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CLIMATE CHANGE AND IMPLICATIONS ON THE ORNITHOFAUNA - CASE STUDY OF THE EURASIAN MAGPIE

SUMMARY

The aim of this study was to estimate the *Eurasian Magpie* (*Pica pica*) population and to give a detailed characterization of the nest site selection in the lower Zeta area. Data were collected in spring 2022. The findings of this study are compared to those obtained in other studies. A total of 73 active Magpie nests were censused in the River Zeta valley (lower part). One of the key factors is food availability. Breeding density, or nests, of Magpies in lower Zeta valley was 0.86 pairs/10 ha.

The results showed that the first nest building occurred at the end of February, but most pairs started in March. Nests were found in 23 trees and in two shrub species. Magpies build nests in strong and tall trees. Taller tree species were preferred to shorter ones and also broadleaved trees (ca 93%) were preferred to coniferous ones (over 40 % of all nests in 2 tree species but also over 60% of all nests in 5 tree species).The type of tree arrangement most frequently used for nesting was single trees (57.5%). The nests distance from the top of the canopy was 0.5 to 4.0 m, demonstrating the Magpie's tendency to place their nests high in the very tops of trees in the rural areas. Distance of nests from the source of food (pigsty, hen house, cowshed, stable, barn, granary, etc.) was up to 50 m in 80.8% of nests. The study shows that Magpies can adapt to changing climate factors, and changes in the choice of introduction tree species help the Eurasian magpie to adapt to climatic and anthropogenic factors.

Keywords: Magpie, *Pica pica*, nest-site selection, breeding density, nest height, rural environment.

INTRODUCTION

The Eurasian magpie is a common breeding bird widely distributed throughout the Montenegrin region. It inhabits a variety of open or semi-open habitats with hedges, bushes, or patches of trees and shrubs. In Western, Central and Southern Europe its breeding distribution is mainly associated with human-

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modified landscapes (Birkhead, 1989; Cramp & Perrins 1994; Hagemeijer & Blair 1997; Marić, 2022 a and b).

The Magpies in Europe are probably the best studied species among Corvidae and most publications refer to central and northern Europe (e.g. Witt, 1985; Jerzak, 1997, 2001; Prokop, 2004; Jokimäk *et al.* 2017), while for Montenegro a large gap in knowledge exists about range, population size and other parameters, and no data are available on breeding (area, habitat, selection of tree, etc.). Bird nests site selection is optimized by building the nest in the habitats that ensures the highest breeding success.

Several factors may drive bird nest-site selection, including predation risks, resource availability, weather conditions and interaction with other individuals. Understanding of factors where birds nest is important for conservation planning, especially in conditions of climate change, where environmental change may alter the distribution of suitable nest-sites. For the last 50 years, there have been significant changes in the nature caused by human activities, but significant variability of climate factors has also occurred. While many bird species have experienced significant declines due to expanding urbanization or abandoned areas, a number of others have adapted well to new environments and breed successfully there (e.g. Marzluff *et al*. 2001; Jerzak, 2001; Antonov & Atanasova 2003; Jokimäk *et al*. 2017; Huang, 2017; Šálek *et al*. 2021; Maric, 2022b)

More quantitative studies have addressed nest site selection in this species in general. Several studies of Magpie have shown a relationship between nest location and characteristics of nesting trees, i.e., species, their height, canopy width and etc. (Mérő *et al*. 2010; Wang *et al*. 2010; Wojciechowska & Dulicz 2014). However, there is little information on the nesting ecology of the Magpie in its area in Montenegro. Main aim was to analyze the Magpie abundance and nest site selection (nest tree species, height of nest) in Montenegro, for example the Zeta valley. This data will also reveal the assessment of some factors affecting the nesting in this study area.

MATERIAL AND METHODS

Study area

The study was carried out in the River Zeta valley (lower part, Montenegro, 42°30′N to 19°14′E, elevation 50–60 m), in the Mediterranean region. The karst depression of the Skadar basin, Zeta valley and Bjelopavlici valley, is one of the largest karst depressions in the area of the Dinarides. River Zeta is the most typical representative of karst's hydrography and, individually, the richest river in Montenegro with water, after Bojana, but with large water level oscillations. The study area characterized by a Submediterranean climate (annual temperature: 7.8 °C, precipitation: 1.200-1.500 mm) (Pešić et al. 2018 and 2020).

Along the banks of the River Zeta, there is a narrow belt (up to 20m) of trees. In some places, along the river banks, there are small forests dominated by *Quercus spp., Fraxinus spp., Carpinus betulus, Alnus spp., Ulmus minor, Salix*

spp. and *Populus spp*. *Carpinus betulus* and *Acer campestris* predominate in parts of the forest parts that have been severely altered by introduced species, such as *Ailanthus altissima*. The trees stand consists mostly of deciduous trees 100–200 years old or older. The undergrowth is very scant and the shrub layer (consisting of *Cornus mas, Rosa spp. Prunus spinosa* and *Paliurus spina-christi*, more numerous than others) covers a small area. Coniferous trees were very rare, less than 1%, mostly *Cupressus spp*. that are usually found next to human structures.

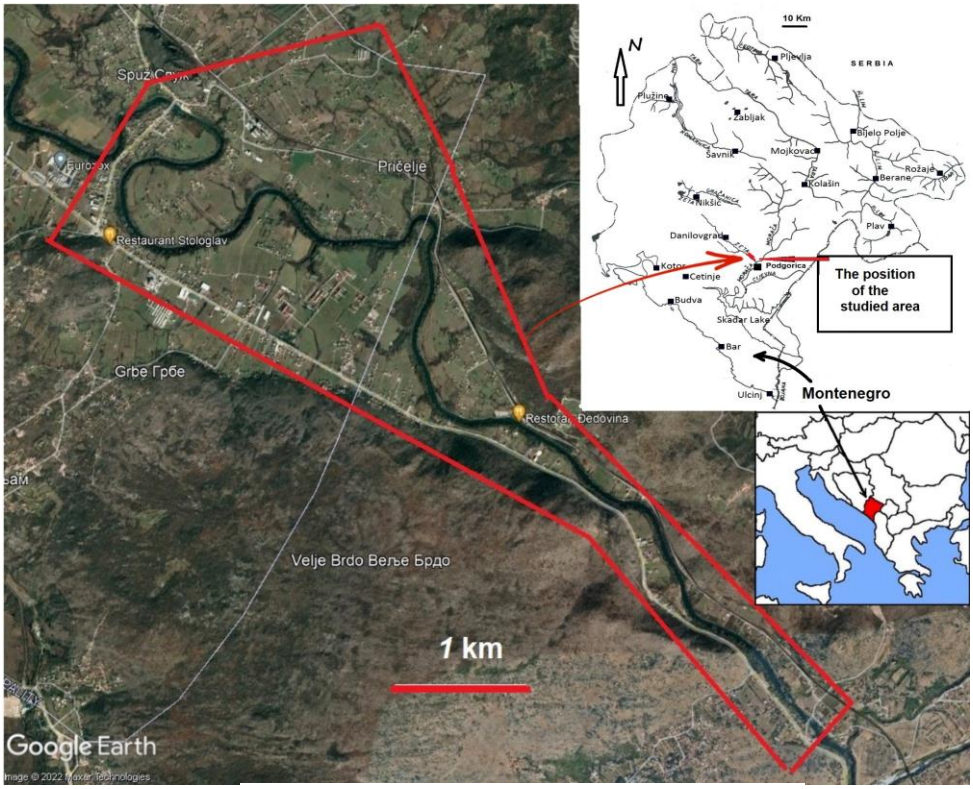

Figure 1. Study area (area bordered by red line)

The area holds one of the most representative traditional and low-intensity agricultural systems. The rural environment mainly consists of anthropogenic habitats, including built-up areas with low-density and mainly consist of green urban habitats. Green areas comprise of private gardens with a considerable proportion of non-native vegetation (evergreen shrubs and flowers). The farmland represents the area consisting of mosaic of farmed (arable fields and pastures) and non-farmed habitats (including forest fragments and non-cropped vegetation, such as hedges, isolated trees and shrub patches). In the settlement areas each private house is typically surrounded by a small garden with single trees (*Tilia spp.* oak, field elm, *Morus spp*. and mature walnut tree) and bushes. Near the houses there is often a pigsty, hen house, cowshed, stable, barn, granary,

outbuilding, garage, garden plot, orchard and lawn. The settlements are dominated by high-stem fruit orchards, and most fruit trees are mature. Fruit species are dominated by *Ficus carica*, plums, apples, pears and cherries i.e. deciduous fruit trees. Also, the trees *Robinia pseudacacia*, oak, field elm, and *Celtis australis* are found along the roads.

Data Collection

Nests were counted at the lower part of the Zeta River between Spuž and Vranske njive (Fig. 1) on a 17.7 km long road transect (measured by means of car). All Magpie nests were recorded within a range of 250 m from the road (i.e. observer) which represents an area of about 10 km2. The road, along the left and right sides of the Zeta River, borders a hill in a total length of 6.5 km, so this area (1.6 km2) was not included in the total area taken for estimation, therefore the total area calculated in this way amounts to 8.6 km2. Road transect counts of Magpie nests were performed during 12 visits in spring: from 25th February to 30th April 2022 (between 12.00 and 14.00 h), i.e. when deciduous trees were without leaves and nests could be easily seen. We systematically searched for nests on each observation point i.e. where we stopped the car. Observations were carried out with binoculars. We registered active/occupied nests, which meant that Magpies were observed in (with nest material) and around the nests (adult birds bringing fresh twigs). It is common that magpies place nesting materials in several adjacent trees before completing just one nest (Nakahara *et al*. 2015),

For each observation point we identified nest trees to the species/genus level. The tree height and the nest height placement were determined by visual method with accuracy to 0.5 m. Nest heights were measured from the ground to the bottom of the nests. Also, the following data were collected: tree species in which a nest was built, tree height and height of the nest placement in the tree, microhabitat type (single tree, tree cluster (2–3 trees, 4–10 trees or more than 10 trees), and additional descriptions of the neighboring pigsty, hen house, cowshed, stable, barn, granary, outbuilding, garages).

Statistical Analysis

The statistical analyses were performed using STATISTICA software package. All tests (t-tests, $\chi 2$-test, z test) were independent and two-tailed. Results are considered significant if $P \leq 0.05$.

Differences between nest sites in nest height (of above the ground) was tested using a t-test for independent samples. Differences between two periods in the frequency of selecting a given nest site and preference for broadleaves over conifers were tested using $\chi 2$-test.

Differences in the frequency of selecting a given nest site were tested using z test. Comparison of nest frequency in given trees between periods using z test.

A correlation-regression analysis was performed to analyze the representation of trees and the preference of nests in them.

RESULTS

Magpie (*P. pica*) nests were built between 25th February and 30th April and a new nest was built for each nesting attempt. 73 nests were observed during the present work and 24 rebuilt nests after being destroyed in storms (26 nests totally destroyed -have not been rebuilt) (see Table 1). The recorded nest density was 8.6 per km². Nests for two couples have not been found in this area. There are no statistical differences between destroyed and rebuilt nests except in the height of the selected trees. (t=2.73, p=0.009). Most of the nests (41.1%) %) were built on *Ulmus minor* and *Quercus spp.*

Table 1. Tree and bush species used as Magpie nest sites in the rural environment in Zeta river valley. RA-Relative abundance: 1) Single occurence or exceptionally rare, 2) rare , 3) average abundance, 4) abundant, 5) dominant

		First nests			Deistroyed nests			Second (rebuilt) nests		
Tree species	RA	N	(%)	Height	N	(%)	Height	N	(%)	Height
Ulmus minor	5	17	(23.3)	10-16	6	(23.1)	11-16	4	(16.8)	8-14
Quercus spp.	5	13	(17.8)	10-18	6	(23.1)	11-17	4	(16.8)	10-15
Robinia pseudacacia	4	8	(10.9)	8-12	1	(3.8)	10	1	(4.2)	10
Celtis australis	2	7	(9.6)	7-15	2	(7.7)	10-15	3	(12.5)	12-14
Fraxinus excelsior	3	4	(5.5)	10-14	-			4	(16.5)	10-12
Cupressus spp.	2	2	(2.7)	8, 12	-			1	(4.2)	8-9
Acer campestre	3	1	(1.4)	8	1	(3.8)	6	-		
Morus spp.	2	3	(4.1)	8-10	2	(7.7)	9, 10	1	(4.2)	7, 8
Pinus sp.	1	2	(2.7)	6, 10	2	(7.7)	6, 10	2	(8.3)	6, 7
Juglans regia	2	2	(2.7)	9, 10	1	(3.8)	9	-		
Malus domestica	3	2	(2.7)	6, 7	-		-	-		
Melia azedarach	1	2	(2.7)	7, 8	-		-	-		
Populus nigra	2	3	(4.1)	10-15	2	(7.7)	9, 10	-		
Populus nigra cv. italica	1	1	(1.4)	15	1	(3.8)	15	-		
Platanus sp.	1	1	(1.4)	13	1	(3.8)	13	-		
Betula pendula	1	1	(1.4)	15	-		-	-		
Broussonetia papyrifera	1	1	(1.4)	8	1	(3.8)	8	-		
Ligustrum lucidim	1	1	(1.4)	7	-		-	-		
Prunus spinosa	2	1	(1.4)	6	-		-			
Prunus cerasifera	1			-	-		-	1	(4.2)	6
Carpinus betulus	1	1	(1.4)	8	-		-	1	(4.2)	7
Ficus carica – cult.	4							1	(4.2)	5
Pirus communis	1							1	(4.2)	5
Total	23	73	(100%)		26	(100%)		25	(100%)	

For nesting, the Magpies selected common tree species rather than rare, exotic species used for gardens. Furthermore, the most preferred tree species were the *R. pseudacacia*, *C. australis* and *F. excelsior* (Table 1). The vast majority (94.2%) of Magpies' nests were located on trees (5.8% on shrubs) and mainly on deciduous trees (94.5%) as opposed to coniferous ones (5,5). Only one nest was located on a shrub of *P. spinosa*. There was a significant preference for broadleaves over conifers ($\chi 2 = 15.7$, df = 1, $p < 0.001$). Only two conifers (5 nests) of the 23 in total species were selected for nests. Also, only 5 nests were found in conifers of the 73 nests in total found in this area ($\chi 2 = 54.4$, df = 1, $p < 0.0001$).

Most species of fruit trees in this area were utilized to some extent by Magpies. There was a significant correlation in abundance between available trees and the number of those chosen for nesting ($r = 0.71$, $p = 0.00001$, $n = 73$).

No significant correlation in abundance between available trees and trees knocked down by wind or by the number of those chosen for nesting in second period ($p > 0.05$) (fig. 1).

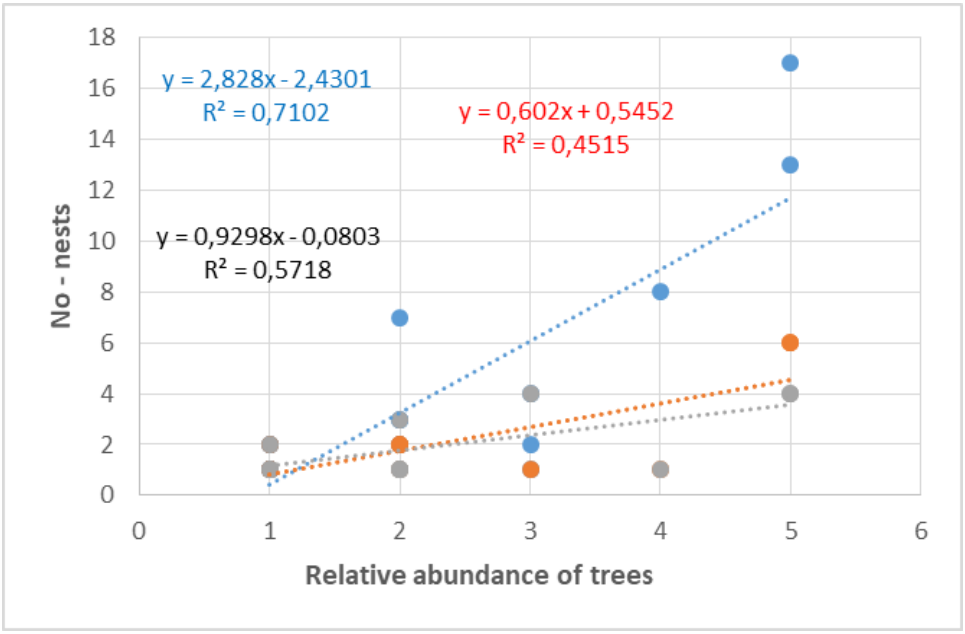

Figure 2. Correlation between relative abundance trees and number of nests (1- Single occurence or exceptionally rare, 2-rare, 3- average abundance, 4-abundant, 5- dominant)

The mean nest height was 11.85±0.14 m in the first try, whilst the mean nests height were 9.83±0.44 m in the second one. The mean destroyed nests height were 12.38±0.42 m. A significant statistical difference was found between the height of subsequently built nests (n=24) and demolished ones (n=26), as well as the mean value of all nests built (n=73) in the first period (t= 2.65, p=0,009 and t=2.73, p=0.009 respectively). No significantly differences of nests height between the first and second period of nest building (t=0.71, P=0.48).

In this study, Magpie nests were built in the upper part of the crown (canopy) and more often on the side branches than in the middle of the tree ($\chi 2=44.7$, df=1, $p < 0.0001$). Nest height was strongly correlated with nest tree height ($r=0.94$, $p < 0.0001$, $n=73$), i.e. whatever the tree height, the nest was positioned in the top part. Nests was built to the axis of tree only on four species of trees: *Cupressus spp.*, *Pinus spp.*, *Poplar piramidalis (Populus nigra 'Pyramidalis'*) and *Broussonetia papyrifera*. The distance between the nests varied between 20 and 450 m.

The mean distance of nests from the top of the canopy (±SD) was 2.3±0.93 m (range=0.5−4,0 m). Distance of nests from the source of food (pigsty, hen

house, cowshed, stable, barn, granary, etc.) up to 50 m was measured in 59 nests in the first and 18 in second period (80.8% and 75% respectively) and over 50 m of distance (65 to 230) was measured in 14, and 6 (19.2% and 25% respectively), so this difference is statistically significant ($\chi 2=27.7$, df=1, $p < 0.001$ and $\chi 2=6.0$, df=1, $p < 0.05$ respectively), but no significant differences between the first and second period (z=0.61, P=0.542) was noticed. Several nests were directly above the food source.

Figure 3. One example: small distance between the nests near the livestock farm.

The type of tree arrangement most frequently used for nesting was by solitary trees (57.5%) and then two clusters (2-5 and 6–10 trees) and a small groves (more than 10 trees) along the river and streams in equal proportions (see table 2).

Table 2. Number of nests by the type of tree arrangement

	Microhabitat type - single tree or tree cluster			
Tree species	single tree	2-5 trees	6-10 trees	more than 10
Ulmus minor	9 (52.9/n=17)	2	2	4
Quercus sp.	4 (30.8)	1	3	5 (38.5)
Robinia pseudacacia		2	4	1
Celtis australis	7 (100)			
Fraxinus excelsior		3	1	
Other species	22	2		1
Total	42 (57.5)	10	10	11

Figure 4. Position of the nest on the oak (*Quercus cerris*) –left, on the birch (*Betula pendula*)- right

DISCUSSION

Abundance

There is no data on magpie nesting in Montenegro. Currently, the density of the Magpie in this area is about 8.6 pairs per square kilometer, this being a small to average density compared to figures given in the consulted literature. Thus, the density of Magpie pairs observed along the riverbanks of Suhodolska and Darvenishka rivers (Bulgaria) were between 6,38 and 20,83 pairs/10ha (Kamburova, 2004). However, in a more agricultural area in Sheffield (United Kingdom), the breeding density was 0.81 pairs/10 ha (Birkhead, 1989), which is slightly lower than the densities in this area. In contrast, according to Antonov & Atanasova (2003) density in the rural habitats in Bulgaria is significantly higher and was 40.1 pairs/km2.

One of the highest known breeding densities of Magpies were inthe city Zgierz (Poland) the downtown density were 67 pairs/km2 (Wojciechowska & Dulicz 2014) then 56.8 pairs/km2, is recorded in the city of Sofia (Bulgaria) (Antonov & Atanasova 2002). However, the overall breeding density of Magpies in Sombor (Serbia) was only 0.94 pairs/10 ha (Mérő *et al*. 2010) which is significantly lower than the densities in European cities. Also, according to Bauer *et al*. (2005), the breeding densities in large cities of Central Europe vary between 0.6 and 1.4 territories/10 ha, while in smaller cities (up to 300,000 inhabitants) they do not exceed 2.1 pairs/10 ha. We conclude that specific conditions in habitats affect the number of magpies or their nests.

Trees and nests-sites characteristics

This work showed that magpies prefer certain types of trees when nesting. A total of 23 species were selected, of which 20 were selected in the first and 12 in the second nesting period, i.e. three new species, after the strong wind destroyed the first ones. Nest position or height (and the height of selected trees)

in the rebuilt new nests (24 nests) was significantly lower than in the ones that were demolished by the wind (n=26) (t=2.73, p=0.009). This and the selection of three new species shows that Magpies are very adaptable and choose nests according to the environmental and the weather conditions. Magpies selected for nesting a very wide array of tree species, which is in agreement with data from other studies. However, Vogrin (1998) found Magpie nests only in 14 woody plant species in Dravsko Polje (NE Slovenia). Considerably more types of trees have been selected in European cities: Nests were located on 47 trees and bush taxa in Zgierz and on 34 in Olsztyn (Poland) (Dulisz, 2005), on 33 tree + fruit trees (on 27 tree) in Sombor (NW Serbia) (Mérő *et al.* 2010).

The tree species preferred by Magpies in the River Zeta velley have a fairly large abundance (Table I). However, the *Ailanthus altissima* and *Salix spp*. are avoided as a nest site in this area, although they represent more abundant types of trees. It indicated that Magpies actively select (and avoid) certain species of trees in which to nest. Some study in rural habitats show that Magpies mainly place their nests in willows *Salix sp*. (59.7%) and Blackthorn bushes (Dolenec, 2000), while Vogrin (1998) found them in *Pinus silvestris* (20%) in Slovenia. These findings confirm the reported wide range of nesting tree species used by Magpies, generally according to their local abundance (Cramp & Perrins 1994). This provided many potential nesting places preferred by the Magpies.

In European cities, Manchester (UK), about 38% nests were in *Populus spp*. (Tatner, 1982), 44% nests in Zielona Góra, Poland, (Jerzak, 1995), 49% in Cracow, (Barszcz 1988) in Bonn, Germany (Witt 1985), and even 51% in Beijing,China (Wang et al. 2010). In Sombor (Serbia), magpie preferred *Celtis occidentalis* (31.1%) and *Robinia pseudacacia* (11,3) (Mérő *et al*. 2010) which is somewhat similar to our research (both species 20.5%).

The use of mainly deciduous trees for nest building in this area are in accordance with the results of researches conducted in many European countries (Jerzak, 1997., Dulisz, 2005; Wang *et al*. 2010; Tatner, 1982; Šálek *et al.* 2021). In some areas, on the contrary, according to (Jokimäki *et al.* 2017) Magpies preferred ever-green coniferous trees over deciduous tree species as their nest sites in urban areas. Also, according to Vogrin (1998) 24% of nests (4 tree species) were found on coniferous trees. In this case, the magpies in the subsequent (second) nest building period, selected a slightly different species (and a lower average height of the nest) than in the initial nest building period.
According to Kosiński (2001) or Bensouilah *et al.* (2015) this variability may be explained by the species capacity to build a nest in different nesting conditions and to adapt nest placement to the structure of available sites. Also according to Wysocki (2005), Osiński & Kempa (2007), Bensouilah *et al.* (2015), Brambilla *et al.* (2007), Şahin Aslan & Aalan Akveren (2019), etc. the birds of the same species nest at different tree species in different habitats.

The type of tree arrangement most frequently used for nesting was single trees (57.5%). This is in accordance with other studies in Europe and Asia noted by Prokop (2004); Wang *et al*. (2010); Nakahara *et al.* (2015), Huang (2017), and

Jokimäki *et al.* (2017). On the contrary, according to Xu (2020) Eurasian Magpies in Beijing (China) placed their nests preferentially in tall trees occurring in sites with high tree density, which in this research was rare, only 20%. Mérő *et al.* 2010 stated that the majority of nests were found in tree avenues (39.6%) and groups of trees (31.5%), while the lowest number of nests was recorded in solitary trees in the city of Sombor. The taller the trees were, the higher the position of the nest was from the ground. Distance of nests from the top of the canopy in this area are in accordance with the results of researches in many European countries (Jerzak, 1997., Dulisz, 2005; Wang *et al.* 2010; Tatner, 1982; Šálek *et al*. 2021). Also, this showed that Eurasian Magpies favoured tall trees as noted by many previous studies (e.g., Tucakov & Kucsera 2008; Wang *et al.* 2010; Mérő *et al*. 2010.; Nakahara *et al.* 2015, Xu *et al*. 2020., Ciebiera *et all.* 2021). However, studies carried out in rural areas e.g. in the Krapina river valley (Croatia), the nest height mean was 6.74 m, range 1−16 m (Dolenec, 2000), then, in Slovenia it was 5.7 m (Vogrin 1998), whereas in Sofia (Bulgaria) the mean nest height was 6.9 m (range 1.2−14 m) (Antonov & Atanasova 2002). This paper shows that the nests are often built on/in single trees with good all-round visibility some 6 to 18 meters off the ground, but in the most fruit trees, the height chosen was 6 or 7m. These differences probably occur due to the specific types of trees and their age. In the research area, there is a large number of species that are more than two hundred years old and reach a height of over 20 m.(e.g. *Quercus spp. Ulmus spp., Celtis sp., Fraxinus spp., Robinia sp*. *etc*). All these species, as well as *Tilia spp*. and fruit trees, are mostly present in the immediate vicinity of pigsty, hen house, cowshed, stable, barn and granary. According to our results we suggest that food availability is the main factor influencing the selection of nesting sites. According to Jerzak (2001), Kristan & Boarman (2007) and Chamberlain *et al* (2009) additional food sources such as human-provided food are important resources for some species and according to Maric (2022b) there are no Magpies in abandoned villages.

CONCLUSIONS

Magpies in the River Zeta valley nest in most available species of trees but clearly prefer some, including the *Quercus spp*. and *Ulmus minor* which is the most common species in the area. Preferred tree species typically provide a close knit canopy which (it is suggested) offers some protection to the nest site and facilitates building of the nest super-structure. In addition to *Quercus spp*. and *Ulmus minor*, most nests built in this area were in *Robinia pseudacacia* and C*eltis australis* (31%), the species which were planted very commonly in rural area. Our study shows that old *Quercus spp.* and *U. minor*, are the preferred nesting microhabitats for *P. pica*. Magpies select the best places for better breeding success. These are: proximity to food sources, visibility of micro-locations, etc. It looks as if the differential availability of human-provided food is the only factor causing the differences in densities in this area. Because the average nest height was higher in the first period than the average nest height in the second, it

suggests that birds prefer higher trees. Nest number also correlated with species tree abundance. Although there are larger numbers of willows (*S. alba*) and *Ailanthus altissima* available for nest building, the Magpie nests preferentially in large *Quercus spp*. or *U. minor*. Therefore, the maintenance of old, isolated trees in the lower section of the River Zeta is an essential condition for the conservation of this species. The present results showed that Magpies exhibited preference for certain species of tree when placing their nest, and that this is specific for the conditions in this area. Also, they showed that there was no destruction of nests in *Fraxinus excelzior* and *Cypress* (probably *Cupressus sempervirens*) and these species are recommended for planting in order to ensure nesting success in the coming period, which climatologists predict to be changeable and destructive.

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