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HABITAT PREFERENCES OF COMMON KESTREL *Falco tinnunculus* IN ZAGREB

*Izbor staništa vjetrove *Falco tinnunculus* u Zagrebu*

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ABSTRACT

Common Kestrel *Falco tinnunculus* is a bird of prey that colonized European cities most successfully. It is a resident bird in Zagreb, nesting in the centre of the city. The main purpose of this study was to locate and analyse the positions of active nests of Common Kestrels during the breeding season of 2017 in Zagreb. "The Atlas of breeding birds of Zagreb" was used as the basis of knowledge about the distribution of Kestrels in Zagreb. After the field research, the characteristics of nesting sites were analysed; subsequently – by using GIS program – the distances between nesting sites and nearest urban green areas that are used for foraging were measured. This study gave insight into the habitat preferences for the nesting of Kestrels in Zagreb. It has been shown that the most suitable buildings for the nesting of Kestrels in Zagreb are residential buildings with an average height of 50.1 meters. Beside smaller urban green areas, large green areas outside the city centre were also of great importance, with the embankment of the Sava river proved to be the most significant one.

Keywords: *Falco tinnunculus*, birds of prey, nest, nesting, urban areas

INTRODUCTION

Urban areas are nowadays becoming more and more widespread. Urbanization is considered one of the most important factors responsible for the decrease of biodiversity and the homogenization of environments (JOKIMÄKI *et al.* 2016). Increased urbanization usually leads to an increase in biomass of birds, but also

to a decrease in species diversity (CHACE & WALSH 2004). Domination of some bird species and low level of diversity can lead to homogenisation in bird communities. It has been shown that the number of breeding bird species in urban core zones of European cities is approximately 20% of the total number of European breeding bird species (JOKIMÄKI *et al.* 2016). One of the factors that have an effect on bird species diversity in urban areas is disturbance caused by human activities, although it is been shown that some bird species are still capable to successfully colonise urban environment (JOKIMÄKI *et al.* 2016). Although urbanisation reduces the diversity of animal species by destroying natural habitats, to a lesser extent it also creates new habitats for some species (CHARTER *et al.* 2007). Bird species often depend on vegetation structure. Therefore, some native bird species inhabit urban areas, which, despite important habitat changes, keep the native vegetation. For some birds, urban areas provide rich food supplies, either directly (at bird feeders) or indirectly – in areas of waste treatment, collection and transfer (CHACE & WALSH 2004).

Urban habitats can be of superior quality for some raptor species, because in these habitats raptors are often free from persecution, and may have an adequate food supply. This may encourage raptors to inhabit some, usually unsuitable, nesting sites. Many species of raptors have taken advantage of artificial nesting sites, which can sometimes lead to a greater reproductive success than on wild sites (CHACE & WALSH 2004). Many species of falcons respond well to urban habitats because of the greater biomass of small birds (CHACE & WALSH 2004). Some studies have also shown that some raptor species have changed their diet habits after moving from agricultural habitats (where they usually feed on rodents) to urban areas (where they feed on passerine birds) (SORACE 2001).

Common Kestrel breeds throughout much of Europe, Africa and Asia (VIL-LAGE 1990). Compared to other birds of prey, it has successfully colonised cities. This is shown through higher breeding densities in cities than in farmland populations (RIEGERT *et al.* 2007). As permanently changing the ecosystem, urban areas suffer from decreasing biodiversity, and now they are characterized by lower proportions of green space and the conversion of original vegetation or farmlands to parklands and backyards (SUMASGUTNER *et al.* 2014). The main part of Kestrels diet being rodents, they are forced to hunt them outside the urban centres. This is why one of the most important factors for successful nesting is short distance from nesting sites to open green areas (RIEGERT *et al.* 2007). The availability of suitable nesting sites in urban areas can be a limiting factor for Kestrels breeding occurrence, although it is known that any kind of building that provides protection and can hold eggs is a potential nesting site for Kestrels (SUMASGUTNER *et al.* 2014). On the other hand, studies have shown that Kestrels breeding in urban habitats use different types of nests and prey on more bird species than those breeding in rural habitats, which leads to higher reproduction

level of urban pairs (CHARTER *et al.* 2007). Urban populations of Kestrels showed genetic and behavioural differences compared to Kestrels from rural habitats (SUMASGUTNER *et al.* 2014).

Common Kestrel is a numerous and widespread breeding species in Croatia. The breeding population was estimated to around 9,000 – 10,000 pairs (KRALJ *et al.* 2013). Common Kestrel is a resident bird in Zagreb, nesting even in the centre of the city. Studies on urban Kestrels have been conducted in few European cities (KÜBLER *et al.* 2005, SUMASGUTNER *et al.* 2014, RIEGERT *et al.* 2007, SALVATI *et al.* 1999, SORACE 2001), but not in Croatia. The main purpose of this study was to locate the positions of active nests of Common Kestrel during the breeding season of 2017 in Zagreb and analyse the habitat preference of urban Kestrel population.

MATERIAL AND METHODS

The analysis of Common Kestrel habitat has been conducted in Zagreb, Croatia (45°49'N, 15°59'E). Zagreb situated in the northwest part of Croatia, on the slopes of the Medvednica mountain along the Sava river (DEPARTMENT OF APPLIED COMPUTING, OFFICIAL WEBSITE 2017). The climate in Zagreb is of continental type, the summers are hot and dry, with an average temperature around 21°C, and winters are cold, with an average temperature around 1°C. In the spring of 2017, when the study was conducted, maximum and minimum temperatures were as follows: March 23°C/-2°C, April 25°C/-1°C, May 31°C/7°C, and the first half of June 31°C/9°C (ACCU WEATHER 2017). The surface area of Zagreb is 641.355 km², and the population was 790,017 in 2011 (CITY OF ZAGREB, OFFICIAL WEBSITE 2017).

“The Atlas of breeding birds of Zagreb” (KRALJ & KRNJETA 2015) was used as the basis of knowledge about the distribution of Common Kestrel in Zagreb. For the purpose of the breeding bird survey, Zagreb area was divided into a 1x1 km grid. The city was thereby divided into a total of 161 squares, of which 88 were surveyed quantitatively. The presence of Common Kestrel was recorded on a total of 37 squares, and the breeding population was estimated to 45-50 pairs. As the Atlas survey was undertaken in the period from 2003 to 2015, the latest data of currently active nests had to be collected, and the list of new locations completed.

Field research was conducted in the period from the end of March to early June 2017, at the time of the highest activity of Kestrels, when they may easily be spotted thanks to loud calls and frequent flythrough in search for food. This research was concentrated on the central, urban part of the city. Therefore, from 37 squares with the recorded nesting of Kestrels, this study was carried out on the initial 28 squares. The study included a survey of previously known locations, on which nesting of Kestrels had been recorded by KRALJ & KRNJETA (2015), but also on three new locations, on which nesting of Kestrels was recorded in the past

two years by ornithologists, colleagues, and citizens of Zagreb. After the activity of Kestrels had been spotted, the locations of nests were located by observing the birds. Once a nest was located, for each nest type and height of the building and presence of higher buildings in the surrounding area were recorded. For two sites where the pair was active, but the nest has not been located, average height and type of surrounding buildings that might potentially serve as the nesting site were taken. In the analysis of habitat, besides the currently active nests, the locations of five previously known nests were included in order to achieve better coverage of the studied area.

During this study, the hunting activity of Kestrels was recorded on green areas around the nesting sites, and on larger green areas that are more distant from the recorded nests; thus, the characteristics of the used green areas were analysed. For the purpose of this analysis, the QGIS program was used (QGIS Development Team 2017). Using QGIS application (Version 2.18.14.), the Google Maps (Google Satellite) layer has been uploaded via Open Layers plug-in. According to the data collected during field research in the Zagreb area using the Measure Area function, the size of green areas, where the activity of the Kestrels has been recorded, have been measured. Furthermore, using Measure Line function, the air distances between each nest location and nearest urban green areas have been measured. After the analysis, the urban green areas that had been used were divided by size into four categories:

- 1 Green areas up to 5 hectares
- 2 Green areas from 5 to 50 hectares
- 3 Green areas from 50 to 100 hectares
- 4 Green areas larger than 100 hectares

The fourth category includes all large green urban areas (over 100 ha: Sava river embankment, Jarun, Bundek, Grmošćica, Tuškanac, Maksimir).

Using the QGIS application, a view of the analysed locations has been made by uploading the coordinates of locations in the form of Comma Delimited file. For better visibility, the locations have been displayed on the Bing Maps (Bing Road) layer uploaded via Open Layers plug-in.

RESULTS

Nesting locations included in the analysis

After field research conducted on a total of 32 atlas squares, the activity of Kestrels was recorded on a total of 13 squares, out of which on 11, nesting locations were recorded; whereas on 2 squares, the activity of Kestrels was recorded, but the location of the nest has not been specified. Out of the 13 confirmed squares, nesting was recorded on 3 new squares compared to former studies, and activi-

ties without specified nest location were recorded on one new square. Besides the locations on which Kestrels activities were recorded in the breeding season of 2017, additional 5 locations of once active nests were also included in the analysis of nesting sites (Figure 1), giving the total of 18 nests included in the analysis.



Figure 1. Nesting locations of Common Kestrel that have been analysed.

Slika 1. Položaj analiziranih lokacija gniježđenja vjetroše.

Characteristics of nesting sites

The average height of the buildings, on which Kestrels were nesting, was 50.1 ± 26.1 m. The highest building, on which nesting of Kestrels was recorded, is the Zagreb cathedral, which is 105 m high. The majority of nests were located on buildings between 25 and 70 m high. Table 1 shows the height and type of the buildings on which nests were located. Out of the 18 nest locations, on 7 (39%) locations higher buildings were found within a 500 m radius around the building chosen for nesting. On the remaining 11 (61%) locations, the building that was chosen for nesting was the highest in the neighbourhood.

Table 1. Height and type of buildings where nesting of Common Kestrel was recorded.

Tablica 1. Visine i tip građevina na kojima je zabilježeno gniježđenje vjetroše.

	Location	Square	Height of the building (m)	Type of the building
1.	Jordanovac – Dobri dol	G14	30	Residential building
2.	Dubrava - Dankovečka	G19	60	Residential building
3.	Čnomerec – Gjuro Szaba	I9	18	Residential building
4.	Trg bana Jelačića - Katedrala	I13	105	Church tower
5.	Voltino – Dragutina Golika	J9	50	Residential building
6.	Remiza – Jablanovečka ulica	J10	58	Residential building
7.	Trešnjevka – Cibonin toranj	J12	92	Business building
8.	Marulićev trg	J12	25	Business building
9.	Ferenščica	J16	30	Residential building
10.	Prečko – Paljetkova ulica	K6	25	Residential building
11.	Srednjaci	K10	73	Residential building
12.	Knežija - Vjesnik	K11	67	Business building
13.	Vrbik - Prisavlje	K12	73	Residential building
14.	Zeleni trg	K12	70	Residential building
15.	Most Slobode	K13	15	Lightning pole
16.	Trnje - Lastovska	K14	40	Residential building
17.	Knežija - Horvaćanska	L10	35	Residential building
18.	Travno – Božidara Magovca	M14	35	Residential building

The nesting location in relation to urban green areas

In Table 2, the air distances of analysed locations to the nearest green area from each category have been presented. Eleven nests were situated within urban green areas (Figure 2).

The most of the nests were located within category 2 (from 5 to 50 ha), while there were no nests inside category 3 (from 50 to 100 ha). Nests that were not located within one of the categories of green areas were on an average distance of 222.8 (± 204.3) m from the nearest green area.

Figure 3 shows the number of the nests to the nearest green area from category 4. For the largest number of nests (50%), the nearest large green area was the embankment of the Sava river.

Table 2. Distances between nesting locations and green areas.

Tablica 2. Udaljenosti lokacija gniježđenja od zelenih površina.

		Distances between nesting locations and green areas by category (m)			
Location	Square	1. < 5 ha	2. 5–50 ha	3. 50–100 ha	4. > 100 ha
Jordanovac – Dobri dol	G14	100	Within	800	1600
Dubrava - Dankovečka	G19	300	400	2100	1200
Čnomerec – Gjüre Szaba	I9	40	1100	400	850
Trg bana Jelačića - Katedrala	I13	330	Within	500	1500
Voltino – Dragutina Golika	J9	Within	550	3300	2300
Remiza – Jablanovečka ulica	J10	650	1300	3900	2800
Trešnjevka – Cibonin toranj	J12	160	750	2600	2100
Marulićev trg	J12	Within	100	3000	2500
Ferenščica	J16	Within	700	1200	2600
Prečko – Paljetkova ulica	K6	Within	380	670	100
Srednjaci	K10	320	Within	650	1500
Knežija - Vjesnik	K11	140	300	1400	900
Vrbik - Prisavlje	K12	530	Within	660	170
Zeleni trg	K12	100	Within	1400	950
Most Slobode	K13	390	440	140	Within
Trnje - Lastovska	K14	100	200	2200	850
Knežija - Horvaćanska	L10	170	430	1800	500
Travno – Božidara Magovca	M14	80	Within	450	2200
Average distance (m)		190	370	1500	1300

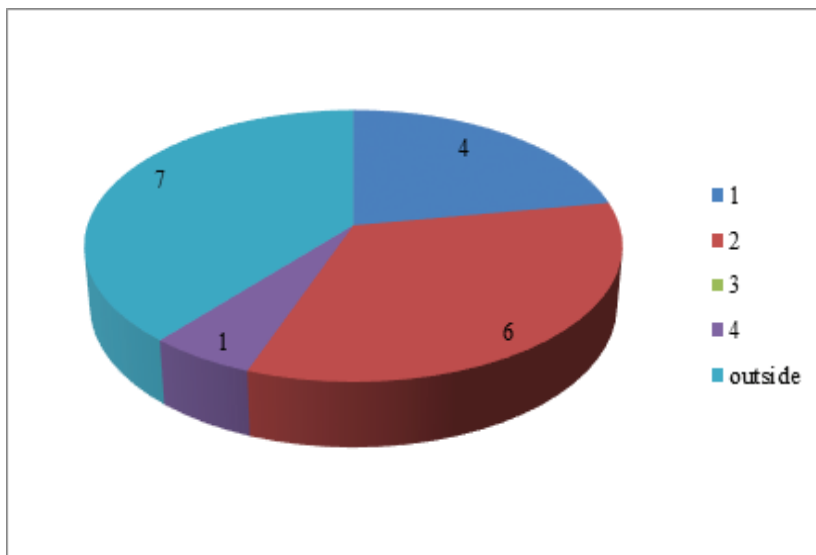


Figure 2. Numbers of nests within a certain category (1-4) of green areas.

Slika 2. Prikaz broja gnijezda unutar određene kategorije (1-4) zelenih površina.

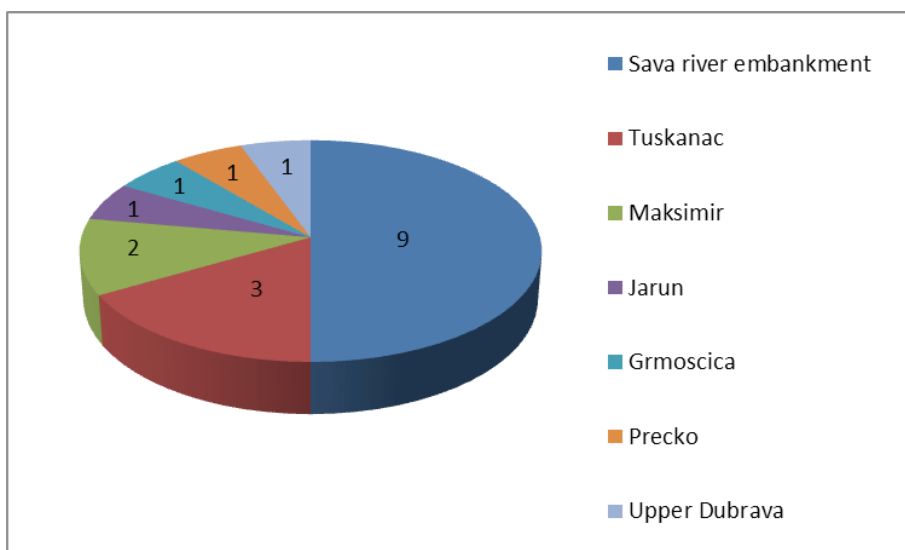


Figure 3. Distribution of the nests by the nearest surface belonging to category 4.

Slika 3. Distribucija broja gnijezda prema najbližoj površini 4. kategorije.

DISCUSSION

The nesting of Common Kestrel in 2017 was recorded on a total of 13 atlas squares. Since this figure also includes the additional 3 squares, in 2017 nesting was confirmed on only 10 out of 28 initially analysed squares. Although this research does not exclude the possibility of Kestrels nesting within some other squares, it should be noted that data from the Atlas, on which this research was based, were up to 14 years old. Over the past period, there have been many changes within the city, both in the construction of new buildings and in the loss of old ones, but also in the creations of new green areas. The unsustainability of some nests is likely to be largely caused not only by human disturbance, but also by abandoning nests due to new and more favourable nesting sites. The study taken in Israel (CHARTER *et al.* 2007) showed that human disturbance caused 41% of all nesting failures of Kestrels, while 14% of the nests were abandoned. Besides human disturbance, the increasing population of urban House Crow *Corvus corone cornix* in Zagreb may also cause breeding failures in Kestrels or abandonment of nesting sites. Although this research has not shown nesting on many of the locations listed in the Atlas, this does not necessarily indicate a significant decline in Kestrel populations in Zagreb. Research in Berlin (KÜBLER *et al.* 2005) has shown that Kestrel populations have been self-sustaining and stable over the years despite annual fluctuations up to 30%.

The results have shown that the largest share (72%) of nests was found on residential buildings. Three nests were placed on a business building (only one of them was active in 2017), one on the church tower and, one on a lightning pole. It can be concluded that residential buildings in Zagreb suit best as a nesting site for Kestrels. This has also been confirmed by the fact that the only currently active nest located in a business building in Zagreb is actually located in a historical building, which does not look like modern business buildings. The research in Rome (SALVATI *et al.* 1999) has also confirmed that Kestrels were usually choosing residential buildings for nesting in urban and rural areas, while avoiding old nests of crows and holes in the trees, probably due to shorter durability and lower protection compared to nesting on buildings. Unlike business skyscrapers, residential buildings are characterized by multiple openings, windows, windowsills and balconies. The great importance of old historic buildings for the nesting of Kestrels has further been confirmed in Vienna (SUMASGUTNER *et al.* 2014). Research in Israel (CHARTER *et al.* 2007) has shown that the majority of Kestrels in urban areas are nesting in flowerpots on windowsills. There was a similar situation in Budapest in 2006: 25 nests were recorded on windows, 11 in holes on walls, 3 on sculptures, 2 on cranes (in service), 1 on an airplane (out of service), 1 in a pigeon nest on the roof, and 1 in a crow's nest on a tree (MORANDINI 2008). On the other hand, researches in Vienna (SUMASGUTNER *et al.* 2014) and in Berlin (KÜBLER *et al.* 2005) have pointed out the

importance of nest-boxes. While in Berlin most pairs are already nesting in nest-boxes, in Vienna it is pointed to a growing importance of setting up nest-boxes due to widespread renovations of buildings. Furthermore, there were some examples in Budapest (MORANDINI 2010) where the owners of the buildings did not want to keep old nests during renovations, but most frequently there are cases where owners are helpful in keeping the nests and even enforce them after renovations.

Our research has shown that Kestrels choose buildings between 25 and 70 m high and mostly, but not exclusively, the highest buildings available, as 61% of the nests are located on the highest buildings in a range of 500 m.

The analysis of the distances of nests from urban green areas has shown that Kestrel nests were closer to smaller green areas than to larger ones. This might be explained by the fact that there are more small green areas in the centre of the city, while larger green areas are mostly located in the city surroundings. The research in Vienna (SUMASGUTNER *et al.* 2014) has shown that Kestrel nests are located in areas characterized by high density of buildings, a greater number of green yards and greater distances to open green areas, as it is in Zagreb. The same research has also shown that nesting in the immediate vicinity to the green yards is related to earlier periods of laying eggs, higher hatching rates and larger fledged brood sizes, but these values are still lower than outside the city. Kestrels nesting in the city centre with a higher density of buildings have got more nesting possibilities, but less green areas needed for hunting. The importance of smaller green areas in Zagreb is shown by the fact that 55% (10) of the nests were situated within smaller green areas, while 38% (7) of the nests that were not located within green areas were between 40 and 650 m away from the nearest green area, which was usually category 1 area.

Despite the vicinity of a large number of smaller green areas, major importance for successful nesting of Kestrels is the possibility of hunting, i.e. the distance to open green areas outside the city centre. The research in the Czech Republic (RIEGERT *et al.* 2007), where Kestrels were tracked by using transmitters and wing tags, has shown that in urban Kestrels, the size of the hunting area varies from 0.8 to 25 square km, and that male Kestrels spend a lot of energy while flying from unfavourable nesting locations in city centres to suitable hunting grounds. Due to the fact that similar research has not been conducted in Zagreb, it cannot be confirmed how often some of the analysed green areas are used for hunting. Without research that would include some of the bird tracking methods, we can only assume the importance of analysed green areas according to the data taken by observing Kestrel hunting activity during this period.

The centre of the city may be characterized by lower diversity in Kestrels' prey. The research in Berlin (KÜBLER *et al.* 2005) has showed a lower variety in Kestrels' prey in the centre of the city compared to areas far from the centre; therefore, the distances between the nests and open green areas are of great importance.

The long green embankment of the river Sava stretching through the city was shown to be the most important great green area in Zagreb, representing the nearest category 4 area for 50% of the nests. Besides the embankment of the Sava river, urban park Tuskanac was also of great importance being the nearest large green area to the city centre.

The nesting of Kestrels has been recorded in several Croatian cities, especially on high buildings such as church towers (MICEVSKI 1989, RUCNER 1998, VIDOVIĆ 2006). However, this is the first study of habitat selection of the urban population of Kestrels in Croatia. It has been shown that the most suitable buildings for nesting of Kestrels in Zagreb are residential buildings with an average height of 50.1 meters. Both small and large urban green areas are important for hunting. Since many previously active nests were recently uninhabited, it is recommended to conduct monitoring of urban Kestrels in order to be able to identify the trend of this population.

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SAŽETAK

Urbanizirana područja sve se više šire te uništavajući prirodna staništa utječu na smanjenje raznolikosti životinjskih vrsta, a u manjoj mjeri stvaraju i nova staništa za određene vrste. Povećanje urbanizacije obično dovodi do povećanja biomase ptica ali i do smanjenja raznolikosti vrsta. Za ptice grabljivice urbana staništa mogu biti od vrhunske kvalitete, jer su u takvim staništima grabljivice često zaštićene od progona te mogu imati i zadovoljavajuću opskrbu hranom što im omogućava nastanjivanje inače neprikladnih ili neproduktivnih mjesta za gniježđenje. Među europskim grabljivicama, vjetruša (*Falco tinnunculus*) najuspješnije zauzima urbana područja što pokazuje viša stopa razmnožavanja kod urbanih populacija u usporedbi sa populacijama poljoprivrednih zemljišta. Vjetruša je jedna od najčešćih malih grabljivica u Europi koja, u usporedbi sa ostalim vrstama grabljivica, najuspješnije zauzima urbana područja. Stanarica je u gradu Zagrebu, prisutna je u gradu kroz cijelu godinu, te se gnijezdi i u samom centru grada. Cilj ovoga rada bio je najprije locirati a zatim i analizirati položaj trenutno aktivnih gnijezda vjetruša na području grada Zagreba u sezoni gniježđenja 2017. godine. Kao osnova poznavanja rasprostranjenosti vjetruše u Zagrebu poslužio je Atlas ptica gnjezdarica grada Zagreba. Nakon provedenog terenskog istraživanja, analizirane su značajke gnjezdišta, te su pomoću GIS programa izračunate udaljenosti analiziranih gnijezda do najbližih gradskih zelenih površina koje vjetruše koriste za lov i prehranu. Ovo istraživanje dalo je uvid u izbor staništa za gniježđenje vjetruša u Zagrebu. Rezultati su pokazali da je vjetrušama od najveće važnosti pri odabiru staništa tip građevine na kojima se gnijezdi te udaljenosti gnijezda do zelenih površina unutar i izvan centra grada. Stambene zgrade pokazale su se kao najpogodniji tip građevina za gniježđenje vjetruša, a visine građevina u većini slučajeva iznose između 25 i 70 metara (prosječno $50,1 \pm 26,1$ metara) visine. Također je dokazano i to da vjetruše većinom biraju najviše dostupne građevine. Važnu ulogu pri odabiru staništa unutar centra grada predstavljaju manje zelene površine unutar kojih se nalazi većina analiziranih gnijezda, no od velike važnosti zbog mogućnosti lova predstavljaju i velike zelene površine udaljenije od samog centra grada.