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COMPARING BAT ACTIVITIES IN NUMEROUS CITY PARKS OF ANKARA METROPOL BY USING MANUAL DETECTORS

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MOHAMMED KHALID JAMAL AL-JANABI

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COMPARING BAT ACTIVITIES IN NUMEROUS CITY PARKS OF ANKARA METROPOL BY USING MANUAL DETECTORS

By Mohammed Khalid Jamal AL-JANABI

August 2023

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ABSTRACT

COMPARING BAT ACTIVITIES IN NUMEROUS CITY PARKS OF ANKARA METROPOL BY USING MANUAL DETECTORS

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The exponential expansion of urban centers worldwide in recent decades has underscored the heightened need of conserving the remaining green areas inside these cities. These regions provide a secure and appropriate habitat for several animal species, including bats. Bats are often found in urban environments, where they tend to segregate themselves based on the presence of buildings, forested streets, and non-wooded streets. This behavior is particularly noticeable in heavily vegetated urban parks situated inside the city. Urban parks provide significant advantages for the preservation and enhancement of bat variety. The three urban parks in the capital city of Ankara, Turkey (DikmenVadisi Park, Genclik Park, and Altinpark Park) provide a suitable habitat, green areas, trees, water, and food sources for a variety of living organisms, particularly bats. The study aimed to survey and document bat species in urban parks in Ankara City, Turkey, focusing on their existence, frequency, and community features. The research was conducted between May and November 2022, observing bat populations and frequencies using manual detectors. The parks, with their unique characteristics, were compared to natural habitats. The study aimed to investigate the function of urban parks in preserving bat species. The research found nine bat species acquired in parks, including cosmopolitan and other adaptable species. The parks show a decrease in bat activity due to human interventions like increased light, noise, and movement. However, no statistically significant difference was observed in community metrics such as species richness, variety, evenness, dominance, similarity, and yearly biological activity of bat species. The statistical analysis and linear hypothesis revealed no noticeable difference among parks in relation to all bat species, particularly when evaluating the t value. The primary rationale for this phenomenon may be attributed to the scarcity of refuge sites inside the urban landscape, which has significance in the present and foreseeable future, hence limiting options for animals.This research sheds light on the significance of urban parks in the development and expansion of metropolises worldwide, particularly in relation to their role in supporting animal populations inside cities, with a specific focus on bats. Additionally, the study explores potential strategies for enhancing the management of urban ecology in cities.

2023, 52 pages

Keywords: Bats, City parks, Wildlife, Ankara, Manual detector, Echolocation, Biodiversity in urban, Conservation, Urban ecology

ÖZET

ANKARA BÜYÜKŞEHİR MERKEZİ'NDEKİ BAZI PARKLARDA YARASA AKTİVİTELERİNİN HAREKETLİ DEDEKTÖRLER KULLANILARAK KARŞILAŞTIRILMASI

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Son yıllarda dünya çapında kent merkezlerinin katlanarak genişlemesi, şehirlerin içinde kalan yeşil alanların -bu tarz alanların yarasalar dahil birçok hayvan türü için güvenli ve uygun bir yaşam alanı sağladığından- korunmasına yönelik ihtiyacın da artmasına yol açmaktadır. Yarasalar genellikle binaların, ağaçlı sokakların ve ağaçlık olmayan sokakların varlığına göre kendilerini ayırma eğiliminde oldukları kentsel ortamlarda bulunur. Bu davranış özellikle kentlerin içinde yer alan yoğun bitki örtüsüne ve su varlığına sahip kent parklarında fark edilir. Kent parkları yarasa çeşitliliğinin korunması ve geliştirilmesi konusunda önemli avantajlar sağlamaktadır. Türkiye'nin başkenti Ankara'daki şehir merkezinde yer alan birçok park da başta yarasalar olmak üzere bitki, böcek, kuş, sürüngen ve memeli gibi çeşitli canlılar için uygun bir yaşam alanı, yeşil alanlar, su ve besin kaynakları sağlamaktadır. Bu çalışma, Türkiye'nin başkenti Ankara'da şehrin merkezinde yer alan ve birbirinden farklı özelliklere sahip üç kent parkında (Dikmen Vadisi, Gençlik Parkı ve Altınpark) bulunan yarasa türlerinin yıllık biyolojik döngüleri açısından varlığına, sıklığına ve komünite parametrelerine odaklanarak karşılaştırmalı biçimde kent parklarının yarasa türlerinin korunmasındaki işlevinin araştırılması amaçlanmıştır. Mayıs-Kasım 2022 dönemi boyunca, 3 parkta önceden belirlenmiş transekt hatları her 15 günde bir takip edilecek biçimde, cep telefonu ile uyumlu bir manuel dedektör kullanılarak akşam 8-11 saatleri arasında 3 saatlik yürüyüşler sırasında elde edilen yarasa ses kayıtlarının toplanıp, analiz edilmesi araştırmanın materyal-yöntem kısmını teşkil etmiştir. Araştırma sonucu 3 parkta kozmopolit, nadir ve/veya rastlantısal olmak üzere toplamda 9 yarasa türü kaydedilmiştir. Parklarda artan ışık, gürültü ve hareket gibi insan müdahaleleri nedeniyle yarasa aktivitesinde azalmalar görüldüğü bilinse de bu çalışmada yarasa türlerinin tür zenginliği, çeşitliliği, eşitliği, baskınlığı ve benzerliği gibi komünite parametrelerinin yanı sıra yıllık biyolojik aktiviteleri açısından da istatistiksel olarak anlamlı bir farklılık gözlenmemiştir. İstatistiksel analiz olarak tercih edilen ANOVA sonuçlarına göre, özellikle t değeri değerlendirildiğinde, tüm yarasa türleri açısından parklar arasında anlamlı bir fark olmadığı tespit edilmiştir. Bu olgunun temel gerekçesi, kentsel peyzaj içindeki sığınma alanlarının azlığına atfedilebilir; bu durum, günümüzde ve öngörülebilir gelecekte kentsel ekosistemlerde yaban hayatı için uygun yaşam alanlarının daha da sınırlı seçeneklerle temsil edileceği gerçeği göz önünde tutulduğunda kent parklarının daha da fazla bir öneme sahip olacağı ortaya çıkmaktadır. Sonuç olarak bu araştırma, özellikle yarasalara odaklanarak, şehir parklarının dünya çapındaki metropollerin gelişimi ve genişlemesi karşısında kentsel ekosistemlerde yaban hayatı varlığının önemine, özellikle de şehirlerdeki yaban hayvanı popülasyonlarını destekleme rollerine ışık tutmaktadır. Ek olarak, çalışma gelecekte kentsel ekolojisinin yönetimini geliştirmeye yönelik potansiyel stratejileri de ele almıştır.

2023, 52 sayfa

Anahtar Kelimeler: Yarasalar, Şehir parkları, Yaban hayatı, Ankara, Manuel dedektör, Ekolokasyon. Kentsel Biyoçeşitlilik, Koruma, Kent ekolojisi

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Mohammed Khalid Jamal AL-JANABI
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CONTENTS

LIST OF SYMBOLS

A.M	After noon
P.M.	Before noon
°C	Celsius
km	Kilo meter
m	Meter
%	Percent
+	Positive
m^2	Square meter

LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
ALAN	Artificial light at night

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1. INTRODUCTION

Bats (order Chiroptera) are the second-largest mammalian order, with over 1300 extant species. They are unusual among mammals in their development of powered flight (Voigt and Kingston 2016). Bats are tiny animals with the life-history strategies of much bigger species (Barclay and Harder 2003, Altringham 2011). In many regions of the planet, notably the tropics, bats are the most species-diverse mammalian group in a given place, with alpha diversity in the Paleotropics reaching about 70 species (Kingston *et al.* 2010). They play a vital function in ecosystems and serve as reliable bioindicators (Jones *et al.* 2009). Human activity is affecting ecosystems at an unprecedented pace, and people currently control the majority of ecosystems (Vitousek *et al.* 1997, McDonald 2008). The persistence of animals in urban areas might be attributed to opportunism and a high level of ecological and behavioral flexibility (Luniak 2004). Bats are most certainly the most diversified group of animals now living in cities (van der Ree and McCarthy 2005, Jung and Kalko 2011).When people share structures with synanthropic bats, there are numerous immediate advantages. Bats offer important ecological services (such as pest control, pollination, and seed dissemination) around homes, towns, and cities (Jones *et al.* 2009, Kunz *et al*. 2011, Ghanem and Voigt 2012). Bats are animals that have a very good sense of their environment. They can detect the amount and location of resources, like food, in their local area. They also take into account the bigger picture of the landscape they live in, like the size and shape of the area, when making decisions (Mendes *et al.* 2017). Because they are pieces of semi-natural habitat where many species flourish inside the urban matrix, urban parks are critical locations for biodiversity conservation (Baker and Harris 2007). The ongoing trend of urbanization often results in the degradation of animal habitat. Although urbanization is unlikely to be prevented, the effect on animals may be mitigated through the establishment of parks (Bradshaw *et al.* 1986).The impacts of urbanization on bats are poorly known, especially at the landscape scale (Gehrt and Chelsvig 2003).

In the face of a changing climate and expanding urbanization, nature-based green infrastructure such as natural green spaces, street trees, rain and pollinator gardens, and green roofs are increasingly valued in urban development for the many ecosystem services they offer (Aronson *et al*. 2017). Also, the research found that urbanization seems to act as an environmental filter, preventing certain species that are exclusive to rural environments from being present in urban areas (Palheta *et al.* 2020). On the other hand, the researchers mentioned that urbanization is a threat to insectivorous bat communities, leading to decreased overall abundance, species diversity, and possibly lower reproductive success of those present (Kurta and Teramino 1992) due to a lower abundance of insects in the urban environment compared to the rural environment (Geggie and Fenton 1985). This hypothesis is supported by radio-tracking observations, which revealed that E. fuscus foraged for longer periods of time in cities than rural areas, as well as entomological literature, which suggests there are fewer insects available in urban environments (Frankie and Ehler 1978, Taylor *et al.* 1978). Despite the general decrease of many bat populations worldwide and the recent upsurge in the use of autonomous acoustic detectors, the acoustic monitoring of bat assemblages is still an emerging field in bat research and conservation (Tuneu-Corral *et al.* 2020). The selection of this research was based on its emphasis on the pressing need to preserve green spaces in metropolitan areas experiencing fast expansion. This research focuses on the particular investigation of the role played by urban parks in facilitating the presence and well-being of bat populations. By doing so, it contributes to our understanding of the harmonious coexistence between wildlife and urban development. The aim of the study is to comprehensively record the many bat species present in urban parks, with a particular focus on their distribution, frequency, and community traits. Furthermore, the objective of this study is to investigate the role of urban parks in the preservation of bat populations via the creation of artificial habitats that imitate natural environments.The significance of preserving natural spaces has been amplified by the fast expansion of metropolitan areas. Urban parks have a crucial role in providing homes for a wide range of species, including bats, due to their abundant flora, presence of water sources, and diversified ecosystems.

The present study, carried out in Ankara, Turkey, aims to examine the variety of bats in urban parks in order to get a deeper understanding of their behavior and the need to conserve these areas.

2. LITERATURE REVIEW

2.1 Urban Areas

According to Russo and Ancillotto (2015), one of the most important processes of land use change that has significantly altered animal habitats and landscapes is urbanization. According to Baker and Harris (2007), the growth of urban areas has resulted in the destruction of the majority of the world's natural habitats. This trend can be seen in almost every region of the planet. The findings of several studies indicate that biodiversity and species composition exhibit a clear urban-rural gradient shift, which suggests that urbanization is one of the major drivers of species decline, homogeneity, and extinction when compared to other human activities (Ming and Du 2021). Urbanization is one of the major drivers of species decline, homogeneity, and extinction when compared to other human activities.

Stiles (2013) posits that urban parks yield a multitude of advantages for the surrounding environment. Among these benefits are the alteration of climate patterns, influence on the hydrologic cycle, enhancement of biodiversity, promotion of sustainability, and mitigation of noise pollution. As per Wang (2021), urban parks are the most common component of greenspaces and play an essential part in the conservation of biological diversity. In accordance with research by Konijnendijk *et al.* (2013), urban parks are essential to the livability and sustainability of cities. In the findings of Eagles (1993), parks offer a number of important ecological services as a result of the environmental advantages they possess.

The provision of a diverse range of habitats for flora and fauna, in particular widespread bird and animal species, is a significant contribution that urban parks make to the conservation and maintenance of biodiversity (Chiesura 2004, Cornelis and Hermy 2004, Millennium Ecosystem Assessment 2005, Konijnendijk *et al.* 2013; Sadeghian and Vardanyan 2013).

This is one of the reasons why urban parks are so important. In order to achieve habitat variety and biological species diversity, the biodiversity design of more domestic urban parks should focus on utilizing plant features, matching plant community structure, and constructing biological habitats within the scope of urban public green space or wetland (Ming and Du 2021).

As noted by Ming and Du (2021), drainage space, which includes bodies of water such as lakes and rivers, is one of the most important habitats for aquatic animals, plants, and amphibians. An urban park is a fragmented habitat patch that has been preserved in the midst of the rapid progression of urbanization (Ming and Du 2021). This habitat patch has good landscape resources, a variety of landforms, and a large number of animal species, among other characteristics. As outlined in the study by Aronson *et al.* (2017), urban parks frequently play a significant part in the maintenance of biological ecosystems in regions that would otherwise be inhospitable.

It is beneficial to provide urban areas with an environment that is suitable for bats to roost in and feed in order to increase the presence of bat species, which contributes to the natural control of nocturnal insect populations (Li *et al.* 2020). This is because the presence of bats helps to reduce the amount of damage caused by nocturnal insects.

2.2 Bat Activity within Urban Areas

As stated by Rubbo and Kiesecker (2005), different species of bats have varying degrees of susceptibility to the effects of urbanization. The degree to which bats are affected by urbanization seems to vary among species, and researchers have identified a number of factors that may have an effect on the variety and abundance of bats in urban areas. For instance, Avila-Flores and Fenton (2005), Furlonger *et al.* (1987), Kurta and Teramino (1992), and Rydell (1992) found that white streetlights in urban areas are important foraging areas for certain species of bats. As reported by Russo *et al.* (2015), many species of bats are unable to survive in urban environments, while others are able to do so and frequently roost in buildings or forage near street lamps.

Studies of urban birds and other taxa have shown that urbanization can alter the composition and richness of biotic communities, in addition to its direct effects on the survival of individual species (Dixon 2012). This has been shown to be the case. In line with studies (Coleman and Barclay 2012), the diversity of bats in urban riparian areas is significantly lower than in rural ones. On the other hand, research has shown that urban areas are a beneficial habitat for certain species of bats, while other species are more likely to be absent from urban areas (Dixon 2012).

2.3 Bats as Bioindicators of Urbanization

As outlined by the Mammal Diversity Database (2021), bats are the second most diverse order of mammals, with a total of 1440 species currently known to science. They also make a significant contribution to the overall diversity of vertebrates across the globe. At least twenty years have passed since discussions began regarding the utilization of bats as bioindicators (Russo *et al.* 2021). It would seem that bats would make good urbanization indicators because it is relatively simple to keep track of them in urban environments. In urban areas, bats are more likely to roost in man-made structures, which makes them more visible to humans and makes it simpler to count their populations. In addition, the majority of bat species that are found in these areas make loud calls, which means that their presence can be easily recorded by acoustic surveys (Russo *et al.* 2015). Because of their reliance on the weather, bats are great candidates for studying the effects of climate change on biotic communities (Newson *et al.* 2009). There is growing evidence that bats provide essential ecosystem services, such as the control of agricultural pest arthropods, the pollination and seed dispersal of an impressive number of plant species, among which several are of high economic value (Russo *et al.* 2021, Kunz *et al.* 2011). Among the plant species that bats pollinate, several are of high economic value.

It is possible that the fact that many studies focused on different geographical regions, ecosystem types, spatial scales, taxonomic assemblages, data sources, or sampling methods, and sometimes even tackled different goals, is the reason why they led to contrasting findings and, overall, provided a confused general picture about bats as bioindicators (Russo *et al.* 2021). Bats are potentially excellent indicators of climate change due to their high sensitivity to changes in temperature as well as the availability of water (Russo *et al.* 2021).

2.4 Impacts of People's Activity on Bats Inside Urban Parks

Studies have shown that wildlife is moving into urban areas and adjusting to the changes brought about by urbanization, a phenomenon referred to as synurbanization (Luniak 2004). As stated by Luniak (2004), wildlife species that are successful in synurbanization typically have a high tolerance for the disturbances caused by humans and are able to change their behaviors. Human disturbances in urban areas can refer to either the presence of humans (with or without direct interaction with wildlife) or changes in the environment that are caused by human activities (Tablado and Jenni 2017, Grimm *et al.* 2017).

Per the research of Li *et al.*'s (2020), wildlife may change their behaviors in order to adjust to the higher levels of human activity that occur on the weekends and the associated temporal environmental changes. Behavioral changes such as increased aggression, boldness, and vigilance toward humans and other animals in mammals have been documented in studies as a result of synurbanization (Parker and Nilon 2008, Hume *et al.* 2019). These changes were found in mammals. On the other hand, it has been mentioned that there is no evidence suggesting that urban bats avoid flying over human crowds or areas of high human activity (Li *et al.* 2020), and almost nothing is known about the effects of human disturbance in their surroundings (Shirley *et al.* 2001). In addition, it has been mentioned that there is no evidence suggesting that urban bats avoid flying over human crowds or areas of high human activity (Li *et al.* 2020).

However, the presence of humans in or around bat roosts can have a negative impact on the bats, leading to delayed emergence, decreased activity, and even the abandonment of the roost (Shirley *et al.* 2001, Ancillotto *et al.* 2019). Due to the presence of humans in close proximity to the roost, the behavior of bats as they leave the roost is altered, which in turn delays emergence. In accordance with Mikula *et al.* (2016), the decision of when to emerge from hibernation in insectivorous bats represents a trade-off between the risk of becoming prey to visual aerial predators. As outlined by Lowry *et al.* (2013), the absence of many wild animal species in human-dominated landscapes may in fact be due not only to the scarcity of key resources such as food or suitable habitat but also to stressors such as vehicular traffic, artificial illumination, and the presence of people and domestic animals. This may be the case even if key resources such as food or suitable habitat are abundant. In line with the findings of a study (Ancillotto *et al*.2019), it is critical to keep human activity to a minimum in areas where bat colonies are located and there is an immediate requirement that domestic cats be kept away from these areas.

2.5 Benefits of Water Resources to Bats

The bats lose a great deal of water via their body surface, particularly through their respiratory system and wing membranes (Chew and White 1960, Thomas and Cloutier 1992). As a result of their distinct anatomy and physiology, bats are frequently susceptible to dehydration. Furthermore, due to the high ratio of the surface area of their bodies to the volume of their bodies, bats lose a significant amount of water and are perpetually at risk of dehydration; as a result, consuming sufficient amounts of water is of the utmost importance (Studier 1970). For example, bats in the Mediterranean eat in habitats that are vastly different from those used on the continent (Ancillotto *et al.* 2014, Davy *et al.* 2007). These tiny islands are located in the Mediterranean Sea. Ancillotto *et al.* (2014) and Davy *et al*. (2007) found that the swimming pools at resorts and villas frequently offer drinking water that is otherwise hard to come by or nonexistent in the surrounding area. Especially in arid, semiarid, or Mediterranean regions where water is permanently or seasonally scarce, man-made bodies of water developed inside or near urban areas, such as artificial ponds, water reservoirs, livestock troughs, and swimming pools, may provide critical drinking opportunities (Razgour *et al.* 2010, Russo *et al.* 2012, Korine *et al*. 2015). These man-made bodies of water include swimming pools.

It is of the utmost importance to ensure adequate supplies of vital resources like food and water are always available. Therefore, the presence of ponds as characteristic components of urban recreational green spaces increases the value of city parks for wildlife as vital habitats for aquatic or semi-aquatic creatures and as a supply of drinking water for terrestrial organisms (Hassall 2014). This is because ponds serve as a source of drinking water for terrestrial organisms. Bats frequently display behaviors that are unique to their species in response to the environment in which they live (Lintott *et al.* 2015) as well as human-made sources of disruption (Hale *et al.* 2015), such as artificial lighting. According to the findings of a group of researchers (Hale *et al.* 2015), different species of bats have different reactions to the presence of lights as well as the structural characteristics of ponds and the surrounding landscape mosaic. In their natural environments, bats are frequently found in close proximity to bodies of water; ponds, lakes, and rivers are all essential foraging habitats for bats (De Conno *et al.* 2018, Russo and Jones 2003, Walsh and Harris 1996, De Conno *et al.* 2018, Russo and Jones 2003, Walsh and Harris 1996). According to Schnitzler, Moss, and Denzinger (2003), one of the potential factors that influences the usage of water locations is greater ease of navigation. This may be connected to factors such as hedgerows and tree lines that serve as flying markers for bats. Furthermore, in natural ecosystems, bats are frequently connected with bodies of water. For example, ponds, lakes, and rivers are all significant bat migration/commuting markers (Furmankiewicz and Kucharska 2009, Grindal, Morissette, and Brigham 1999). Bats are also related to water sources as a source of potable water (Russo, Ancillotto, Cistrone, and Korine 2016).

The arthropods, such as numerous dipterans, which frequently serve as the primary food source for many species of bats are frequently abundant in water locations, particularly lentic ones. It is in these environments that these insects reproduce and swarm in large numbers, providing an essential trophic resource (Braverman 1994).

In line with the findings of Thomas and Jacobs (2013), the presence of vegetation close to a body of water may also be beneficial because it increases the availability of insects and shields bats from the wind as well as potential predators. Per the research of Ancillotto *et al*.'s (2019) research, the amount of forest that was located close to the ponds as well as the creation of riparian habitat had a significant impact on the amount of bat activity that occurred over urban ponds.

2.6 Effects of Lights on Bats

In accordance with Foley *et al.*'s (2005) research, human disturbance is the primary factor in the reduction of biodiversity across the globe. Anthropogenic light pollution is a growing concern on a global scale, disrupting ecological interactions across a variety of species and having a significant impact on activities that are essential to animal survival such as foraging, breeding, and communication (Rich and Longcore 2006, Longcore and Rich 2004). This problem is a result of human activity. The use of Artificial Light At Night (ALAN) is the cause of light pollution, which affects 23% of the land surface of the earth, including 88% of Europe, and is expanding at a rate of 6% per year globally (Falchi *et al.* 2016, Holker, Moss, *et al.* 2010). Light pollution is a threat to the health of humans and wildlife alike. Not only can urbanization have an effect on biodiversity through the destruction of habitat and the fragmentation of existing habitat, but it can also have an effect through the introduction of various types of pollution. Some examples of these types of pollution include chemical runoff (Moore and Palmer 2005), noise pollution (Arroyo-Sols *et al.* 2013), and light pollution (Hale *et al.* 2013).

As reported by Ancillotto *et al.*'s research from (2019), different species of bats have different reactions to the presence of lights, as well as to the structural qualities of ponds and the surrounding landscape mosaic. According to research by Azam *et al.* (2018), the majority of bat species will avoid using ponds if there is nearby artificial lighting.

Artificial lighting may concentrate food, which is then taken by a few opportunistic species; however, the vast majority of bat species are sensitive to light and are endangered as a result of illumination (Wakefield *et al.* 2018).

According to Azam *et al.* (2018), researchers found that light-sensitive bats' surrounding habitats were significantly altered by streetlights, which most likely contributed to an increase in the amount of habitat loss, change, and fragmentation caused by urbanization.

In line with the findings of Gaston *et al.* (2014), light pollution disrupts the natural light cycle that both diurnal and nocturnal species rely on to synchronize their biological rhythms with the environment. According to Boldogh *et al*. (2007), Nordt and Klenke (2013), and van Geffen *et al.* (2015), this desynchronization has significant effects on individual fitness, sexual selection, and reproductive achievement.

Pursuant to Azam *et al.* (2018), researchers believe that the alignment of streetlights results in the creation of crossing obstacles that impede the movement of light-sensitive bats. In keeping with Stone *et al.* (2009), obstacles can have a negative impact on an individual's fitness level and reproductive success because they decrease the accessibility of optimal foraging areas and cause longer commute lengths. Longer commute lengths are linked with high energy expenditures and stress, so these obstacles can also have a negative impact on an individual's fitness level. Because of the shape of its wings, the *Myotis* genus is particularly susceptible to habitat loss and fragmentation caused by light, which results in higher commuting costs and restricted dispersion capacities (Safi and Kerth 2004). This makes light-induced habitat loss and fragmentation a particular cause for concern for the conservation of *Myotis* species. As reported by Hale *et al.* (2015), even though *P. pipistrellus* prefers bright regions as foraging patches, ALAN can affect its mobility and ability to bridge gaps in the terrain. Light pollution has been shown to have major implications for the conservation of a vulnerable bat species as a result of changes in the utilization of regular flight routes and delays in commuting behavior (Stone *et al*. 2009).

Other studies, however, have shown that certain species of fast-flying bats are drawn to white lights due to the high insect densities seen around such light sources (Rydell and Racey 1995, Blake *et al.* 1994, Rydell 1991). These findings were uncovered by Rydell & Racey (1995),Blake *et al.* (1994), and Rydell (1991).

As per to Stone *et al.* (2009), light pollution must be taken into consideration when developing conservation strategies because it can force bats to take flight paths that are less than optimal and can result in the separation of preferred feeding locations.

As outlined by the findings of Azam *et al.* (2018), researchers hypothesize that streetlight alignments produce crossing obstacles that impede the migration of light-sensitive bats. According to Stone *et al.* (2009), obstacles can have a negative impact on an individual's fitness level and reproductive success because they decrease the accessibility of optimal foraging areas and cause longer commute lengths. Longer commute lengths are linked with high energy expenditures and stress, so these obstacles can also have a negative impact on an individual's fitness level.

3. MATERIALS AND METHODS

3.1 Materials

In order to determine the bat activity in the urban parks, specially developed manual detectors/voice recording devices were used to detect the status (such as frequency, time interval, species etc.) in the study areas of the bats, which came out of their roosts after sunset and started to the activities, by indirect (non-intervention) methods (Korner-Nievergelt *et al*. 2013, Correia et *al*. 2013) (Figure 3.1).

Figure 3.1 Manual detector echo meter touch 2 pro device for android with it's accessories

This was done in order to determine the bat activity in the urban parks. Within the city of Ankara, we visited three distinct parks in order to gather the necessary materials, which included the bat species' voice recordings. We made use of a manual detector

(Echo Touch Meter 2 Pro for Android) in addition to the software that came with it As seen in (Figure 3.2, Figure 3.3 and Figure 3.4)

Figure 3.2 Manual Detector Echo meter touch 2 pro using at the sunset at Dikmen Valley (Dikmen Vadisi)

Figure 3.3 Manual Detector Echo Meter Touch 2 Pro using at Youth Park (Gençlik Park)

Figure 3.4 The student using the Manual Detector Echo Meter Touch 2 Pro with the his advisor at the Youth Park (Gençlik Park)

The bat voice analysis was done on a computer that had the operating systems MacOS and Windows 8.1 installed on it. In order to conduct an analysis of the recorded voice files, licensed analysis software such as bcAdmin, batIdent, and bcAnalyze2 was utilized. (Russo and Jones 2002, Rydell *et al*. 2007). The rate that was determined for the consensus system regarding the type of voice in this study was 95% (Russo and Jones 2002, Rydell *et al.* 2007). This rate was determined after taking into consideration factors such as the error margin of the software and the voice quality in the voice analysis programs that were used for the identification of the voice recordings obtained from the manual detector. On the other hand, despite the fact that it was lower than this rate, the voice recordings were also factored into the evaluation. The accuracy of the voice recordings could be verified by looking at the voice graphics. In the research conducted by Russo and Jones (2002), the results of the analyses performed on the voice files were converted into graphics by using the voice recordings and analyses carried out in various parts of Turkey. The spreadsheet program Microsoft Office Excel

2013 was utilized for all of the mathematical calculations, graphical drawings, and figure drawings.

3.2 Methods

3.2.1 Study areas

In order to accomplish what this study set out to do, the following procedures were carried out: As a method of indirect observation, this process consisted of three hours of walking between the hours of 8:00 and 11:00 p.m. and standing in front of a manual detector to capture bat echo locations. We collected data on bat activity in three different urban parks in Ankara Metropol, which is the capital city of Turkey see Figure 3.5, so that we could gain a better understanding of the role that urban parks play in the management of wildlife and the provision of ecosystem services.

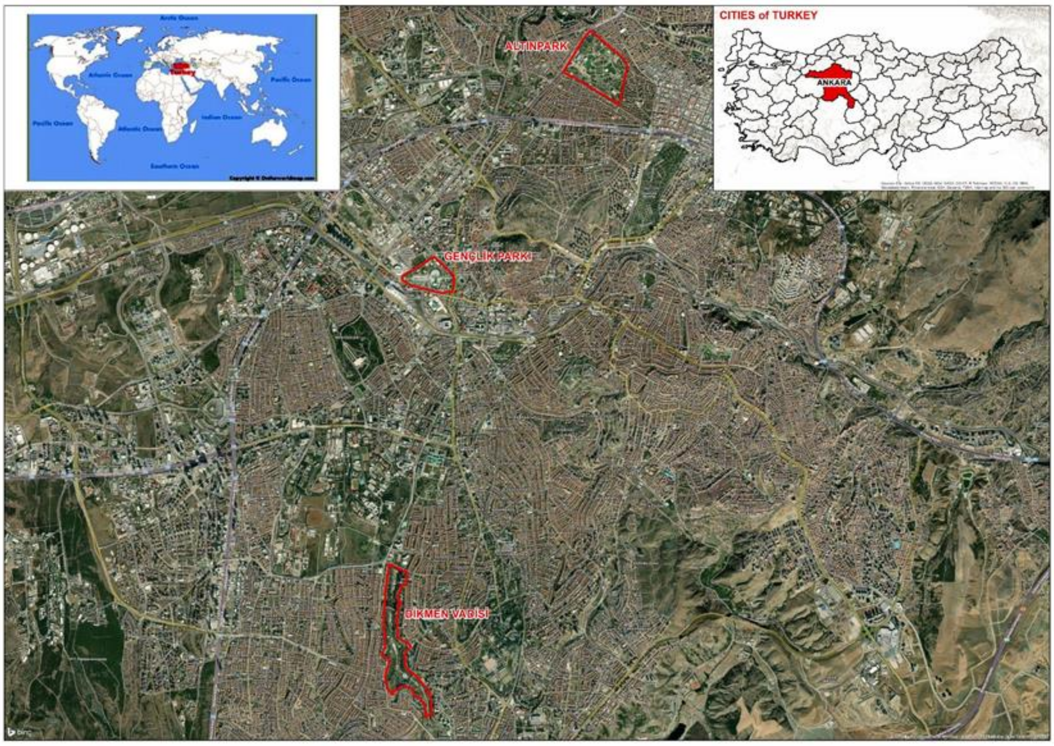

Figure 3.5 The map of studied parks (Up-left: Turkey in the world). Up-right: The Borders of Ankara in Turkey The main map shows the locations of the studied parks in Ankara City

In order to compare the results to be obtained in a meaningful way, some descriptive information specific to these parks has been obtained and summarized in Table 3.1.

Table 3.1 Some features of the studied parks

Features	Dikmen Vadisi (Dikmen Valley)	Gençlik Parkı (Youth Park)	Altınpark (Golden Park)
The year the park was founded	1994	1936	1977
Brief descriptions	In 1989, it was decided to implement an urban transformation plan in the valley, which was in a very neglected state until the 90s and where unplanned urbanization prevailed. This project, which was finished in 1994, is also the first urban transformation project prepared for the slum areas of the country.	Youth Park is one of the historical parks of Ankara. It was established on 28 hectares of land covered with swamps in the first years of the Turkish Republic.	It was used as a golf course until 1977, after which it was converted into a city park with renovations.
Distance to Ankara Stream (km)	6.9 km	2.4 km	1.4 km
Distance to Ankara Castle (Old City) (km)	5.1 km	1.3 km	3.3 km
Total area (ha, %)	**61,96ha, %100,00**	**27,54ha, %100,00**	**60,69ha, %100,00**
Water bodies (ha, %)	2,74ha, %4,43	4,42ha, %16,04	3,32ha, %5,48
Buildings (ha,	19,64ha, %31,69	12,84ha, %46,64	25,68ha, %42,32

%)			
Green areas (ha, %)	39,58ha, %63,88	10,28ha, %37,33	31,68ha, %52,21
Light pollution (Low, Moderate, High)	Moderate	High	High
Noise pollution (Low, Moderate, High)	Low	High	Moderate
Density of activities (Low, Moderate, High)	Low	High	Moderate
Field work dates during 2022	11 May 2022 To 30 November 2022	12 May 2022 To 29 November 2022	13 May 2022 To 28 November 2022
Transect length	6,2 km	3,5 km	4,9 km

3.2.1.1 Dikmen valley (Dikmen Vadisi)

History of the park

The valley in question is named after Dikmen, a residential area located within the Çankaya district of Ankara. The valley was largely overlooked until the 1990s, at which point a decision was made in 1989 to implement an urban transformation plan in areas characterized by significant urbanization issues. The legislative measure in question is commonly referred to as the Dikmen Valley Urban Transformation and Development Project.

Park characteristics

The Dikmen Valley project encompasses an approximate land area of 378,000 square meters and is currently in its second phase of development. The area of land measuring 31,000 square meters contains a pond, while an adjacent area measuring 87,500 square meters consists of an embankment. Within the remaining area of 260,000 square meters, an abundance of 120,000 deciduous and coniferous trees can be found, along with an approximate count of 50 distinct plant species. In the valley, there are three waterfalls, two of which are of considerable magnitude, while the remaining one is of lesser significance. Considerable efforts are being undertaken to ensure the preservation of the natural environment to the greatest extent feasible. The valley is home to a variety of amenities, including numerous cafés, conference rooms, two mosques, and other social facilities that cater to individuals of all age groups. These amenities are situated amidst contemporary, multi-story residences as in (Figure 3.6).

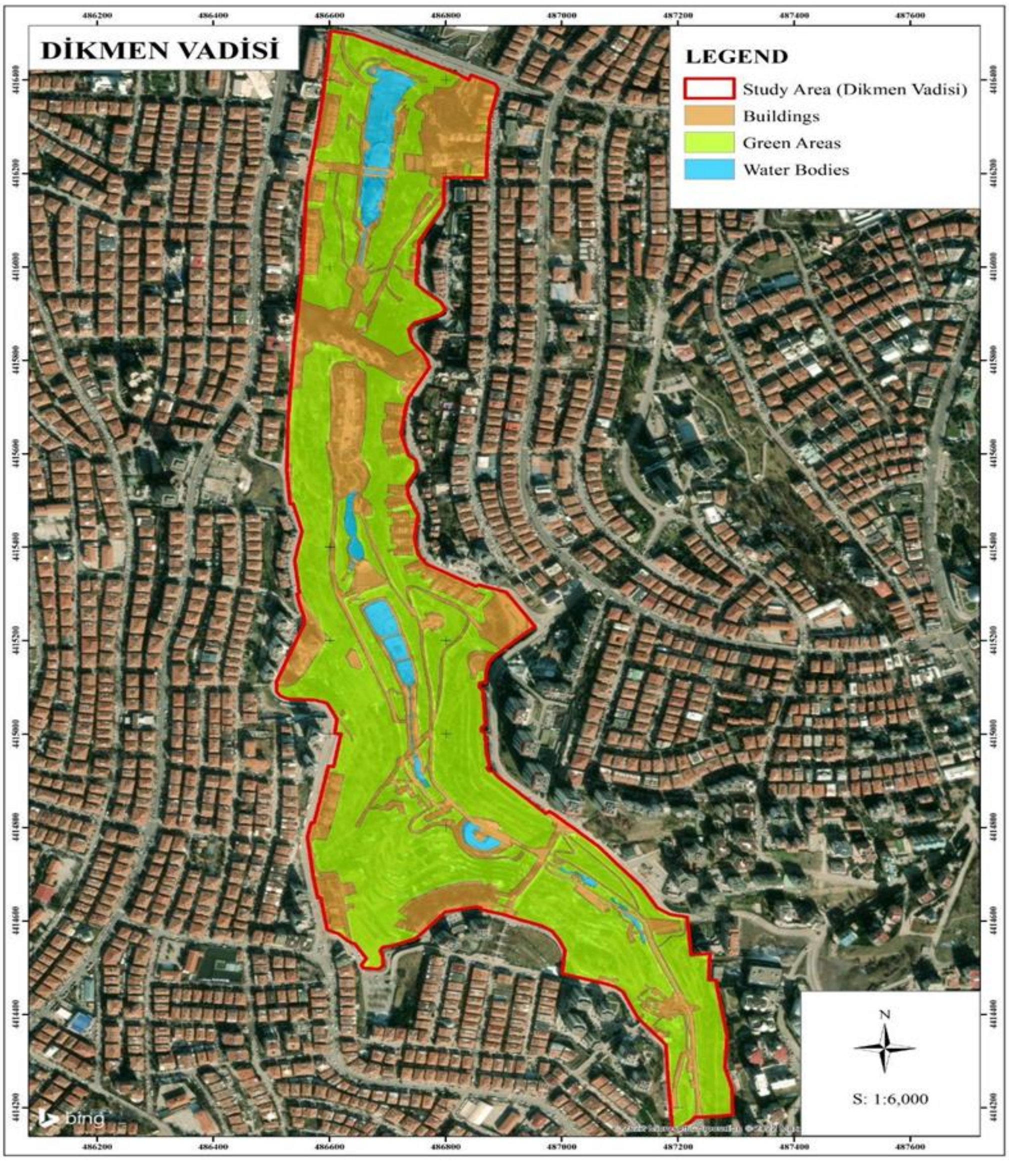

Figure 3.6 Dikmen valley (Dikmen Vadisi) map

Figure 3.7 Water Ponds inside Dikmen valley (Dikmen Vadisi)

Figure 3.8 Dikmen valley (Dikmen Vadisi) from above

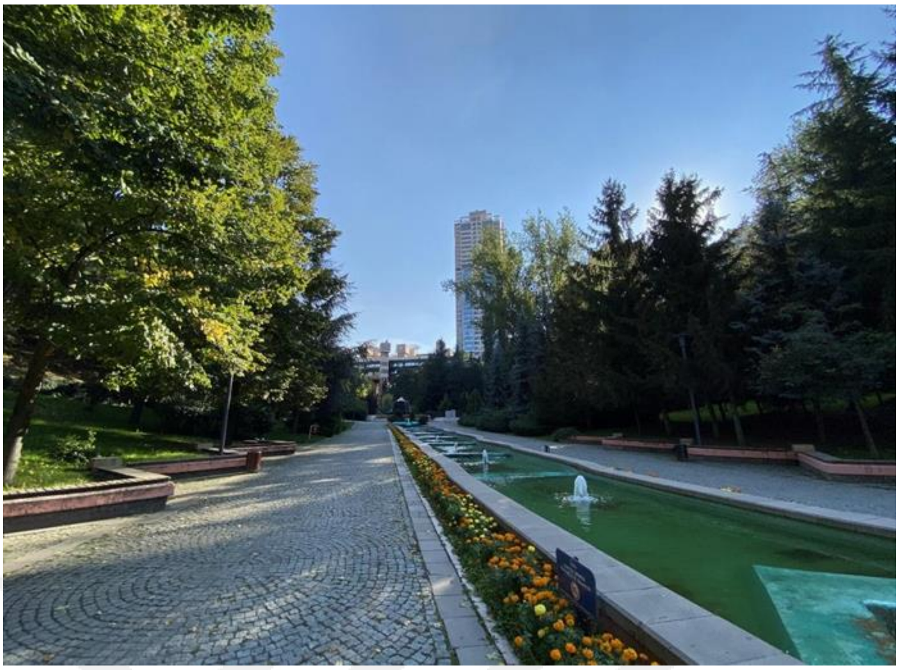

Figure 3.9 Artificial Waterfalls inside Dikmen valley (Dikmen Vadisi)

Figure 3.10 Small stream inside Dikmen valley (Dikmen Vadisi)

3.2.1.2 Youth park (Gençlik Park):

History of the park

Gençlik Park, situated in the heart of Ankara, stands as a prominent testament to the city's rich historical heritage. This park, renowned for its historical significance, has become an integral part of Ankara's cultural landscape. With its origins dating back to a bygone era, Gençlik Park has evolved into a cherished public space that not only offers recreational amenities but also serves as a symbol of Ankara's historical and cultural identity. As a historical park, the inaugural urban park of the Republic of Turkey is situated in the Ulus district of Altındağ, which is positioned near the heart of Ankara, the capital city.

The location in question is encompassed by various prominent landmarks. To the north lies Ulus Square, a significant public space that holds historical and cultural significance. Towards the east, one can find the Ankara Opera House, which was previously known as the Ankara Exhibition Building. This architectural marvel serves as a hub for artistic performances and cultural events. Moving towards the south, the area is flanked by the Selim Sırrı Tarcan Sport Hall, a venue that hosts a multitude of sporting activities. Additionally, the Ankara Central Station, a pivotal transportation hub, is also situated in close proximity. Finally, to the west of the location lies the 19 Mayıs Stadium, a renowned sports arena that attracts a multitude of spectators.

During the formative years of the Turkish Republic, the geographical location where the park currently stands was characterized by the presence of marshland. This particular topographical feature, known for its waterlogged and low-lying terrain, played a significant role in shaping the early development and subsequent transformation of the surrounding area. After the successful drainage of the marshes, a significant transformation took place in the form of the establishment of Youth Park. This remarkable park, which came into existence in the year 1936, stands as a testament to the ingenuity and determination of those involved in its creation. The marshes, once characterized by their wet and swampy conditions, were meticulously drained to make way for this recreational space that would cater specifically to the needs and interests of the younger The construction of the park commenced and spanned a duration of seven years, culminating in its establishment and subsequent opening to the public on the auspicious date of 19 May 1943, which coincided with the commemoration of National

Youth Day.In this discourse, we shall delve into the subject matter at hand, namely the user's text, The vicinity of the expansive 42,000 square meters (0.016 square miles) main pool was adorned with various coffee houses, providing a recreational space for individuals to indulge in the consumption of this popular beverage. Additionally, the recreational facilities in the area included a swimming pool, a luna park, an open-air theatre, and tracks, further enhancing the overall entertainment value of the location. In the year 1957, a notable addition was made to the park's array of amusement attractions in the form of two intricately designed miniature trains. These trains were carefully established within the park area, serving as captivating features that added to the overall allure and entertainment value of the park .

The park characteristics

The establishment was situated on a land area measuring 275,000 square meters. The altitude of the location is approximately 850 meters (2,790 feet), rendering it among the least elevated areas within Ankara. The park is equipped with six distinct entrance doors and encompasses a total area of 61,724 square meters of hard flooring, 45,782 square meters of pool area, and 1,790 square meters dedicated to a children's playground as in as in (Figure 3.11).

Figure 3.11 Youth Park (Gençlik Park) Map

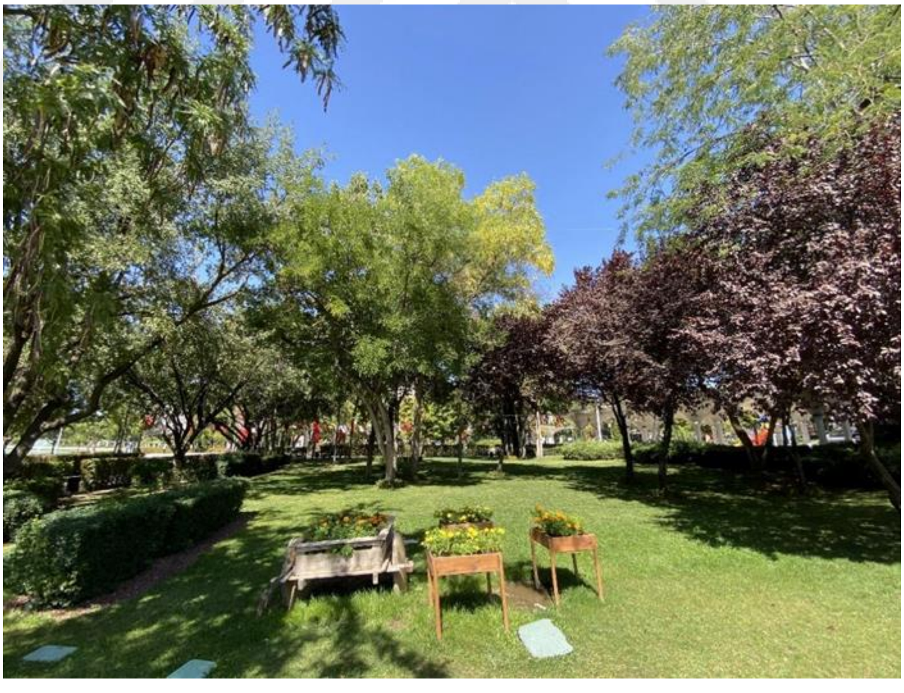

Figure 3.12 Green areas inside Youth Park (Gençlik Park)

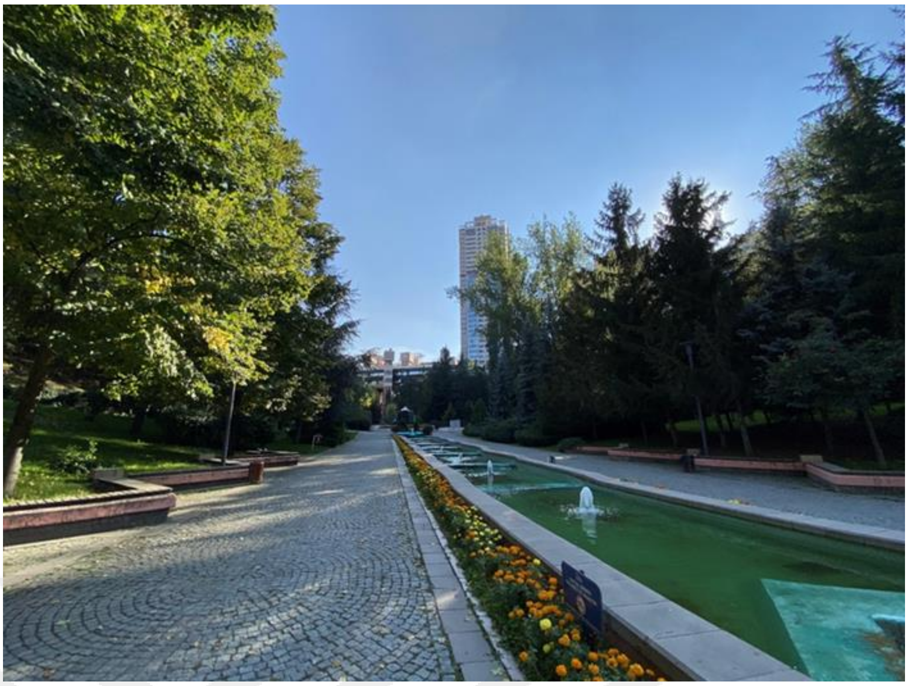

Figure 3.13 Artificial water falls inside Youth Park (Gençlik Park)

3.2.1.3 Golden park (Altınpark)

History of the park

In the Altinpark neighborhood, which is located in the Altinda district, you'll find one of the city's most extensive recreational areas. Up until the year 1977, this location served as a golf club. The project that ended up winning the competition was used to create the one and only Altnpark that exists today. It was opened in 1985.

Park Characteristics

It has a total area of 640 thousand square meters, of which only 15% is taken up by buildings, and the remaining 85% is made up of green space and ponds. Out of the 640 000 m^2, there are green areas that comprise 261,160 m^2, ponds that comprise 32,700 m^2, and bushes that comprise 46,758 m^2.

Trees can be found across an area that is 17,466 square meters in size. Ponds, gardens, production sites, an Olympic swimming pool, a mini golf course, horse backgammon, the Cultural Center, henna, and wedding halls are included in the recreation and entertainment areas of this park as in (Figure 3.15).

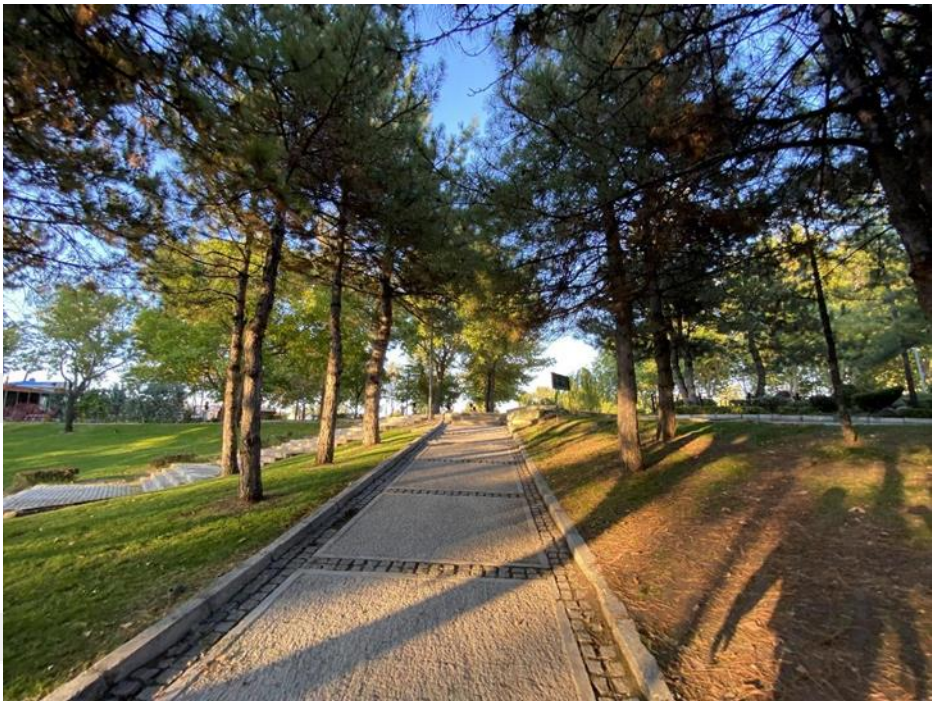

Figure 3.14 Walking paths inside Golden Park (Altınpark)

Figure 3.15 Golden Park (Altınpark) map

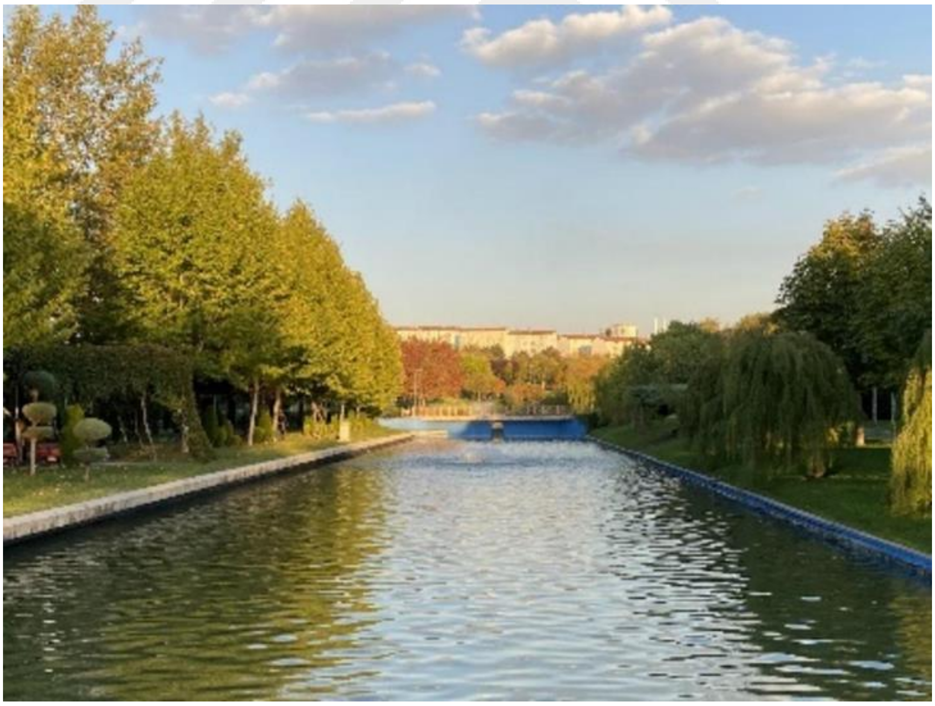

Figure 3.16 Water stream in Golden Park (Altınpark)

Figure 3.17 Urban buildings in Golden Park (Altınpark)

3.2.2 Data collection and analyzing

The bat voice recordings were recorded along the same pathways (which covered the buildings, green areas, ponds, and other features of the parks) beginning on May 10th, 2022 and continuing until November 30th, 2022, a total of seven months See Figures 3.6, 3.11, 3.15. On Google Earth, buildings, bodies of water, and patches of vegetation were mapped out for each of the three urban parks whose boundaries were determined. Within the ArcGIS program, a database pertaining to these regions was developed. The regions that were drawn on Google Earth were exported to the ArcGIS program, where they were digitized, and then added to the database. Using these data, maps that belonged to three different urban parks were created using Bing Maps, which were derived from the online maps in the ArcGIS program.

Area patches were then calculated.The accuracy percentages of the analysis results obtained in species identification do not give clear results, as seen in the studies conducted on a global scale (Rydell *et al.* 2002), so the analysis results of the audio files were transferred to the graphics using the audio recordings and analyses made in different regions of Turkey (Ürker and Yorulmaz 2020). This was done because it is known that the accuracy percentages of the analysis results obtained in species identification do not give clear results. In order to conduct an analysis of the audio files that were captured by the EchoTouchMeter 2 pro device, licensed versions of the analysis programs bcAdmin, batIdent, and bcAnalyze2 were utilized. On a portable computer running Apple Mac Book OSX 10.10.1, the pertinent data was analyzed and recorded.The rate determined for the consensus system regarding the type of a sound in this study was determined to be 95% (Russ 2012, Parsons and Jones 2000, Russo and Jones 2002, Rydell *et al.* 2002, Obrist *et al.* 2004). This rate was determined after taking into consideration the factors such as the error margin of the software and sound quality in the sound analysis programs used for the diagnosis and identification of the sound recordings obtained from the manual detector. On the other hand, the evaluation also took into account audio recordings, despite the fact that they had a rate that was lower than this one and that their accuracy had been verified by analyzing the sound graphics.In the end, the community parameters were determined by taking into account the total number of bat voice records for each species and treating them as a frequency. The Dominance Index, Richness, Margalef's Richness Index (Margalef 1958), Shannon-Wiener's Diversity Index (Spellerberg *et al*. 2003), Evenness Index (Magurran 1988), and Sørensen's Similarity Index (Sørensen 1948) were used to compare bat community parameters in three different parks (Krebs 1989). These indices were developed by Margalef.

Following indices of community properties (Krebs 1989) were used in this study:

Dominance Index: 100*[(y1+y2)/Y]

y1: The number of first species that has highest frequency in the studied park

y2: The number of second species that has highest frequency in the studied park

Y: Total frequency

Richness: Total species number that had been saved during the study

Margalef Richness Index: (S-1)/lnY   S: Richness, Y: Total frequency

Sørensen's Similarity Index: 2a / (2a+b+c)

a: is the number of species shared by the two parks

b: the species numbers in Park 1

c: the species numbers in Park 2

3.2.3 Statistical analyses

In this study, the ANOVA test was used to examine if there exists a statistically significant disparity in the distribution of bat species observed over a period of seven months across three parks in comparison to other parks. ANOVA, or analysis of variance, is a set of statistical models used to examine the means of different groups and the associated processes, such as variations within groups and across groups. Analysis of variance (ANOVA) is an inferential statistical test used to determine the equality or inequality of averages across many groups. This test extends the two-group t-test to include scenarios involving numerous groups.

The multiple comparison test established by Herberich et al. (2010) was used in this research due to the absence of normal distribution and the presence of heterogeneous variance in the data under investigation. The data set was produced using the R software for statistical analysis, as described by Giorgi et al. (2022). The following is a summary of the code flow used.

```
library(sandwich)

library(multcomp)

GP<-NULL

Grup<-factor(data$grup)

GP<-Grup

Species<-data$Species

mdl<-aov(Species~GP)

summary(mdl)

mdl_comp<-glht(mdl,linfct = mcp(GP="Tukey"),vcov=vcovHC)

results<-confint(mdl_comp)

summary(results)
```

Simultaneous Tests for General Linear Hypotheses

Multiple Comparisons of Means: Tukey Contrasts

Fit: aov(formula = Species ~ GP)

Linear Hypotheses: Estimate, Std. Error, t value, Pr(>|t|)

In this study, the multiple comparison test established by Herberich *et al.* (2010) was used due to the absence of normal distribution and the presence of variable variance in the analyzed data. The findings of this test are shown in (Table 3.2). Based on the aforementioned data, it was determined that the value of "Pr(>|t|)" regularly exceeded 1.000.

Table 3.2 Multiple comparisons of the linear hypotheses

Species	Comparisions	Estimate	Std. error	t value	Pr(>|t|)
Hsav	D - G == 0	-2.7857	2.1296	-1.3080	0.399
	Y - G == 0	0.5476	3.7918	0.1440	0.988
	Y - D == 0	3.3333	3.5978	0.9260	0.622
Msch	D - G == 0	-3.357	7.200	-0.466	0.887
	Y - G == 0	-5.190	8.617	-0.602	0.819
	Y - D == 0	-1.833	7.129	-0.257	0.964
Nnoc	D - G == 0	-0.0714	0.6667	-0.1070	0.9940
	Y - G == 0	-0.0714	0.6773	-0.1050	0.9940
	Y - D == 0	0.0000	0.7653	0.0000	1.0000
Pnat	D - G == 0	-9.8040	6.2690	-1.5640	0.2590
	Y - G == 0	-9.9290	6.2480	-1.5890	0.2490
	Y - D == 0	-0.1250	1.1630	-0.1070	0.9930
Ppip	D - G == 0	-11.8900	42.6800	-0.2790	0.9580
	Y - G == 0	-32.6400	38.8400	-0.8410	0.6790
	Y - D == 0	-20.7500	30.3800	-0.6830	0.7730
Ppyg	D - G == 0	1.2500	1.0640	1.1750	0.4580
	Y - G == 0	3.6670	3.4020	1.0780	0.5150
	Y - D == 0	2,4170	3.5650	0.6780	0.7630
Vmur	D - G == 0	-0.1429	0.1543	-0.9260	0.6120
	Y - G == 0	0.3571	0.4047	0.8820	0.6390
	Y - D == 0	0.5000	0.3742	1.3360	0.3730
Tten	D - G == 0	Inconsistent, Invalid			
	Y - G == 0				
	Y - D == 0				
Pkuh	D - G == 0	Inconsistent, Invalid			
	Y - G == 0				
	Y - D == 0				

.

4. RESULTS AND DISCUSSION

4.1 General Findings

The research yielded conclusions about the manual detection analyses conducted in Ankara City from May to November 2022, revealing the discovery of a total of 9 bat species throughout 3 parks. The species listed in Table 3 included *Hypsugo savii (Hsav)*, *Miniopterus schreibersii (Msch)*, *Nyctalus noctula (Nnoc), Pipistrellus kuhlii (Pkuh), Pipistrellus nathusii (Pnat), Pipistrellus pipistrellus (Ppip), Pipistrellus pygmaeus (Ppyg), Tadarida teniotis (Tten)*, and *Vespertilio murinus (Vmur)*.(Table 4.1).

Table 4.1 The bat fauna list recorded in the three urban parks studied as months (The first numbers show total bat voice records) (The numbers in parentheses show the total activity of the bat species in seconds in the total voice records)

Months/Parks	***H sav***	***M sch***	***N noc***	***P kuh***	***P nat***	***P pip***	***P pyg***	***T ten***	***V mur***
May-G	0	43 (535,5)	0	0	31 (354,37)	229 (2660,1)	0	0	0
Jun-G	11 (99,20)	9 (135)	2 (11,7)	6 (87,67)	36 (469,62)	132 (1514,4)	0	0	0
Jul-G	10 (64,2)	16 (213,53)	2 (21,27)	0	1 (15)	139 (1498,4)	0	0	1 (6,8)
Aug-G	7 (67,2)	12 (164,4)	0	0	5 (41,89)	91 (912,35)	0	0	0
Sep-G	2 (15,62)	3 (19,8)	0	0	2 (16,71)	11 (93)	0	0	0
Oct-G	5 (32,04)	0	0	0	2 (11,8)	7 (74,8)	0	0	0
Nov-G	2 (17,8)	0	0	0	3 (25,9)	8 (61,75)	0	0	0
May-D	0	6 (61,5)	0	0	0	53 (510)	0	2 (13,56)	0
Jun-D	0	21 (293,5)	4 (41,23)	0	4 (34)	79 (886,5)	0	0	0
Jul-D	9 (75,17)	6 (72,71)	0	0	0	209 (1996,3)	0	0	0
Aug-D	5 (40,9)	27 (302)	0	0	0	103 (1112,8)	8 (64,4)	0	0
Sep-D	2 (10,72)	4 (22,2)	0	0	3 (20,5)	33 (237,2)	0	0	0
Oct-D	4 (43,8)	0	0	0	0	22 (196,3)	2 (12,87)	0	0
Nov-D	0	0	0	0	0	2 (9,9)	0	0	0
May-Y	0	4 (44,76)	0	0	6 (65,61)	109 (1187,5)	0	0	0
Jun-Y	8 (85,94)	34 (488,8)	3 (38,95)	0	4 (38,15)	98 (1093,6)	0	0	0
Jul-Y	20 (153,73)	0	0	0	1 (15)	94 (1044,3)	0	0	0
Aug-Y	4 (24,05)	5 (46)	0	0	0	69 (673)	19 (136,6)	0	2 (30)
Sep-Y	3 (16,28)	0	0	0	3 (18,93)	52 (581,6)	0	0	1 (7,2)
Oct-Y	0	1 (14,15)	0	0	0	10 (64,1)	3 (18,5)	0	0
Nov-Y	0	0	0	0	1 (9,4)	10 (84,3)	0	0	0

G: Golden Park, D: Dikmen Valley, Y: Youth Park

The study identified nine bat species in urban parks, including both urban-adapted and forest/rock-dwelling species. Some species were recorded in urban areas for the first time. This underscores urban parks' role in supporting diverse bat populations and their conservation. (Figure 4.1).

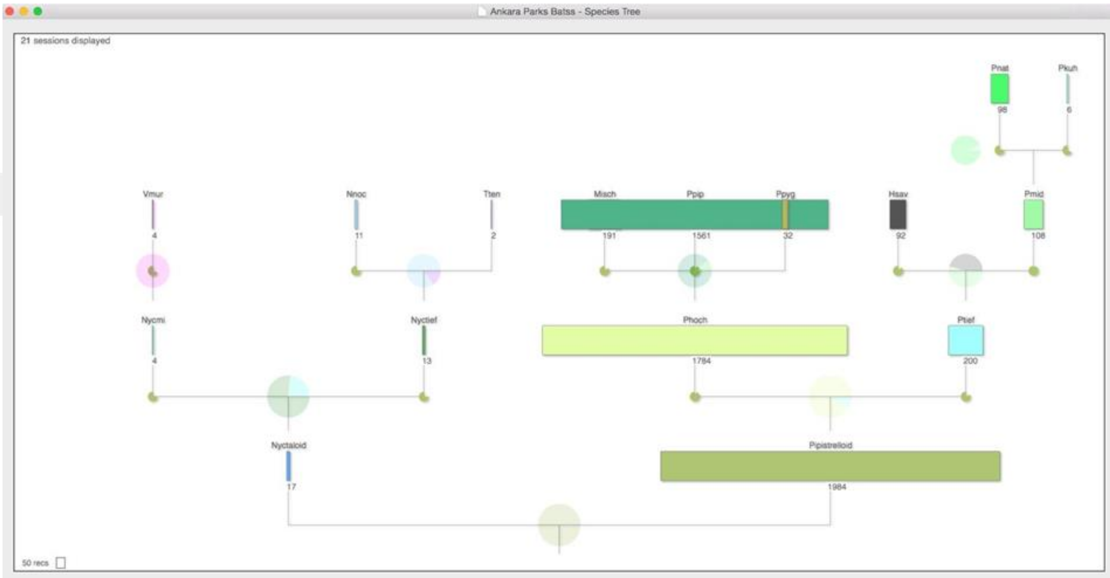

Figure 4.1 Bat species tree

The study unveiled distinct nocturnal activity trends among bats in urban parks. These trends varied seasonally, with heightened activity during the nursery and lactation periods, coinciding with reproduction, and reduced activity during hibernation. This indicates bats' adaptability to urban environments and their biological responses to changing conditions. Recognizing these patterns aids in conservation and urban planning efforts, facilitating the coexistence of bats and humans within urban parks.turnal activity trends (Figure 4.2, Figure 4.3).

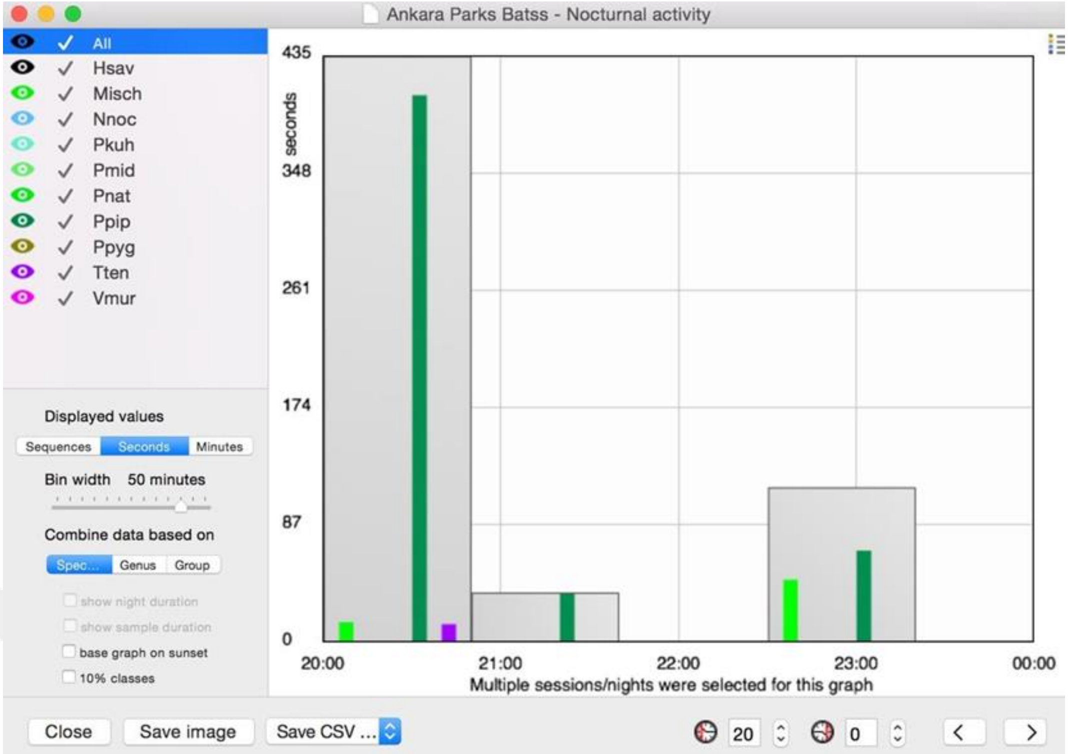

Figure 4.2 Nocturnal activity trends

In the course of a period of seven months, 21,280 seconds of bat activity were recorded in three parks, four days a month (once a week), and for a total of three hours a day. The record for most activities was obtained from Golden Park, which accounted for 43 percent of this time. The Youth Park recorded the fewest number of participants, with only 28.1%. During this time period, *Ppip* was recorded as the most dominant and most active species in all parks, accounting for 77.5% of the total time, whereas *Tten* was recorded as having the lowest activity, accounting for 0.06%. It has been observed that the period of June and July in Golden Park is the most abundant in terms of the variety of species. November is the month that has the least amount of activity, and within this month, Dikmen Valley with a single species had the least amount of activity of any location. *Ppip* achieved the highest activity record of any species during the month of May in Golden Park, accounting for 12.5% of the total activity time recorded throughout the entirety of the study (Figure 4.3).

When the records were analyzed, which had been obtained in accordance with the annual biological cycle of bats, it was found that the period of time immediately following the period of pregnancy in which the bats were nursing their young had the highest activity record. On the other hand, it was discovered that during the hibernation period, very few records of activity were taken (Figure 4.3).

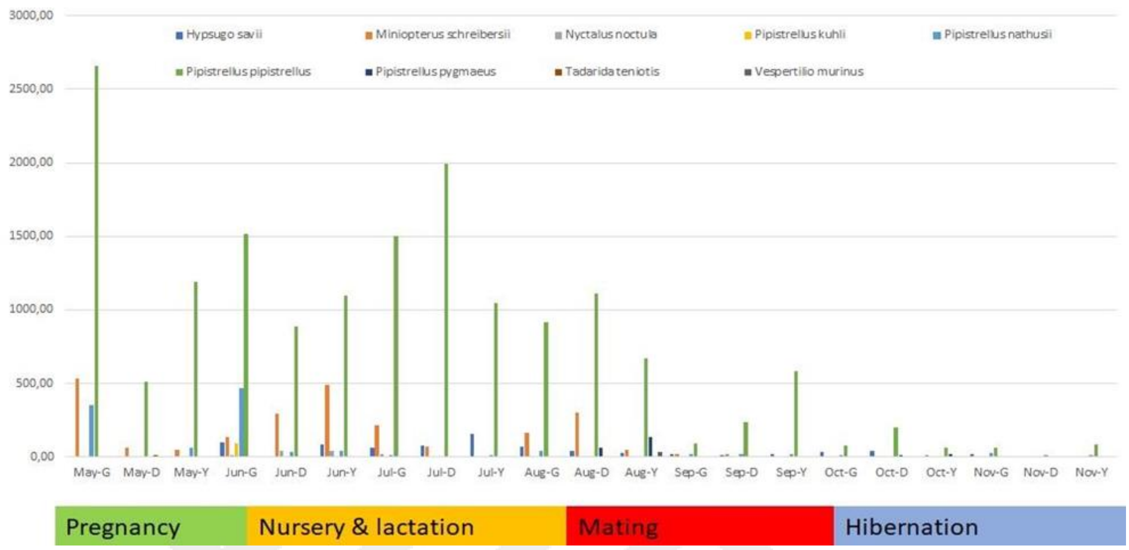

Figure 4.3 Graph of bat species activity (in seconds) by months and parks due to annual biological cyclus

4.2 Community Parameters

The bat community of the three urban parks was assessed by comparing them using several metrics, including Dominancy, Richness, Margalef's Richness Index, Shannon-Wiener's Diversity Index, Evenness Index, Average Population Size, and Sørensen's Similarity Index. Based on an analysis of dominance rates and frequency, it can be shown that Dikmen Valley has the highest dominance ratio among the three parks under consideration. Furthermore, the species *Ppip* demonstrates the greatest level of dominance throughout all three parks.While the richness value of other word species numbers is same across all three parks, it is evident that Goldenpark exhibits greater values in terms of variety, evenness, and average population sizes compared to the other parks.

Simultaneously, it seems that both Dikmen Valley and Youth Park exhibit a comparable and higher Richness Index ratio. Based on the similarity index, the ratio of similarity between Golden Park and Youth Park, as well as Dikmen Valley and Youth Park, is equivalent. However, this ratio is lower compared to the similarity between Golden Park and Dikmen Valley, as shown in (Table 4.2).

Table 4.2 Summary of the bat community parameters for the three urban parks included in the study

Community parameters	Golden Park	Dikmen Valley	Youth Park
Dominancy Index	84.54	92.92	86.17
Richness (Species number)	7	7	7
Richness Index	0.89	0.93	0.94
Diversity Index	0.884	0.680	0.841
Evenness	0.454	0.349	0.432
Average population size	118	86.9	80.6
Similarity Index	Golden Park	Dikmen Valley	Youth Park
Golden Park	*	1.4	0.85
Dikmen Valley	1.4	*	0.85
Youth Park	0.85	0.85	*

4.3 Discussion

Urban parks have a crucial role in supporting a diverse range of plant and animal species, particularly common bird and bat species, hence fostering biodiversity (Baker and Harris 2007, Chiesura 2004, Cornelis and Hermy 2004, Millennium Ecosystem Assessment 2005, Konijnendijk *et al.* 2013, Sadeghian and Vardanyan 2013). This study found that the species *Ppip* and *Pkuh,* which were often detected in human settlements, had the greatest levels of activity inside urban parks. Furthermore, this research documented the presence of *Hsav*, *Tten*, *Vmur*, and *Ppyg* species in urban settings, which were previously only known to inhabit wild regions in Türkiye.

Upon examination of the species identified within the surveyed parks, it was ascertained that a variety of species, including *Hsav, Nnoc, Vmur, Pnat,* and *Ppyg,* which are predominantly observed in forest ecosystems, along with species that have successfully adapted to urban environments such as *Ppip* and *Pkuh*, as well as *Tten*, a species known to inhabit rocky habitats, also utilize urban parks situated amidst densely populated areas.

In contrast, it was noted that the *Ppip* species, renowned for its widespread distribution and diverse feeding and roosting behaviors, had comparably elevated levels of activity throughout the three parks examined. The aforementioned findings indicate that closely related species exhibit comparable behavioral patterns both in their natural habitats and inside urban parks located in densely populated regions (Geggie and Fenton 1985, Gehrt and Chelsvig 2003).

The scarcity of documented occurrences of species such as *Ppyg*, *Vmur*, and *Tten*, even within their native environments, has been established in previous studies (Russo and Jones 2002, Rydel *et al.* 2017). It is important to acknowledge that the data collected in this research may be subject to random variation.

Previous research conducted by Voigt and Kingston (2016) has shown that some species, including *Hsav*, *Nnoc*, and *Pnat*, exhibit adaptations in their roosting and feeding behaviors inside forest ecosystems. Interestingly, these species demonstrate increased activity levels within Golden Park, a park characterized by its older age and greater density of greenery, when compared to other parks. Nevertheless, due to the fact that all three parks serve as zones where heavily vegetated regions are surrounded by a highly inhabited metropolis such as Ankara City, it is possible to gather activity data of these species from all three parks.

While the Richness index values for Dikmen Valley and Youth Park are about the same, the lower value obtained in similarity ratios suggests that the two parks exhibit differences in terms of species composition. The increased dominance of *Ppip* species in Dikmen Valley, although having a comparable species richness to other parks, may be attributed to the low frequency values of some other species reported in this park. This might be attributed to the limited duration of activity recordings, as noted by Altringham (2011). However, it should be noted that while the richness value is consistent throughout all three parks, the richness index is subject to variation due to the varying frequency of species recordings in each park.

Despite variations in dominance and richness index values, the similarity in species composition between Golden Park and Dikmen Valley can potentially be attributed to their comparable area sizes and distribution ratios of habitats, including water bodies, green areas, buildings, and others (Kurta and Teramino 1992, Dietz *et al.* 2009, Avila-Flores and Fenton 2005). According to Kutbay *et al*. (2019), there exists a correlation between variety and evenness values, albeit this connection is influenced by population densities. The community metrics derived from Goldenpark exhibit a comparatively elevated level, so substantiating the pertinent perspective. The Goldenpark area has low dominance and richness index values. However, it is noteworthy that the community dimensions of variety and evenness, as discussed earlier, are much greater.

This observation aligns with previous studies conducted by Cornelis and Hermy (2004), Sherman *et al.* (2008), and Kopec *et al.* (2010), suggesting that such a scenario is anticipated and meaningful.

Studies indicate that animal species are increasingly occupying urban environments and undergoing adaptations to urbanization, a phenomenon often referred to as synurbanization (Luniak 2004). Research findings indicate that synurbanization has been associated with heightened levels of mammalian aggressiveness, boldness, and attentiveness towards both people and other animals (Parker and Nilon 2008, Hume *et al.* 2019). According to Li *et al.* (2020), urban bats do not exhibit avoidance behavior towards crowded or highly active places. Based on the data collected in this research conducted across three distinct urban parks, it is evident that despite the presence of significant human activity, bat activity was consistently observed over the duration of the study. Parks located in urban areas, particularly in large cities, serve as notable instances where bats coexist with people, exemplifying the notion of synurbanization (Luniak 2004, Grimm *et al*. 2017).

In urban environments, human disruptions may arise from the presence of people, whether or not they directly interact with animals, or through alterations to the environment resulting from human activity (Tablado and Jenni 2017, Grimm *et al.* 2017). As outlined by Luniak (2004), synurban wildlife species that achieve success in urban environments have behavioral adaptations that enable them to endure interruptions caused by human activities. As reported in the study by Li (2020), the behavior of animals may be influenced by human activities and environmental changes occurring throughout the weekend. Upon examination of the human activity intensities, namely noise and light pollution, inside the three parks under investigation, it was observed that the highest values were recorded at Youth Park. Based on the results collected in this research, it was observed that the youth park had the lowest overall bat activity. This finding demonstrates that bats are susceptible to the negative impacts of noise, light pollution, and high levels of human activity.

As per Ancillotto *et al.* (2019), the proximity of people to the roost had an impact on the departure behavior of bats, resulting in a delay in their emergence. The emergence duration seen in insectivorous bats may be understood as a trade-off between the potential vulnerability to visual flying predators and the associated danger of becoming prey, as discussed by Mikula *et al.* (2016). According to Shirley *et al.* (2001), the presence of humans in close proximity to bat roosts might result in the postponement of bat emergence, decreased levels of activity, and even the abandonment of the roost. Upon analyzing the daily activity log from 8 to 11 p.m. in this research, it was seen that despite the presence of significant human activity factors such as movement, noise, and light pollution from 8:00 to 9:00 p.m., there was also a notable increase in bat activity during this time period. Hence, a comprehensive assessment has shown that the departure of bats from their roosting sites in urban environments, such as municipal parks, does not exhibit any detrimental consequences (Ancillotto 2019).

5. CONCLUSIONS AND RECOMMENDATION

The study, that was conducted in 2022, aimed to investigate the presence, occurrence, abundance, variety, and ecological impacts of bats on the urban environment of three primary parks located within the metropolitan area of Ankara, the capital city of Turkey. The preservation of bio-ecological conditions for current bat species has also been a topic of discussion in relation to these parks. The significance of this research lies in its collecting of data, which is particularly valuable for Türkiye and its neighboring regions with comparable geographical characteristics.

The study results indicate that human-induced influences, including noise and light pollution, have a negative effect on bat behaviors. Nevertheless, it is important to highlight that urban parks play a significant role as essential habitats for bats during their whole biological life cycle.

Based on the findings of this study, it is evident that further investigation is necessary to enhance our understanding of the correlation between the urban planning components (such as housing areas, public buildings, streets and avenues, industrial areas, suburbs, and urban parks) and the activity patterns of bats. This research is crucial for the purpose of effectively managing conflicts between bats and humans in the future.

This study highlights the significance and immediacy of enhancing the capacity of urban parks. Given the escalating and uncontrolled urbanization in metropolises globally, city parks are anticipated to assume a significantly greater role in supporting urban wildlife, particularly bats, in the foreseeable future. Consequently, it is imperative to incorporate these parks into urban planning processes, recognizing their contribution to ecosystem services.

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