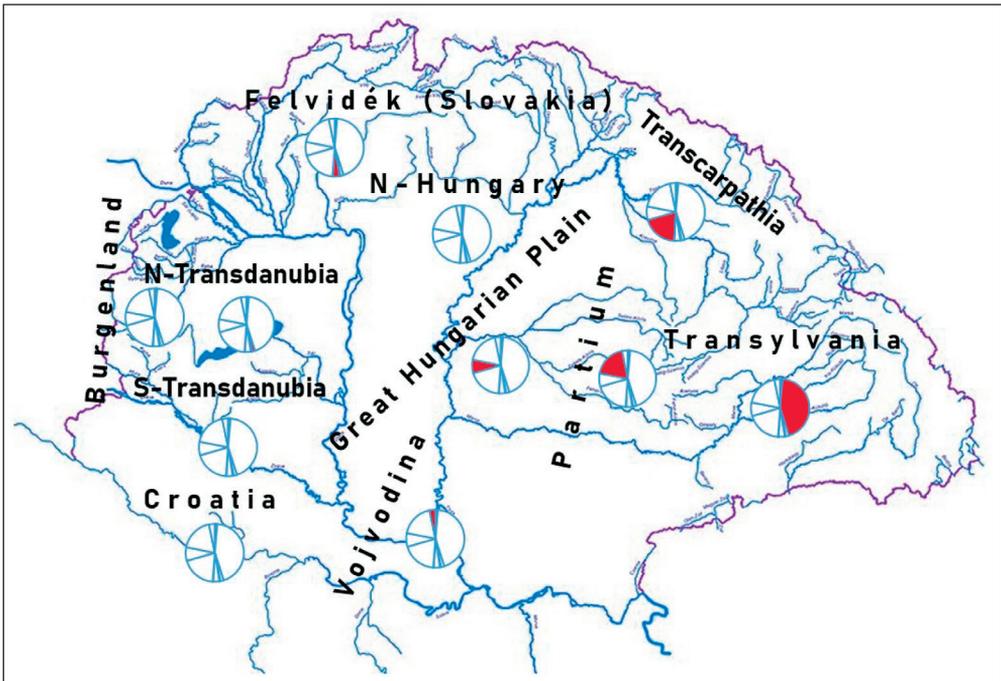
obtained qualitatively similar data: the onset of migration showed an advancing but non-significant trend with the year ( $b = -0.2537$ ,  $p = 0.1013$ ) and the median migration days did not differ among regions ( $p \geq 0.1612$ ).

The LMM fitted on the median migration day as a function of year treating region as random effect term indicated again that the onset of migration non-significantly advanced with years ( $b = -0.1796$ ,  $p = 0.219$ ) and region explained only  $v = 11.20\%$  of the total variance in the variance of the median migration days. The removal of the Vojvodina records from the dataset showed a qualitatively similar pattern: the onset of migration trended to advance with years ( $b = 0.2704$ ,  $p = 0.0731$ ).

Elevation ( $R^2 = 0.022$ ,  $t = 4.285$ ,  $p < 0.001$ ) had a significant positive relationship with day of observation (very weak correlation), while latitude ( $R^2 = 0.004$ ,  $t = 2.542$ ,  $p = 0.611$ ) and longitude ( $R^2 = 0.007$ ,  $t = 0.231$ ,  $p = 0.817$ ) had no effect on the timing of migration ( $F = 13.025$ ,  $p < 0.001$ ).

There was no significant correlation between number of observations and latitude of observation ( $R^2 = 0.0021$ ,  $t = -0.307$ ,  $p = 0.759$ ), but there was a correlation with longitude ( $R^2 = 0.247$ ,  $t = 4.505$ ,  $p < 0.001$ ). Most observations occurred in the eastern regions (*Figure 2, Supplemental material 2*).

Mean temperature between February and April showed a significant negative correlation with migration timing ( $R = -0.658$ ,  $p = 0.0016$ ), especially for March ( $R = -0.564$ ,  $p = 0.0095$ ).



*Figure 2.* Spatial distribution of the Common Crane observations by large regions. Graphs indicates the rate of the observations at the given region

2. ábra A darumegfigyelések térbeli eloszlása a Kárpát-medencében nagyobb régióként. A diagrammok a megfigyelések arányát jelzik

## Discussion

The migratory behaviour of short-distance migratory bird species is much more flexible than that of long-distance migrants (Calvert *et al.* 2012). This may be due to their ability to adapt more quickly to the effects of climate change. We now know that the timing of migration of many short-distance migratory bird species has changed over the past decades and that these changes have not stopped. In several cases, this has been supported by century-long data series (Sparks 1999, Kullberg *et al.* 2015). Such data series are exceptionally rare, but they provide a much more accurate indication of the extent of change.

The Common Crane is a common migrant throughout the Carpathian Basin (Hadarics & Zalai 2008, Végvári 2009), and is also easily recognisable by the ornithologists. Only in the last two decades, changes were detected in both abundances and routes of birds that would be unimaginable for most species. In this paper, we have analysed data dating back more than a century and the results show that there have been significant changes compared to even before the second half of the 20<sup>th</sup> century.

The earliest descriptive, non-quantified analyses in the late 1930s pointed to the fact that the migration of the species concentrated in Transylvania (Schenk 1938a, 1938b). Our analyses fully support this finding. It was possible to show that the number of sightings decreased in a west-southwest direction. Considering that there was an extensive observing network in the northern and western parts of the Carpathian Basin, this result is certainly not an artificial one. The role of the Great Hungarian Plain is less clear, as there were far fewer observers. Therefore, it is not possible to say exactly to what extent the Hortobágy, nowadays the most important stopover site in the world for the species, was used by Common Cranes. However, the peripheral area of the Great Hungarian Plain (Partium) was clearly an important migration route. By the first third of the 20<sup>th</sup> century, these areas were already the most important resting sites for the species (Béczy 1974), but it is possible that they had already played a prominent role in the migration of the species before that time. The areas north, west and south of the Tisza river are clearly outside the migratory range of the species. It was even rare between the lowlands of the Danube-Tisza rivers and was hardly observed in the Transdanubian, Croatian and Burgenland region. The role of the Transdanubian region was not prominent even in the early 2000s (Oláh & Ecsedi 2004), so it is not surprising that it was exceptionally rare there at that time. The data do not provide any insight into where the species' most important spring roosting sites were. The landscape of Central Transylvania is essentially hilly and mountainous, but some major wetland habitats were present in the area both now and then. It is also possible that, as today, they migrated through these regions more quickly and in smaller numbers than in autumn, so that they did not need longer stopover periods (Oláh & Ecsedi 2004). Landscape morphology (at least elevation) may therefore not have had a significant effect on the timing of the species' migration.

The first birds typically arrived in early March, weeks later than today. This practically coincides with the peak of the present-day migration (Végvári 2021), which in the early 20<sup>th</sup> century and even two decades ago fell at the end of March (Végvári 2009). The last birds departed at the end of April, which is similar to the present trends (Végvári 2009,

2021). In this respect, there is probably no difference because it is difficult to separate the true migrants from the over-summering and nesting individuals. The earlier onset of migration over the last century can certainly be linked to climate change. One of the direct causes is the shortening of migration distances due to increasingly northerly wintering grounds (Nowald *et al.* 2012). This is true not only for Common Cranes but also for other migratory bird species (Ambrosini *et al.* 2011). Although it was non-significant, we found an advancing trend in the onset of migration during the 20 years of the study period, which suggests that the changes of the migration timing of the species already started by that time.

In addition, decreasing rainfall and increasing temperatures may also have an impact through changes in the environmental conditions of resting sites. For this reason, for example, one of the most important stopover sites in Spain had an earlier peak in spring migration of 0.37 days per year between 1973 and 2018 (Orellana Macías *et al.* 2020).

We found a two-week long difference in the timing of the migration between the western and eastern parts of the Carpathian Basin. As the distance between the southwestern and northeastern tips of the Carpathian Basin is about 700 km ([www.luftlinie.org](http://www.luftlinie.org)), this means that birds may have travelled an average of about 50 km per day during their migration. A similar pattern and difference is observed for the Eurasian Woodcock (*Scolopax rusticola*), which also has wintering grounds in South-Southwest Europe (Farágó 2009, Bende *et al.* 2023).

There was also a difference of about two weeks in the timing of the migration in different years. Since the air temperature in a given year significantly affected the timing of the migration, it is likely that the difference was caused by weather extremes. They migrated through the Carpathian Basin earlier during mild winters and later during cold winters. Spring migration is in general fast and is determined by not only the air temperature, but also by many weather conditions, such as wind speed and direction, precipitation and cloud cover (Swanberg 1987, Alonso *et al.* 1990a, 1990b, Palm *et al.* 2009). However, these data are not available for the study period, so their impact on migration could not be tested.

The number of migrating birds has also changed significantly over the past decades. While in the early 1980s, the maximum number in autumn in the Hortobágy was less than 10,000 individuals, in the 2010s it reached 160,000 (Végyvári 2017) and 195,000 in the autumn of 2023 (Tokody 2024). Unfortunately, in the present study, due to lack of data, it was not possible to compare the historical and recent numbers of Common Cranes.

Overall, the timing of the species' migration is very different from what we see today. The main migration route is hundreds of kilometres further west than in the past and migration route shifts are still occurring in recent time. Different geographical factors have not affected the migration of the species, and this is probably still the case nowadays. In contrast, weather has had a significant effect on the timing of migration, which is typically the case for short-distance migratory species. As the migration of this species changes rapidly, it is important to monitor it, as changes in migration routes and wintering grounds may subsequently affect the population of the species.

Supplemental material 1. Annual number of observations by larger regions  
 1. függelék A megfigyelések száma nagyobb régióknként

Year	Burgenland	S-Transdanubia	Transylvania	N-Transdanubia	N-Hungary	Upper Hungary (Slovakia)	Croatia	Transcarpathia	Great Hungarian Plain	Partium	Vojvodina
1897	0	0	8	0	0	1	0	5	0	5	0
1898	2	1	8	1	1	5	0	10	4	6	2
1899	0	0	6	3	0	3	0	9	1	6	1
1900	1	1	9	2	0	2	0	8	3	9	1
1901	0	0	13	1	1	2	0	9	1	10	3
1902	0	0	12	1	0	2	0	10	2	3	1
1903	0	0	18	1	0	0	1	8	1	3	1
1904	0	0	11	1	0	1	2	9	1	3	1
1905	2	0	21	1	0	1	0	6	3	8	1
1906	1	2	60	3	1	3	0	22	6	26	1
1907	3	2	85	2	2	7	0	31	17	37	4
1908	1	1	73	3	2	4	0	39	12	38	5
1909	2	2	87	3	0	8	0	36	16	30	8
1910	0	0	63	2	1	4	1	26	14	24	6
1911	0	0	60	1	0	3	0	20	6	24	7
1912	0	0	62	1	0	3	0	18	7	24	4
1913	0	0	25	0	0	0	0	6	5	5	0
1914	0	0	8	0	0	0	0	6	7	4	1
1915	0	0	3	0	0	0	0	1	1	3	0
1916	0	0	3	0	0	0	0	1	3	4	0

*Supplemental material 2.* Number of observation data by smaller administrative units (counties)  
 2. függelék A kisebb közigazgatási egységenkénti megfigyelések száma

County	Large region	Number of data
Kovászna	Transylvania	181
Ungvár	Transcarpathia	159
Brassó	Transylvania	109
Arad	Partium	89
Szeben	Transylvania	82
Bihar	Partium	75
Temes	Partium	73
Máramaros	Transylvania	56
Hargita	Transylvania	51
Huszt	Transcarpathia	42
Técső	Transcarpathia	36
Beszterce-Naszód	Transylvania	35
Szabolcs-Szatmár-Bereg	Great Hungarian Plain	35
Hajdú-Bihar	Great Hungarian Plain	28
Beregszász	Transcarpathia	26
Maros	Transylvania	26
Hunyad	Transylvania	24
Kassa	Upper Hungary (Slovakia)	22
Dél-Bánság	Vojvodina	21
Fehér	Transylvania	21
Kolozs	Transylvania	19
Krassó-Szörény	Partium	18
Szatmár	Partium	17
Békés	Great Hungarian Plain	16
Bács-Kiskun	Great Hungarian Plain	15
Csongrád-Csanád	Great Hungarian Plain	15
Komárom-Esztergom	N-Transdanubia	12
Szilágy	Transylvania	12
Mehedinti	Transylvania	10
Rahó	Transcarpathia	9
Bákó	Transylvania	8
Eperjes	Upper Hungary (Slovakia)	7
Nyugat-Bácska	Vojvodina	7
Besztercebánya	Upper Hungary (Slovakia)	6
nagymarton	Burgenland	6

County	Large region	Number of data
Pest	N-Transdanubia	5
Somogy	S-Transdanubia	5
Szerémség	Vojvodina	5
Torontál	Vojvodina	5
Vas	S-Transdanubia	5
Zsolna	Upper Hungary (Slovakia)	5
Borsod-Abaúj-Zemplén	N-Hungary	4
Munkács	Transcarpathia	4
Ökörmező	Transcarpathia	4
Belgrád	Vojvodina	3
Dél-Bácska	Vojvodina	3
Eszék-Baranya	Croatia	3
Felsőőr	Burgenland	3
Nagyszombat	Upper Hungary (Slovakia)	3
Baranya	S-Transdanubia	2
Győr-Moson-Sopron	N-Transdanubia	2
Heves	N-Hungary	2
Kismarton	Burgenland	2
Közép-Bánság	Vojvodina	2
Nógrád	N-Hungary	2
Észak-Bánság	Vojvodina	1
Fejér	N-Transdanubia	1
Jász-Nagykun-Szolnok	Great Hungarian Plain	1
Pozsony	Upper Hungary (Slovakia)	1
Suceava	Transylvania	1
Sziszek-Monoszló	Croatia	1
Szlovénia	Burgenland	1
Tolna	S-Transdanubia	1
Veszprém	N-Transdanubia	1
Zala	S-Transdanubia	1

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