



Determination and Mapping of Areas Rich in Bird Diversity in Isparta Province, Turkey

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ABSTRACT

This study was carried out to determine and map the areas rich in bird species diversity in Isparta Province (Turkey). The study area, with a total surface area of 8933 km², was divided into 64 sample sites created by dividing it into a 1/25000-scaled grid. Between 2014 and 2015, each sample site was visited over the four seasons. Point count and line transect methods were applied between the early hours of the morning and sunset, when the birds were active. According to Shannon-Wiener diversity values, the diversity was determined to be highest in summer and lowest in spring. Comparisons made among sites according to bird species abundance determined that plots L24c3, L25d4, and L25d3 had the highest Shannon-Wiener diversity indices ($H = 3.081$; $H = 2.77$; $H = 2.77$, respectively). These sites include natural and artificial wetlands with reeds and mountain ecosystems. At the same time, using over 90 years of climatic data for the study area, calculations carried out according to the Thornthwaite method determined the precipitation efficiency index value (Im) to be 2.96. Isparta Province, which is very rich in wetlands and located on the bird migration route, is a very important area in terms of bird species.

Article Information

Received 16 June 2023
Revised 05 December 2023
Accepted 26 December 2023
Available online 01 March 2024
(early access)

Key words

Biodiversity, Biological diversity, Shannon-Wiener, Isparta, Alpha species richness, Birds

INTRODUCTION

Isparta Province is rich in ecosystem diversity, which provides favorable environmental conditions for the shelter, protection and reproduction of birds and other living things (Özkoç, 2020). The more diverse habitats in a given area (terrestrial or wetland), the more diverse the number of species living there. Habitat diversity is one of the fundamental elements of biological diversity (Çepel, 1997; Işık *et al.*, 1997; Işık, 2003; Duran, 2012). Birds are easily affected by environmental changes and are regarded as biological indicators. Therefore, the distribution of birds and their response to changes in environmental conditions is considered important in conservation studies (Khan and Pant, 2017).

Turkey is very rich in terms of ornitho-fauna. The province of Isparta, where the research was conducted, is also a very important area for bird species as it is very diverse in terms of natural water resources and vegetation

types and includes different habitat types, ranging from high mountains to wide meadows. Wetlands, in particular, provide ecosystem services such as water purification and climate regulation, as well as containing a wide variety of biological communities (Zedler and Kercher, 2005). In this context, the importance of the study area is increasing. Although birds are among the important living societies that contribute to the biological richness of Turkey, there have not been enough comprehensive studies targeting biological diversity. Most studies in the literature on bird species within the borders of Isparta Province consist of inventory studies (Gündoğdu, 2002; Tabur and Ayvaz, 2006; Aksan and Mert, 2016; Öztürk, 2017; Bergner *et al.*, 2018). There are two studies on bird species richness. One was carried out by Osmanoğlu and Özdemir (2014) in Gölcük Nature Park, which is a small but important area covering 0.6% of Isparta. The study investigated relationships between stand structure and bird species richness, thus fulfilling the need for studies in this field in order to eliminate the lack of information on this subject and to contribute to the literature.

The aim of this study was to determine the richness and diversity of bird species in Isparta Province, to reveal the rich areas, and to create a bird species richness map.

MATERIALS AND METHODS

Study area features

The province of Isparta, as the study area, is within

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0030-9923/2024/0001-0001 \$ 9.00/0



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the B3 and C3 squares (Davis, 1965). It is referred to as the lake region, and is located adjacent to the provinces of Afyonkarahisar, Burdur, Antalya, Konya, and Denizli. The highest point of the study area is 2981 m and the lowest 246 m above mean sea level. The surface area is 8933 km² and has a heterogeneous landscape structure (Anonymous, 2023; Fig. 1). According to the Thornthwaite climate classification, the province, which is also very rich in terms of wetlands and natural water resources such as rivers and lakes, is in the semi-arid/less humid (C1), semi-humid (C2), and humid (B1) climate classes (Meteoroloji Genel Müdürlüğü, 2016).

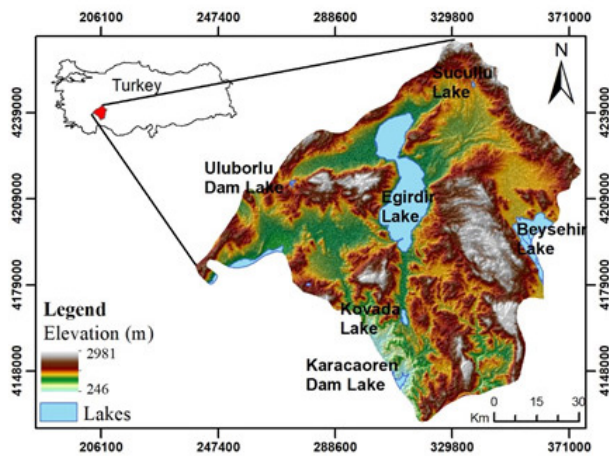


Fig. 1. Study area location map.

Inventory method

The study was carried out between 2014 and 2015 in 64 sample sites created by dividing Isparta Province into a grid of 1/25000-scaled squares. Using point count and line transect methods, bird watching was carried out in each sample site over the four seasons, between the early morning hours and sunset (i.e., when the birds were active) (Dobinson, 1976; Bibby *et al.*, 1992). At each observation point in the sample sites and their close vicinity, the bird species and individual numbers were observed using binoculars and telescopes, and photographed using a high-resolution camera. The Global Positioning System (GPS) was used to determine the locations of the observation points.

Data analysis (calculation of diversity values)

Both the seasonal and total direct bird species richness and the Shannon-Wiener Diversity Index values of each sample area were calculated using the data obtained as a result of the inventory study (Özkan, 2016; Tavuç *et al.*, 2018; Tavuç, 2020). Equations 1 and 2 were used to calculate the direct species richness and the shannon-wiener diversity index values, respectively.

Direct species richness (S) (Peet, 1974).

$$S = \sum_{i=1}^S S_i \dots (1)$$

The value of S_i in the equation represents each species that differs in the sampled areas.

Shannon-Wiener Diversity Index (H') (Shannon, 1948).

$$H' = - \sum_{i=1}^S p_i \ln p_i \dots (2)$$

The p_i expression in the formula represents the proportional values of the species.

Creation of maps

Seasonal bird species diversity maps were produced by transferring the Shannon-Wiener Diversity Index values calculated using the seasonal data of each sample area to the ArcGIS package program. A bird species biodiversity map of Isparta Province was then created by combining the seasonal bird species biodiversity maps (Fig. 3). The dark areas on the map indicate areas rich in bird species diversity, whereas the light areas show regions with poor species diversity.

Determination of climate class

The meteorology station measurement data of the 1927-2018 period for Isparta Province were used to determine the climate type of the study area, using the Thornthwaite precipitation efficiency index formula (Equation 3). In the equation, Im = the precipitation efficiency index, s = the annual excess water (mm), d = the annual water deficit (mm), and n = the annual evapotranspiration value (Thornthwaite, 1948; Dönmez, 1984; Tavuç, 2020).

$$Im = \frac{100 * s - 60 * d}{n} \dots (3)$$

RESULTS

Evaluation of the data obtained as a result of the inventory study carried out over the four seasons in the study area showed that 266 bird species belonging to 53 families had been identified. A total of 60,120 individuals had been counted. Movement patterns of the species are given in Figure 2.

A direct examination of the bird species richness values of the sample sites indicated the richest site to be plot M25c1 and the poorest site to be L26d3 (Fig. 4). Considering the Shannon-Wiener Diversity Index value of each sample site, those with the highest biodiversity value were determined to be L24c3 and L24c4, and that with the lowest to be M25b1 (Fig. 3).

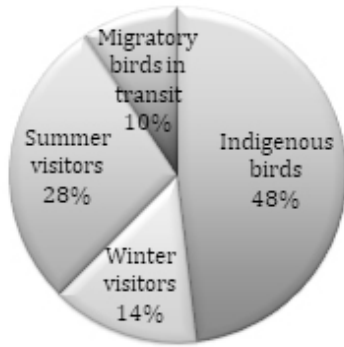


Fig. 2. Movement patterns of birds in Isparta.

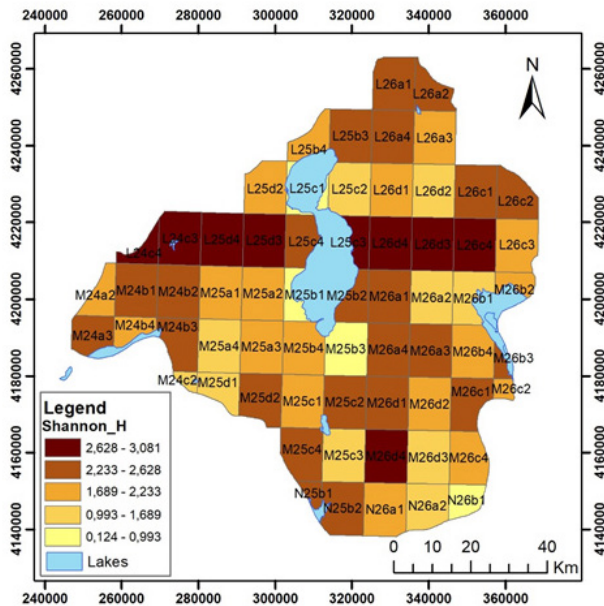


Fig. 3. Isparta Province bird species diversity map.

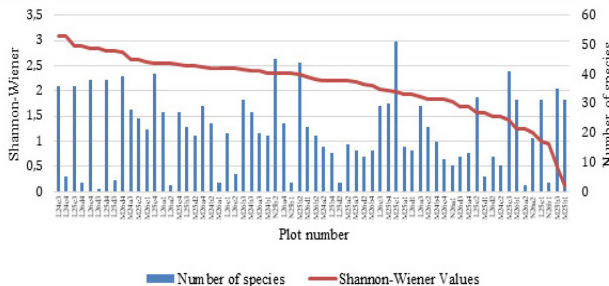


Fig. 4. Species richness and species diversity values of sample sites.

The diversity was found to be the highest in the four artificial wetlands (Uluborlu Lake, Atabey Lake, Gönen

Lake, and Barla Lake) and the natural Lake Eğirdir, which lie along the line of the L24c3, L25d4, and L25d3 plots. Kapı Mountain (2643 m) and Barla (Gelincik) Mountain (2798 m) are among the high-altitude mountains in the area. On the M26c1 plot, Dedegöl Mountain, with an elevation of 2981 m, is another area with a high diversity value. The L25c3 plot, which lies on the shore of Lake Eğirdir, is also home to two important reed areas.

As a result of the calculations made according to the Thornthwaite method using over 90 years of climatic data, the value of the precipitation efficiency index was determined as $Im = 2.96$. According to this value, Isparta Province is in the semi-humid climate class.

The lake region of Isparta Province has a very rich geography in terms of wetlands, with humid (B1), semi-humid (C2), and semi-arid-less humid (C1) climate types. Due to its location the effects of both continental and Mediterranean climates are observed in the northern parts of the study area. When the long-term temperature data were evaluated, the highest average temperature value in the region was found as 30.8 °C in August, and the lowest as -2.2 °C in January. The highest average annual temperature value was 41.2 °C and the lowest -21 °C.

The months when water storage in the soil was high were determined to be between December and May, whereas water deficiency was found between July and September. In addition, precipitation was at the lowest level between June and September (Fig. 5).

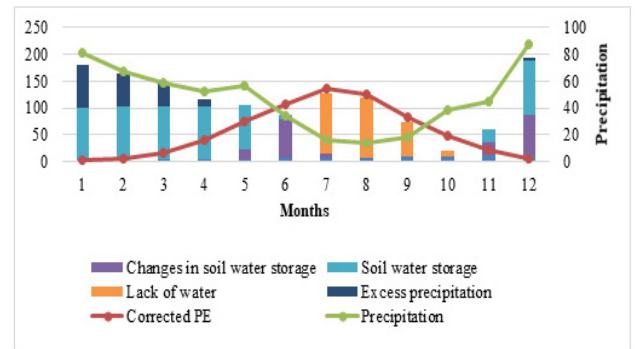


Fig. 5. Study area water balance chart.

The Shannon-Wiener diversity values of Isparta Province were calculated according to all seasons and showed that whereas the diversity was the highest in the summer months, it was the lowest in the spring (Fig. 6). In the summer season, the highest diversity was found in the 11 plots close to the reedy wetlands. For the M25c3, M25c4, M25c1, and M25d2 plots located in and around Kovada Lake, the average bird's eye distance to the lake is 9.532 ± 4.79 km.

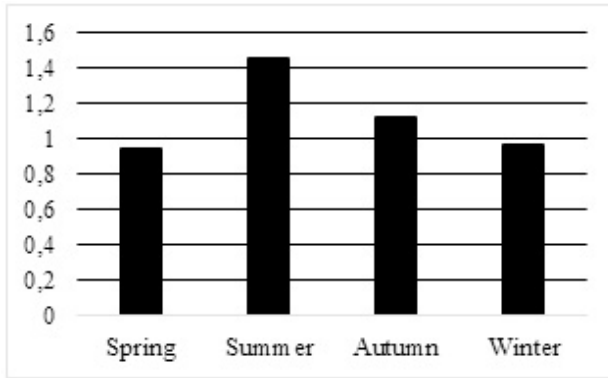


Fig. 6. Shannon-Wiener diversity values according to season.

DISCUSSION AND CONCLUSIONS

Birds and plants are the two taxonomic groups most commonly used as biodiversity indicators (Nagy *et al.*, 2017), and a number of studies have confirmed their importance in this role (Flather *et al.*, 1997; Ricketts *et al.*, 1999; Sauberer *et al.*, 2004; Qian and Ricklefs, 2008). These taxa have been determined to show good correlation in geographical and ecological contexts, especially at scales larger than 100 km² (Sauberer *et al.*, 2004).

Isparta Province is located in the B3 and C3 squares according to the Davis (1965) grid system, and is home to many plant species as it includes different habitat types such as forests, scrublands, rocky areas, wetlands, and agricultural areas (Özçelik *et al.*, 2015). The province is under the influence of different climate types (MGM, 2020) and is very rich in flora and vegetation (Gül *et al.*, 2012; Özçelik *et al.*, 2015). This situation also affects bird diversity positively and the results obtained are in agreement with the literature data. The fact that the region is rich in flora creates feeding, nesting, and hiding areas for birds. Therefore, the study area has become a center of attraction for birds, which explains the high diversity of bird species.

Two of the four bird migration routes in the Palearctic region pass through Turkey (Yiğit *et al.*, 2008). Isparta, on the other hand, is located on the northwest-south bird migration route and therefore, bird diversity varies seasonally. A study carried out in April, June, and August in the Isparta-Atabey plain determined that the highest diversity was seen in April and the lowest in August (Aksan and Mert, 2016). However, in our study conducted between 2014 and 2015, data covering all seasons were evaluated, and the findings differed from the literature, with the highest Shannon-Weiner Diversity Index values being found in summer and autumn. This difference was

predicted because the study in the literature did not cover all the seasons.

Turkey has the richest wetlands in Europe and the Middle East (Durmuş and Adızel, 2011). Wetlands are important habitats for many living species, especially waterfowl (Sebastian-Gonzalez and Green, 2014; Rahman and Ismail, 2018). Although the majority of birds obtain the water needed for their metabolism from the foods they consume, some obtain this need from fresh water sources such as streams, creeks, lakes, ponds, or springs (Luo *et al.*, 2019). In addition, birds exhibit bathing behavior in water sources. The province of Isparta is very rich in terms of natural water resources such as rivers and streams and has many natural and artificial lakes (reservoirs) of various sizes. Due to their characteristics, wetlands contain many vertebrates and invertebrates (Zedler and Kercher, 2005). Thus, favorable environmental conditions are provided in terms of grounds for shelter, feeding, and breeding for both migratory and native waterfowl (Rajpar and Zakaria, 2013; Giosa *et al.*, 2018). As the study area is located on bird migration routes, it is frequently visited by migratory birds, thus contributing to the bird species richness of Isparta Province.

The most suitable living environment in the study area for raptors and songbirds was determined to be along the line covering Uluborlu and Senarkent districts (L24c3, L25d4, and L25d3). This was evident from the presence of the old natural forest stands in these areas. The high structural diversity in old natural forest areas increases the biodiversity (Hansen *et al.*, 1991; Akdemir and Özdemir, 2015) and provides a large number of micro-habitats for bird species.

In our study, the Shannon-Wiener diversity value was found as 2.576 in the sample area covering Dedegöl Mountain (M26c1). In another study conducted in this area, it was determined that under the conditions of the *Rosa canina* species habitat, the plant species diversity was high and therefore, concluded that these regions would be valuable areas in terms of other biodiversity (wildlife, insects, reptiles, etc.) (Negiz *et al.*, 2017). These data concur with our study, showing that the area provides feeding, hiding, and breeding areas for birds in parallel with its plant diversity, thus explaining the reason for the bird diversity.

The L25c3 plot, with its natural reeds, has a high Shannon-Wiener diversity value ($H = 2.901$) and is home to many living species. This area contains the Gelendost Stream, one of the most important streams feeding Lake Eğirdir (Ministry of Forestry and Water Management, 2017). These features of the area enable the birds to feed, hide, and nest, thus increasing the diversity. However, sometimes the existence of some species is better explained

by the structure, heterogeneity, and interconnections of the landscape at larger spatial scales (Saab, 1999).

In Lake Eğirdir, the Eurasian coot (*Fulica atra*) population was determined to be high. This reduced the Shannon-Wiener diversity value in the sample areas where the population is located because this index is based on the number of individuals. Soylu and Tabur (2015) determined that the reason for the increase in the number of individuals in the Eurasian coot population breeding in Kovada Lake (fed from Lake Eğirdir) was the inclusion of offspring after hatching.

Examination of the areas with high Shannon Wiener Diversity Index values shows that the regions are rich in fruit orchards (cherry, apricot, apple, etc.) and vineyards, which are important feeding grounds for birds. Therefore, bird populations are concentrated around these areas. However, the greatest problems threatening these areas stem from the practices of washing tools and tanks used for pesticides in the lake, emptying empty pesticide containers in these areas, and discharging domestic wastes into the environment without treatment. Studies have determined that total nitrogen (TN), total phosphorus (TP), and fecal coliform values in Lake Eğirdir have increased (Ministry of Forestry and Water Management, 2017). This can result in harm or even death to living things. Today, the responsible use and management of fresh water resources is vital and of great importance for all living things. In this context, international conventions to which Turkey is a party are important tools for the protection of biodiversity and living things.

Finally, to date, 393 bird species have been identified in Turkey (Bird Life International, 2021). The number of bird species recorded in Isparta Province is 266, constituting 68% of the birds distributed in Turkey. In this respect, Isparta Province is a very principal area for both local and migratory bird species. As seen on the map (Fig. 3), plots L24c3, L25d4, and L25d3 are very important in terms of bird species diversity. For this reason, among protected areas, those with high diversity in particular should be given priority because bird diversity is also related to plant diversity (Negiz et al., 2017). At the same time, birds are considered important in conservation studies in terms of their distribution and their response to changes in environmental conditions in their role as indicators. Isparta Province is very rich in wetlands and is located on the bird migration route. Thus, it is a very important region in terms of bird species and all the data highlight the need for special conservation strategies for regions with high reproduction and diversity. Protecting the birds means protecting the area along with all its species diversity.

Funding

I would like to thank the project teams for TUBITAK project no. 2229 entitled “Biological Diversity Measurement Processes- Inventory, Data Transfer and Calculation Techniques” and no. 2237-A “Using GIS and Satellite Images for Natural Ecosystems” supported by the TUBITAK Scientific Education Activities Support Program. I am indebted to Assoc. Dr. Ahmet MERT and Dr. Biologist İbrahim TAVUÇ.

Statement of conflict of interest

The authors have declared no conflict of interest.

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