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RESEARCH ARTICLE

Spatial Analysis of Honey Yield by Province Based on Registered Honey Production Data: Exploring Spatial Patterns

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ABSTRACT

Throughout history, bees and their products have gained ever-increasing importance. Honey, valued for its diverse uses, has driven the emergence of new industries and products, fueled by the growing demand for beekeeping as a sustainable source of income. Providing spatial information is very important to ensure the sustainability of products. Therefore, this study aimed to reveal the spatial distribution of honey yield outputs in Türkiye using exploratory spatial data analyses. Honey yield outputs in four time periods (2005–2010; 2011–2016; 2017–2022; 2005–2022) were tested by autocorrelation analysis, and Moran's I scatter plot was produced for each period. Standard Z statistics were found to be 4.1064, 3.1910, 2.1980 and 3.4427, respectively ($p<0.05$). Results showed that, it was observed that there are spatial associations and different spatial clusters in honey yield at the provincial level in Türkiye. It has been shown that honey yield in Türkiye tends to be partially clustered and production outputs tend to decrease in the east. This analysis implies several consequences for the sustainability of bee-based food production, including the potential for spillover effects from hot spot regions and the need to prioritize resource allocation towards these areas.

Key Words: Beekeeping, Honey, Spatial Autocorrelation, Spatial Pattern, Türkiye

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Kayıtlı Bal Üretim Verilerine Dayalı İl Bazında Bal Veriminin Mekânsal Analizi: Mekânsal Kalıpların Keşfedilmesi

ÖZ

Tarih boyunca arılar ve ürünleri giderek artan bir önem kazanmıştır. Çeşitli kullanım alanları nedeniyle değer verilen bal, sürdürülebilir bir gelir kaynağı olarak arıcılığa yönelik artan taleple desteklenen yeni endüstrilerin ve ürünlerin ortaya çıkmasına neden olmuştur. Ürünlerin sürdürülebilirliğini sağlamak için mekânsal bilgi sağlamak çok önemlidir. Bu nedenle, bu çalışma açıklayıcı mekânsal veri analizleri kullanarak Türkiye'deki bal verimi çıktılarının mekânsal dağılımını ortaya koymayı amaçlamıştır. Dört zaman periyodundaki (2005–2010; 2011–2017; 2017–2022; 2005–2022) bal verimi çıktıları otokorelasyon analizi ile test edilmiş ve her periyot için Moran'ın I saçılım grafiği üretilmiştir. Standart Z istatistikleri sırasıyla 4,1064, 3,1910, 2,1980 ve 3,4427 olarak belirlenmiştir ($p<0.05$). Sonuçlar, Türkiye'de il düzeyinde bal veriminde mekânsal birliktelikler ve farklı mekânsal kümelenmeler olduğunu göstermiştir. Türkiye'de bal veriminin kısmen kümelenme eğiliminde olduğu ve doğuda üretim çıktılarının azalma eğiliminde olduğu gösterilmiştir. Bu analiz, arı bazlı gıda üretiminin sürdürülebilirliği açısından, sıcak nokta bölgelerinden yayılma etkileri potansiyeli ve kaynak tahsisinin bu alanlara önceliklendirilmesi ihtiyacı dahil olmak üzere çeşitli sonuçlara işaret etmektedir.

Anahtar Kelimeler: Arıcılık, Bal, Mekânsal Otokorelasyon, Mekânsal Desen, Türkiye

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INTRODUCTION

The beekeeping industry in Türkiye plays a significant role in the country's economy, with exports representing a significant proportion of its overall value. The notable increase in beekeeping activities observed in recent years is indicative of this trend (Çevrimli and Sakarya 2018; Polat et al. 2023). The main product of beekeeping activities is honey. Honey has rich nutritional value and is a product that can be used in alternative medicine, cosmetics, and many other areas (Haydak 1970; Denisow and Denisow-Pietrzyk 2016). Bees are mysterious creatures that can offer us different products and services at every stage of life (Wratten et al. 2012; Sonmez Oskay et al. 2023). Beekeeping activities contribute to regional development in the economy across numerous developing nations through the production of items including honey, beeswax, royal jelly, pollen and bee venom which are crucial for agricultural pollination and human health (Lee et al. 2008; Wright et al. 2018; Sarı et al. 2020). There are many unexplored benefits offered by beekeeping, including therapeutic, apitherapy, tourism, gastronomy and support for ecological health (Şahingöz and İnci 2018; Bozkurt 2019; Onbaşlı et al. 2019; Akpınar and Bozkurt 2021; Tabatabei and Nisbet 2021). It has been reported in many studies that honey and its products reduce the inflammatory response of the COVID-19 epidemic, which has caused the deaths of many people recently, and have promising effects against the epidemic (Al Naggar et al. 2020; Berretta et al. 2020; Lima et al. 2020; Yang et al. 2020; Al Naggar et al. 2021). It has also been reported that the use of honey products in nutritional habits increased during the COVID-19 pandemic period (Doğan et al. 2021).

A large portion of indirect financial gain is generated by agriculture-related activities as honey bees are the primary pollinator for 33% of species of crops (Maris et al. 2008; Oldroyd and Nanork 2009). Türkiye has a lot of opportunities for beekeeping because of its diverse flora, favorable habitat conditions, and presence of colonies (Köseman et al. 2016). However, the Turkish beekeeping sector has not been able to benefit sufficiently from the abundant resources available. To ensure effective and long-lasting efficiency, oversight and analysis of beekeeping practices have become more crucial (Sarı et al. 2020).

There are many studies on the beekeeping industry in the literature. Sarı (2023) predicted future land use to determine the potential impacts of land use changes on beekeeping and to identify circumstances that the beekeeping industry may face in the future. Examining the effects of land structure on beekeeping is important. In another study, Sarı et al. (2020) created a conceptual model for beekeeping suitability assessment that not only improves beekeeping in Konya province but also can be applied to any region of the world. Beekeeping activities have been a subject researched at different times in different regions. Kumova and Korkmaz (2000) evaluated the place and importance of the Çukurova Region in Türkiye's Beekeeping. Similarly, another study Teoman and Yeni (2021) evaluated the formation of a cluster in Türkiye's Black Sea Region to develop a more effective market framework for the honey and beekeeping products sector. Beekeeping, which is always one of the most important agricultural activities that should be emphasized, has been the subject of various studies. Koday and Karadağ (2020) researched the regional distribution of beekeeping activities and honey production in Türkiye. One of the key parameters in beekeeping is the business aspect. Businesses play an integral role in the supply, diversity and efficiency of products. Kaya and Gürcan (2021) employed data envelopment analysis to investigate the activities of beekeeping enterprises from both technical and economic perspectives. One of the most significant issues in beekeeping is migratory beekeeping, as businesses engaged in this practice account for the majority of honey production in Türkiye. Akpınar and Bozkurt (2022) evaluated the current situation and problems of the beekeeping sector of immigrant beekeepers in Afyonkarahisar.

The selection of a particular analytical method needs to be determined by an evaluation of the data's features and previous information on the observations, as is the case with any analysis that uses statistics. Among these, Exploratory Spatial Data Analysis (ESDA), which is based on Geographic Information Systems (GIS) methods, is frequently used as a foundation for spatial analysis and has been described to be a successful way to quantify both global and local spatial autocorrelation (Anselin 1996; Anselin 2003). To better organize the beekeeping industry in the nation, promote the growth of the local agricultural economy, and provide superior amenities and services to meet nutritional requirements, agricultural policymakers and associated governments can benefit from analyzing the spatial patterns of beekeeping products. Making adequate spatial pattern management is crucial from the perspective of the local manager to identify the best places for the beekeeping sector. This study was conducted with the help of the ESDA method, to examine whether there is a spatial autocorrelation and to examine the spatial patterns of honey production by using the registered production amount and number of hives in 81 provinces.

MATERIAL and METHOD

Study Area

The data on outputs of honey at the province level in 2005-2022 were obtained from the Turkish Statistical Institute (TurkStat). Turkish provinces are smaller administrative and geographical units than regions. Geographically, Türkiye is separated into seven regions: Mediterranean, Eastern Anatolia, Aegean, Central Anatolia, Southeastern Anatolia, Black Sea and Marmara (Figure 1). This study focuses on Türkiye, with 81 provinces as sample analysis units.

Figure 1: Geographical Regions of Türkiye

Statistical Analysis

Honey production (tons) and hive data recorded in the database of the Turkish Statistical Institute were created in Excel format by province and honey yield was calculated by dividing the total amount of honey by the number of hives on a provincial basis. The Levene's test for homogeneity of variances and the Shapiro-Wilk test for normality were used as parametric test assumptions to analyze the data before statistical analysis. Each region's descriptive statistics were computed and displayed as "Mean ± SEM, Median, Minimum, Maximum." Kruskal-Wallis H Test was employed to evaluate whether there was a regional difference between the total honey yields between 2005 and 2022. Dunn-Bonferroni Test was used for post-hoc analysis. The statistical analysis was performed using SPSS 23.0 (IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp).

Spatial Statistical Analysis

The entire study period was split into three subperiods, 2005–2010, 2011–2016, and 2017–2022, and analyzed spatially. This study focused on the spatial clustering and spatial pattern of honey yield. Firstly, the distribution of calculated honey yield by provinces was mapped. In this study, the exploratory spatial data analysis (ESDA) is used to identify the presence of spatial dependency and heterogeneity in honey yield among provinces in Türkiye. ESDA is a set of methods for describing and visualizing spatial patterns of distribution, detecting clustering and outliers, revealing patterns of spatial relationships, and suggesting spatial structures (Anselin 1999).

Spatial Autocorrelation Analysis

Spatial autocorrelation measures are divided into two categories as global scales and local scales based on the scope or scale of the analysis. The Moran's I statistic, a well-established measure for investigating spatial autocorrelation and detecting global spatial clustering, was employed (Moran 1948; Moran 1950).

LISA Analysis

In this study, to evaluate local spatial relationships, identify local spatial autocorrelation, and assess the importance of hot spots and cold spots, the Local Indicator of Spatial Association (LISA) is used (Anselin 1996; Yang and Wong 2013; Bayir 2023).

To construct certain shape files (shp) using QGIS 3.18.3 software, we first integrated the data of the outputs of honey yield for each province into a vector map of Türkiye with administrative boundaries at the provincial level. GeoDa software is then used to perform ESDA analysis in the current analysis based

on certain shape files. Using a Monte Carlo permutation method, significance is tested (Anselin 2003). The LISA significance maps are then produced, containing data on the importance of the local spatial patterns. (1) High-High shows provinces with high honey yield are adjacent to provinces with high yield (positive spatial autocorrelation, is indicated in red); (2) Low-Low shows provinces with low yield that are adjacent to provinces with low yield (positive spatial autocorrelation, is indicated in dark blue); (3) Low-High shows provinces with low yield that are adjacent to provinces with high yield (negative spatial autocorrelation, is indicated in green); (4) High-Low indicates provinces with high yield that are adjacent to provinces with low yield (negative spatial autocorrelation, is indicated in yellow) and (5) "not significant" indicates provinces with no spatial autocorrelation.

RESULTS

Statistical analyzes were made according to registered TurkStat data. However, it should not be forgotten that most of the honey production in Türkiye is carried out by businesses engaged in migratory beekeeping. Honey yields were determined by proportioning the honey production amounts (kg) of each province to the number of colonies. Descriptive statistics of honey yields calculated for 18 years by region are given (Table 1). According to these results, a statistical difference was determined between regions in honey yield values ($p<0.01$). A comparative analysis of the 18-year honey yield of each province in the regions revealed that the Marmara Region yields the greatest quantity of honey, while the Southeastern Anatolia Region yields the least.

Table 1. Distribution of honey yield data reported between 2005–2022 by regions in Türkiye

Region	Number of provinces	n	Mean±SEM	Median (Min-Max)	P
Aegean	8	144	13.50 ± 0.32^{ad}	13.97 (4.02–23.57)	p< 0.01
Black Sea	18	324	11.94 ± 0.30^{b}	11.16 (2.97–31.34)	
Central Anatolia	13	234	11.76 ± 0.27^{ab}	11.63 (3.02–21.34)	
Eastern Anatolia	14	252	13.02 ± 0.32^{a}	12.68 (2.36–26.27)	
Marmara	11	198	13.57 ± 0.37^{ad}	12.94 (6.73–65.41)	
Mediterranean	8	144	13.31 ± 0.36^{a}	12.37 (5.87–25.60)	
Southeastern Anatolia	9	162	9.96 ± 0.42^{c}	8.70 (1.63–31.63)	

(^{a,b,c} letter values within a column with different superscripts differ significantly at $p< 0.01$. SEM: Standart Error of Mean, n: 18 x number of provinces in each region)

The study period was divided into three subperiods: (a) 2005–2010; (b) 2011–2016; and (c) 2017–2022. Each subperiod was then analysed in terms of its spatial distribution. In addition, the entire period from 2005 to 2022 was also analysed spatially. These areas were shaded with different colors according to the ratio of the total honey production of each province to the number of hives. Honey yield was evaluated according to five levels (Figure 2-A, B, C, D).

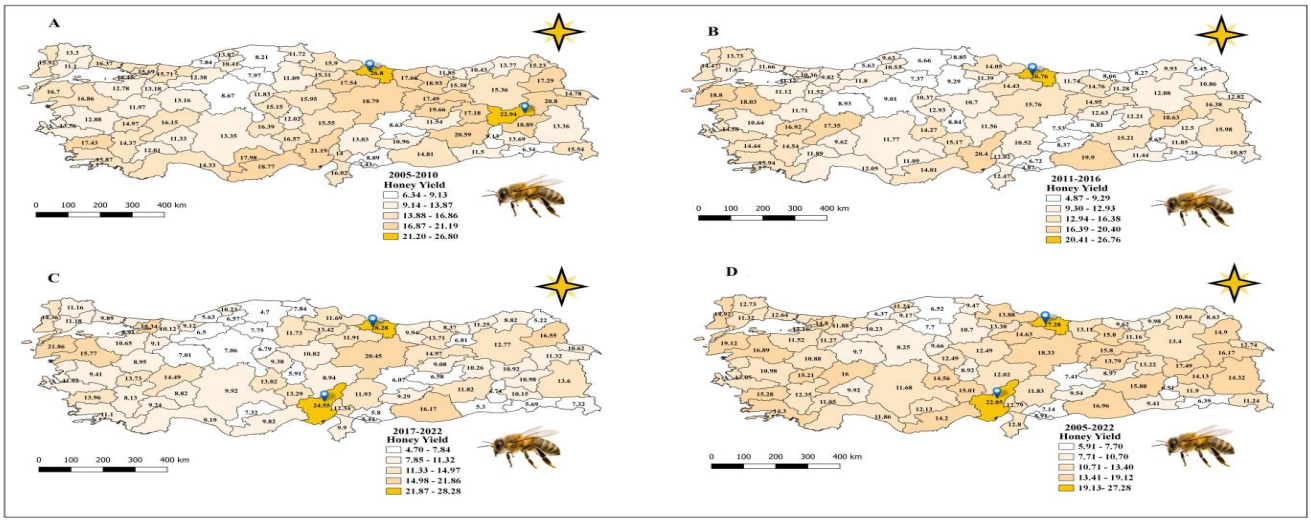

Figure 2: Distribution of honey yield in Türkiye for 2005-2010, 2011-2016, 2017-2022, and 2005-2022 (at province level, A, B, C, D)

When all periods were evaluated, the province with the highest productivity was Ordu, located in the Black Sea Region. Following Ordu, Muş province in Eastern Anatolia between 2005-2010 and Adana province in the Mediterranean Region between 2017-2022 were the provinces with the highest productivity. It was determined that the yield was higher in Eastern Anatolia in the first period and the yield decreased over time. Especially in the Black Sea, Central Anatolia and the Southeastern, some provinces with very low honey yield were observed (white color) (Figure 2-A, B, C, D).

Spatial Autocorrelation of Honey Yield

Moran's I measurements were made for the relevant periods to assess the association between the value of honey yield in each province and the value of honey yield in provinces adjacent and the Moran's I scatter plot of each period was produced (Figure 3-A, B, C, D). Moran's I values were all greater than 0, showing that honey yield had a positive spatial association and that exhibited spatial clustering. However, there was not a very high positive spatial autocorrelation (Table 2).

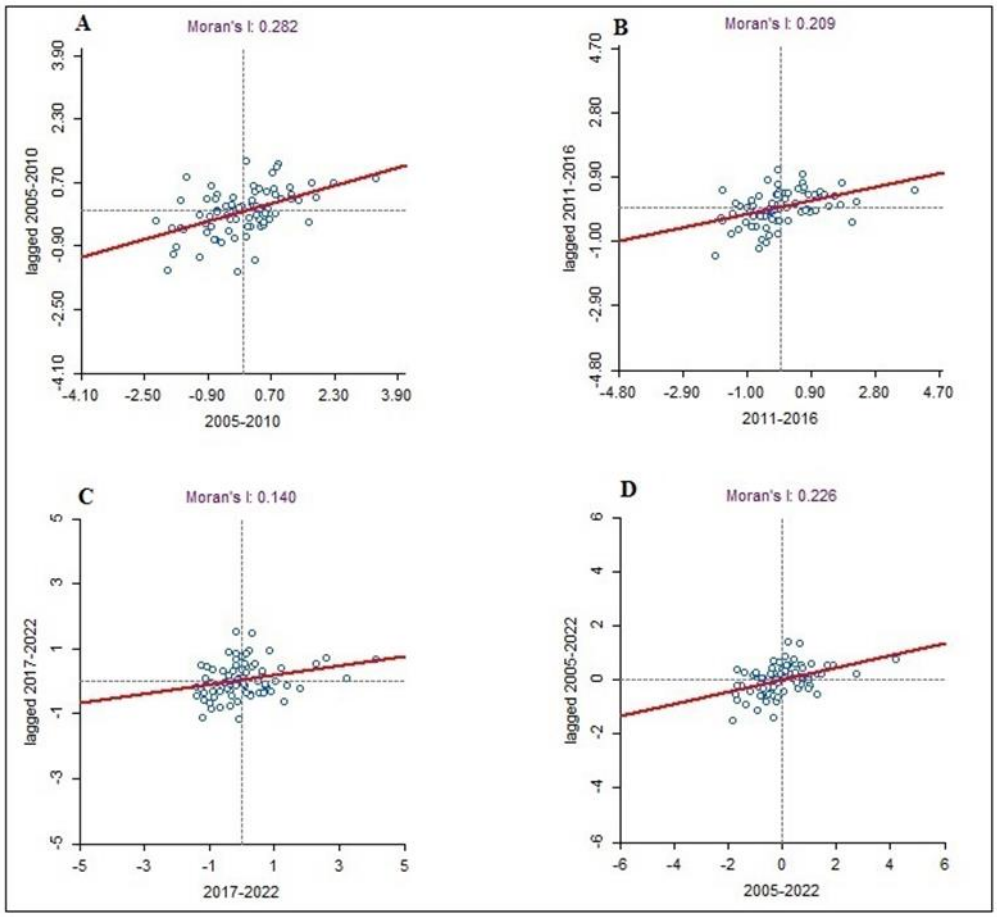

Figure 3: Moran's *I* scatter plot of the value of honey yield

Table 2. Spatial autocorrelation of different period considered for hotspot analysis of the honey yield using Moran's I statistics

Period	Moran's I	Z-score	*P*	Pattern
2005-2010	0.282	4.1064	0.002	clustered
2011-2016	0.209	3.1910	0.003	clustered
2017-2022	0.140	2.1980	0.021	clustered
2005-2022	0.226	3.4427	0.002	clustered

For 2005-2010, 2011-2016, 2017-2022 and 2005-2022, only 18.52%, 9.88%, 8.64% and 11.11% respectively, and a positive spatial association (containing categories High-High and Low-Low) was described significant provinces (95% confidence interval). For 2005-2010, 2011-2016, 2017-2022 and 2005-2022, only 28.40%, 18.52%, 19.75% and 22.22% respectively, and a positive spatial association (containing categories High-High and Low-Low) was described significant provinces (90% confidence interval) (Table 3).

Table 3. Number of cities in various LISA clusters

Sig. filter	2005-2010			2011-2016			2017-2022			2005-2022		
	HH	LL	Total %	HH	LL	Total %	HH	LL	Total %	HH	LL	Total %
5%	8	7	18.52	2	6	9.88	3	4	8.64	4	5	11.11
10%	10	13	28.4	5	10	18.52	7	9	19.75	7	11	22.22

HH: High-High cluster, LL: Low-Low cluster.

The maps showed that the production of honey clearly exhibits local clustering tendencies. Compared to local spatial outliers (High-Low or Low-High), there was more local clusters (High-High or Low-Low). When the honey yield was evaluated between 2005-2010, it was seen that there was two important local spatial clusters (eight High-High clusters). These High-High clusters were Ordu and Giresun in the Eastern Black Sea region, Tokat in the Middle Black Sea Region and Erzurum, Ağrı, Muş, Bingöl and Iğdır provinces in the Eastern Anatolia region. There were also significant local spatial outliers (one Low-High and one High-Low). When honey yield between 2011 and 2016 was evaluated, it was seen that there was important local spatial clusters (six Low-Low clusters). But, when evaluated between 2017-2022, it was seen that local spatial clustering has decreased. When the entire time period was evaluated, it was seen that there was High-High clusters in the provinces of Ordu, Samsun, Giresun and Tokat (Figure 4-A, B, C, D).

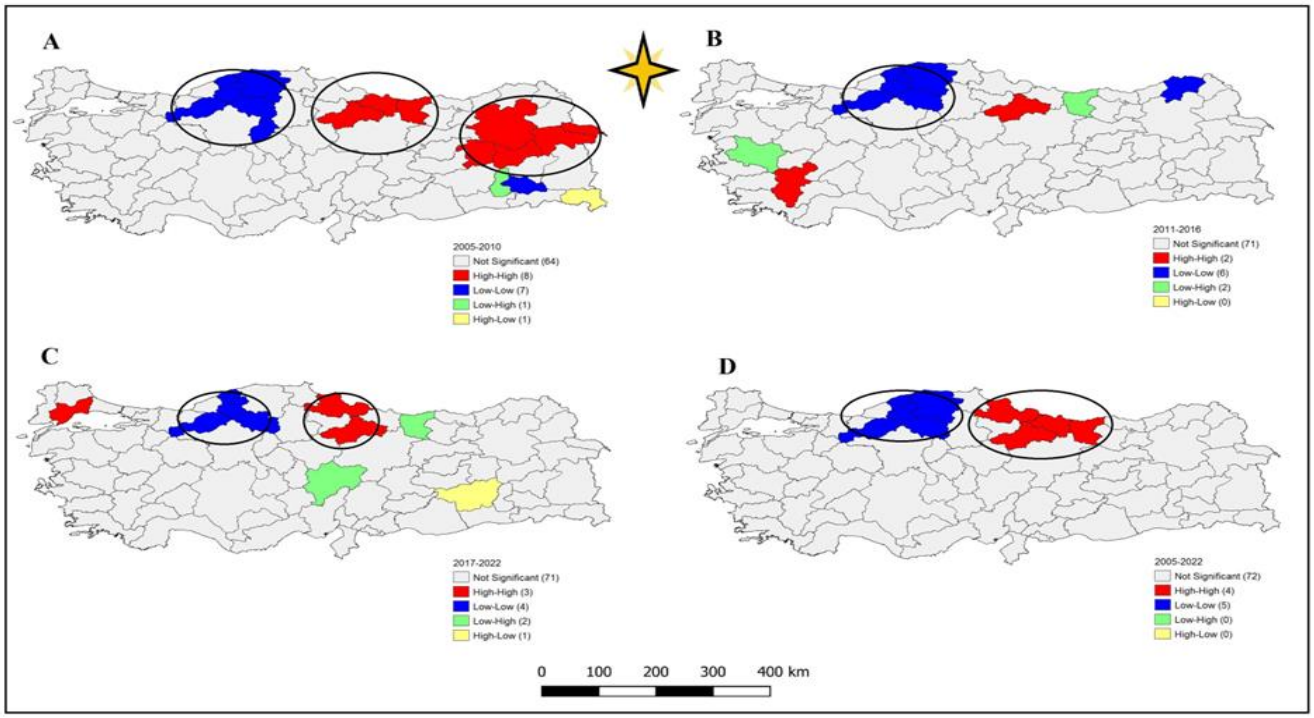

Figure 4: Spatial clustering and outliers of honey yield using LISA clustering for 2005-2010, 2011-2016, 2017-2022, and 2005-2022 (95% confidence interval, p-value=0.05, A, B, C, D).

When analyses were performed at a 90% confidence interval, clusters could be detected in different regions. For example, between 2017 and 2022, High-High clusters were identified in Edirne, Tekirdağ and Çanakkale provinces. According to, in the analyses made with both confidence intervals, it was determined that there were clusters in Eastern Anatolia at first and were not seen over time. Clusters were seen in Ordu province and its surroundings, which have the highest productivity, in every period. Results showed that different clusters can be detected by changing the parameters produced (Figure 5-A, B, C, D).

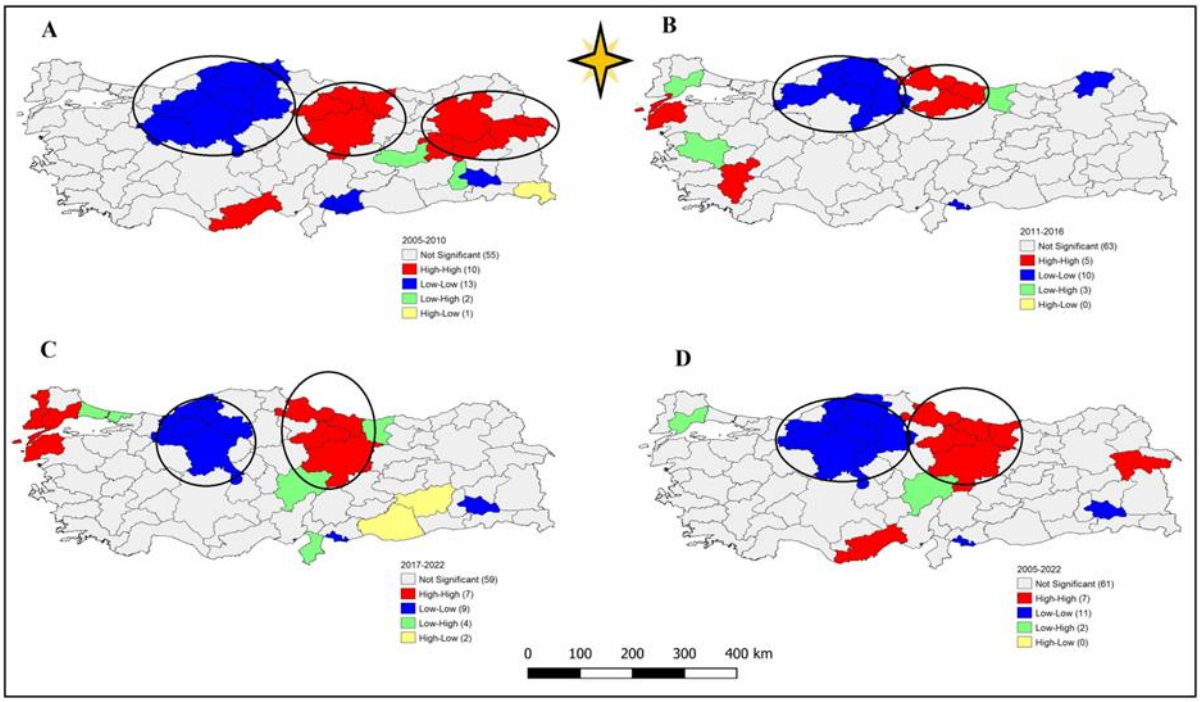

Figure 5: Spatial clustering and outliers of honey yield using LISA clustering for 2005-2010, 2011-2016, 2017-2022, and 2005-2022 (90% confidence interval, p-value=0.10, A, B, C, D)

DISCUSSION

Beekeeping is generally an animal husbandry activity carried out to produce honey. In addition, beekeeping activities are the branch of production most compatible with the economic and ecological cultivation model for every society. In the present study, the spatial distribution characteristics of honey yield were defined by using exploratory spatial analysis methodologies. As far as we know, the data regarding the calculated honey yield has not been examined so far with exploratory spatial analysis methods by creating a database based on GIS.

In this study, Marmara (13.57), Aegean (13.50) and Mediterranean (13.31) regions were the three regions with the highest productivity according to recorded data. Before the forest fires on the Aegean and Mediterranean coasts in 2021, the Eastern Black Sea Region (22.5%), the Mediterranean Region (19.2%) and the Aegean Region (13.4%) were the top three regions of Türkiye in honey production in 2020 (Burucu 2021). The necessity of migratory beekeeping for high production and profitability has been emphasized (Kekeçoğlu et al. 2014). It has been reported that the Aegean Region has an important place in honey production and the rate of migratory beekeeping enterprises is 82% (Özbilgin et al. 1999; Korkmaz et al. 2018). In Türkiye, beekeeping businesses that engage in migratory or permanent beekeeping activities differ from one another (Akpınar and Bozkurt 2022). In contrast to their stationary counterparts, migratory beekeepers use honey bee colonies with better hive capacities and superiority (Özbilgin et al. 1999, Cengiz and Dülger 2018; Akpınar and Bozkurt 2022). By moving hives along a prearranged path and timing it to correspond with the honey plant's blossoming times, migratory beekeepers can prolong the honey season (Korkmaz et al. 2018).

When provinces with similar honey yields tend to be next to one another, there is positive spatial autocorrelation; nevertheless, when provinces with high and low honey yields are next to one another, there is negative spatial autocorrelation. In this study, Moran I statistics for all periods examined showed that there was a spatial relationship, although it was not a very strong spatial relationship. In this context, ensuring interaction between provinces is of great importance in terms of increasing honey yield. According to local Moran I statistics and honey yield results calculated by taking into account registered data, it can be said that registered beekeepers in Ordu province make significant contributions to honey production. For this purpose, everyone should fulfill their duties in the most effective way in order to maintain the extremely strong beekeeping potential in Ordu province (Sıralı 2016). There is an issue that should not be ignored here. Mobile beekeeping, which we call migratory beekeeping, is practiced in many parts of our country and makes up a considerable portion of Türkiye's overall honey production (Akpınar and Bozkurt 2021). As a matter of fact, the majority of beekeepers in Ordu province take their bees to flower fields in Eastern provinces in the summer. For this reason, the total honey production and yield of this province are high due to high honey production per hive (Koday and Karadağ 2020). If the cooperation of beekeepers in this region

can be well ensured, significant increases in honey production can be achieved by increasing production not only in Ordu province but also in neighboring provinces. Because when provinces with similar honey yield tend to be side by side, High-High clusters occur.

High-High clusters were detected in Edirne, Tekirdağ, located in the Thrace region, and Çanakkale, which is adjacent to these provinces. Although colony productivity, colony strength and diligence are important factors in achieving high efficiency in beekeeping, the variety and abundance of nectar and pollen sources are also important (Sıralı 2002). In beekeeping, beehives are placed in agricultural areas to provide as many pollen and nectar sources as possible to the bees and to ensure the pollination of cultivated plants (Bozkurt 2019; Decourtye et al. 2019). Thus, identifying appropriate production areas and their capabilities will guarantee optimal utilization of plant resources and will have a direct impact on output and efficiency (Doğaroğlu and Genç 1994). Cultural plants important for beekeeping are grown in the Thrace Region. This makes the existing climatic and floral conditions conducive to beekeeping, and the northern parts of the region are considered some of the best places for the production of the highest quality honey in our country (Sıralı 1993; Sıralı 2002).

In recent years, honey and other hive products, long valued for their properties and high demand, have experienced a surging popularity both domestically and internationally in Türkiye. This rise, coupled with the growing recognition of beekeeping as a viable source of alternative income and the increasing importance of bees and their by-products, is fueling the development of new beekeeping-related goods and businesses (Ceyhan et al. 2017; Topal et al. 2021). To continue expanding the beekeeping sector in ways that benefit people, communities, and the environment, we must promote sustainable growth. Otherwise, poorly thought-out plans could be developed that would lead to incorrect procedures, such as introducing honeybees to regions where they are not suitable since increasing in one area can upset delicately balanced ecosystems (Sarı et al. 2020). Based on this idea, cooperation can be established with beekeepers in Ordu province, which has the highest production and High-High clustering, in order to follow sustainable honey supply chains for products in Türkiye. The rate of migratory beekeeping is high in Ordu province and the effect of migratory beekeeping on production is very important. According to the clustering results obtained, there was a High-High clustering in Erzurum, Ağrı, Muş, Bingöl and Iğdır provinces between 2005 and 2010, but no clustering could be determined in the following years. In fact, High-High clusters can be created again by providing more incentives in these provinces in the region, which has a significant potential. Because, the majority of beekeepers in Ordu province take their bees to flower fields in Erzurum, Kars, Ardahan, Ağrı, Iğdır, Muş and Bingöl provinces during the summer (Koday and Karadağ 2020). Thus, the use of outlets from these hotspots will inevitably contribute to the advancement of the immediate environment. Additionally, areas will be provided to raise honey bees suitable for the region.

Our research supports to some extent previous studies showing regional differences in the beekeeping industry. In addition to the fact that previous studies were generally limited in terms of the area examined, a spatial examination of honey yield was not carried out (Sarı et al. 2020; Teoman and Yeni 2021; Aşkan 2023; Polat et al. 2023; Sarı 2023). However, unlike previous studies, we detected clusters (High-High and Low-Low); For example, we observed that the clustering in the distribution of honey yield was more intense in Eastern Anatolia in the first period, but gradually decreased. We also observed clusters in Western Marmara. The findings clearly show the benefit of using honey yield output as a statistical indicator to identify hotspots at the province level. We also discovered that there are various spatial clustering structures (High-High and Low-Low) and clusters associated with honey yield. Therefore, these cluster maps from our study have significant consequences for future work mapping the supply and demand for honeybee byproducts, as well as for planning how to connect these hotspot provinces to their neighboring provinces through roadways and regional collaborations. Thus, more hotspot locations that are larger can be built to increase honey production and decrease uneven yield within regions. In addition, aggregating activities related to beekeeping (historical beekeeping activities, bee products, beehive air, bee museums, apitherapy, production activities) to a larger region can attract beekeepers and people who tend to earn money and increase the beekeeping industry and country income (Vilas-Boas 2018; Adanacıoğlu et al. 2019; Semkiw and Skubida 2021).

The distribution of bee populations can alter depending on both environmental factors like vegetation, temperature, altitude, and water supply as well as human factors like population density and product demand (Sarı et al. 2020; Sarı 2023). In our study, High-High clusters were observed in eastern Türkiye between 2005 and 2010, but the density decreased afterward. Consistent with the findings of our study, Koç et al. (2010) stated in their study that in their long-term trend analysis in the Eastern Anatolia region will be no improvement in honey and beeswax production in the long term. However, due to a variety of reasons, including climate, regional variation, and sunlight, the eastern regions contain an enormous variety of plant flora. Despite the region's hard winters, the spring and summer seasons may get rather warm because of the region's abundant sunshine. Beekeeping is a great opportunity for rural areas with rich plant flora, as it requires relatively little

investment and does not have a limited area, and provides an important economic opportunity (Ateş and Yaşar 2020). If beekeeping enterprises become more efficient, production will increase and the increasing demand will be met, and with the increase in production, the economic income of the producer will increase. In this way, it is believed that the tourism industry, particularly in rural regions, will grow and become stronger while also promoting rural growth and *Apis mellifera (API)* and gastronomic tourism (Aşkan 2023).

The protection of all ecosystems together with the most accurate and effective use of resources is the basis of sustainable agricultural production, which includes beekeeping as well as all areas related to food production (Bozkurt 2019). With the rise in global population, the honey bee's ability to produce, which provides vital items for the health and well-being of humans, has grown considerably more crucial. It is also important to note how future changes in the world may affect many of the environmental factors supporting the beekeeping industry (Decourtye et al. 2019; Mouillard-Lample et al. 2023). Utilizing geographic information techniques, various geographical analyses, and the combination of non-stationary spatial variables with environmental and socio-economic data will all help in such a situation. The emergence of spatial patterns in space and time can therefore be predicted with more accuracy by understanding the connections between the spatial distribution of honey yield and environmental processes.

Our investigation highlights a few gains. The initial and significant gain is the integration of new data for the analysis of honey yield distribution in Türkiye. Another significant gain relates to the scale of the study area in terms of space. By using provincial-level data, it is possible to reach more accurate and dependable conclusions with a broader perspective on honey yield on a national scale. The summary of honey yield 18-years period is an extra substantial gain in our study. Additionally, from the perspective of the nation's economic growth and development, these novel consequence maps of our study may offer more significant inputs for subsequent attempts to map the need and supply of bee-based products.

CONCLUSION

This study, for the first time, investigated the spatial relationships of honey yield at the provincial level in Türkiye in the periods 2005-2010, 2011-2016, 2017-2022 and 2005-2022, respectively. Honey production outputs in 81 provinces of Türkiye were used as an indicator to examine spatial correlations of honey yield. The point that needs to be taken into consideration in this study is to consider the extent to which beekeepers registered in the regions where the cluster is present engage in migratory beekeeping and to what extent they contribute to the production achieved. We can say that beekeepers in Ordu province, where High-High clustering has always been seen, contribute greatly to production, and people living in the Eastern Anatolia Region do not attach as much importance to beekeeping activities as before. As a result, we recommend increasing the competitiveness between provinces with high production in high potential regions and surrounding provinces, enabling better use of existing resources and establishing strong collaborations.

Conflict of interest: The authors have no conflicts of interest to report.

Authors' Contributions: TB, EA and Şİ conceived the study. EA collected data and designed it. TB performed the statistical and spatial analysis. EA and Şİ wrote the manuscript. All authors reviewed the manuscript.

Ethical approval: This study is not subject to the permission of HADYEK in accordance with the "Regulation on Working Procedures and Principles of Animal Experiments Ethics Committees" 8 (k). The data, information and documents presented in this article were obtained within the framework of academic and ethical rules. Data gathered from the official website of the Turkish Statistical Institute (TurkStat) regarding is public use data.

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