Nesting tree selection in urban Woodpigeon; applications in urban planning to reduce the conflicts with human activities

Eduardo Gil[1], Anika Meyer[2] & Diego Villanúa[2*]

[1]Independent Researcher
[2]Navarra Environmental Management (GAN-NIK) diegovillanua@yahoo.es

*corresponding author: diegovillanua@yahoo.es

DV 0000-0002-0846-6644

Abstract - The urban populations of Woodpigeon (*Columba palumbus*) is increasing throughout Europe, generating conflicts with humans associated with damage resulting from their feces deposition or with their role in the maintenance of zoonotic diseases. Despite this, the species has a significant conservation value, as it is an important part of the diet of various threatened raptors like the Bonelli´s (*Aquila fasciata*) and Iberian Imperial Eagle (*Aquila adalberti*). Also, it is a game species whose hunting generates large income in certain regions.

In the present work, we assessed the habitat selection during the nesting period, analyzing the tree species used for nesting and nest distribution patterns in streets and urban parks.

It has been verified how the location of the nest is not random, with a percentage of them in evergreen trees significantly higher than expected and with a significant selection of certain tree species like *Pinus* sp., *Robinia pseudoacacia* or *Ulmus* sp., while others like *Prunus* sp., *Melia azedarach* or *Populus sp* were avoided.

Significant differences were also found in the density of nests, being significantly greater in the streets (12.3 ±11.6 nest/ha) than in parks (5.7 ±3.7 nest/ha).

It is discussed how the plantations in areas with benches or vehicle parking of tree species negatively selected by Woodpigeons for nesting and tree species positively selected by Woodpigeons in the rest of the park areas might lead to a reduction of the species associated conflicts while guaranteeing its conservation.

Keywords: Design, conflict, nest, parks, streets, trees.

INTRODUCTION

With the industrial revolution, there was a massive rural exodus of people towards the cities, with their consequent growth (Manolopoulou 2017). This trend continues, with most of the world's population concentrated in cities, which implies an occupation close to 6 million square kilometers (Rebolo-Ifrán et al. 2017). This change in land use has had a negative effect on biodiversity (Sol et al. 2014), due to habitat fragmentation (Erritzoe et al. 2003, McKinney 2006, Bishop & Brogan 2013), an increased incidence of some animal diseases (Dhondt et al. 2007), noise and light pollution (Fuller et al. 2007, Kempenaers et al. 2010), collisions with buildings and vehicles

(Erritzoe et al. 2003) and the presence of high densities of domesticated (Schlesinger et al. 2008) or allochthonous predators (Bonnington et al. 2015). However, some species have been able to adapt to the changes and have colonized these new habitats; being called urban adapters or exploiters (Kettel et al. 2018). Urban environments provide higher temperatures (Newhouse et al. 2008), food availability (Newhouse et al. 2008), lower natural predators densities (Muhly et al. 2011,) and absence of hunting (Sakhvon & Kövér 2020), which has allowed some species to reach higher densities in urban areas than in natural habitats (Slater 2001, Bea et al. 2011, Zbyryt 2014, Rebolo-Ifrán et al. 2017, Leveau et al. 2022). This has been the case of the Woodpigeon (*Columba palumbus*), that, since the middle of the 19th century, has been colonizing urban environments in Central and Northern Europe (Tomiałojć 1976, Slater 2001, Bea et al. 2011, Zbyryt 2014, Fey et al. 2015, Sakhvon & Kövér 2020). In the Iberian Peninsula this colonization started in the 70s (Alonso & Purroy 1979), being currently extended to most cities (Fernández-García 2022).

The Woodpigeon is the largest breeding pigeons in Europe (Baptista et al. 2018). With a distribution area that spans from North Africa to Siberia (Baptista et al. 2018), a population estimated at 51-73 million specimens and a positive trend, it is listed as least concern according to the IUCN (BirdLife International 2020). It is part of the diet of many species of predators, some as threatened as the Bonelli's eagle (*Aquila fasciata*) (Ontiveros et al. 2005; Moleón et al. 2009) or the Spanish Imperial Eagle (*Aquila adalberti*) (Sánchez et al. 2008). These raptors have substituted their more traditional preys, the Red-legged Partridge (*Alectoris rufa*) and the Wild Rabbit (*Oryctolagus cuniculus*), whose population have suffered an important decrease in last decades (IUCN, 2024), with the increase in the capture of Woodpigeons (Moleón et al. 2009, Sánchez et al. 2008). In addition, Woodpigeon is a game species of great importance in southern Europe (Bea et al. 2003) both from the economic and social point of view (Andueza et al. 2018). On the contrary, the increase in their populations can cause damage to agriculture (Inglis et al. 1997, Ó hUallachain & Dunne 2013) and their presence in cities can cause conflicts due to dirt problems or the maintenance of certain diseases (Lloyd-Smith et al. 2009, Krawiec et al. 2015, Peters et al. 2022), as it has been widely described with feral pigeons (Jerolmack 2008).

Considering these situations, it would be necessary to seek a balance that guarantees the conservation of the species in these humanized habitats, while reducing the negative effects of its presence in cities. In this context, the objectives of this work are i) to study the possible selection of the different tree species available to place the nest and ii) assess how this selection could be used to reduce the negative effects of the presence of Woodpigeons in the city.

MATERIALS AND METHODS

Study area

We conducted our research in Zaragoza, a city of 700000 inhabitants located at 215 m.s.n.s. in the northeastern part of Spain (40º39´N, 0º53´W and Fig. 1). This region is characterized by an arid steppe cold climate (BSk according to Köppen climate classification), with an average annual rainfall below 347 mm/m^2 and an average temperature of 14.7ºC with minimums of -8ºC and maximums of 41ºC. The city is crossed by the Ebro, Gállego and Huerva rivers, whose riparian forest has been transformed into parks. In addition to these green areas, the city has an important network of parks that account for almost 20% of its 4616 hectares. Zaragoza is immediately surrounded by agricultural crops (mainly corn, wheat and barley) that the Woodpigeons that nest in the city visit to feed.

Nest census and trees characterization

Fieldwork was carried out between the months of March and September of 2018 and 2019, in order to include the entire reproductive period of the species in the region (Gallego 1981). The censuses were conducted in the 12 most important parks and the

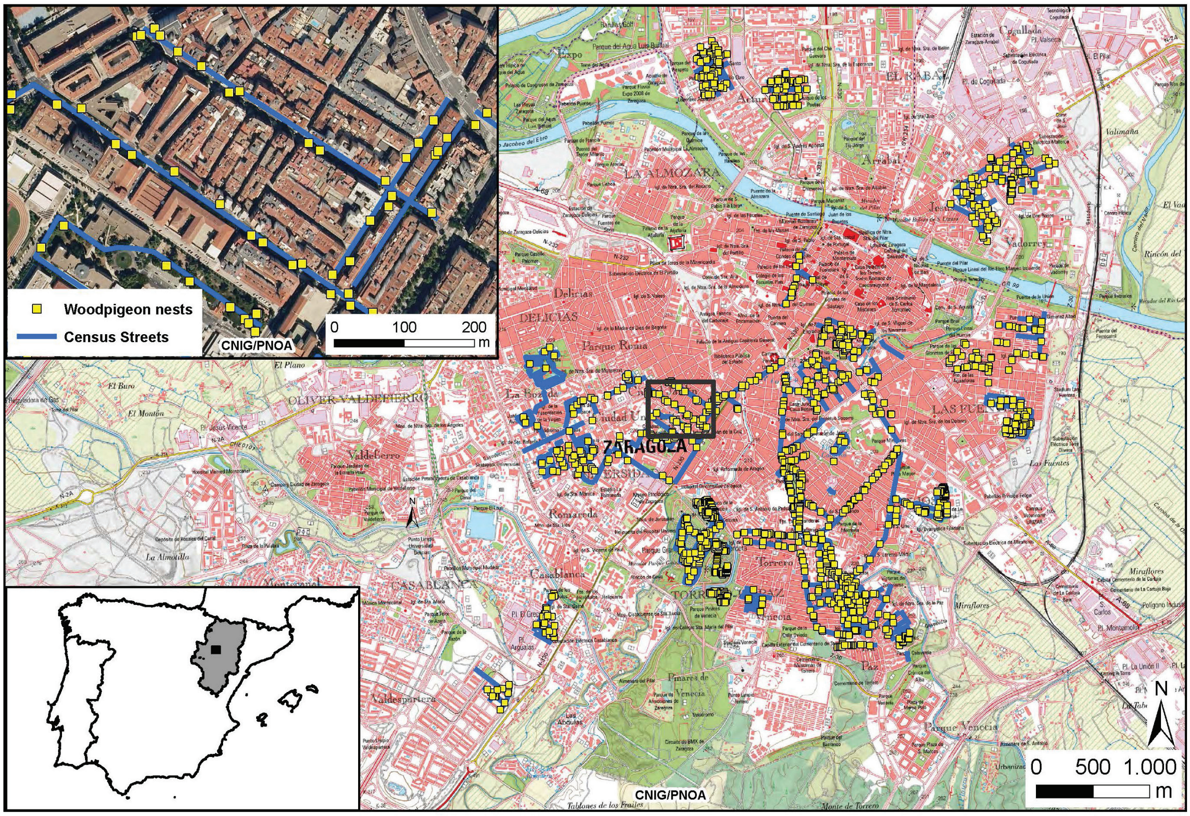

Figure 1. Study area, distribution of nests in the city of Zaragoza and example of nest locations on various streets.

150 streets adjacent to them (Fig. 1). In each census transect, all trees were searched for nests using 8 × 40 binoculars (Slater 2001). Since the detection of nests was not affected by bird activity, censuses were carried out at any time of day but always with good visibility. A nest was considered as active when it contained chicks or an incubating adult (Hanane et al. 2012). When an occupied nest was detected, its location was georeferenced and the species of the tree in which the nest was located was recorded (Gallego 1981, Slater 2001, Hanane & Besnard 2013). In addition to this information about the trees used by Woodpigeon, the number of specimens of each tree species present in each census transect was also counted to obtain information on the availability of each tree species.

Data treatment and statistical analysis

To analyze whether the percentage of nests located in evergreen trees was different from expected based on the tree species availability, we performed a Chi^2 test (Hammer et al., 2001). After this first step, the selection of different tree species for nesting was calculated. Prior to that, the distribution of the data was tested according to the test Kolmogorov-Smirnof goodness-of-fit for normality (Hammer et al. 2001). Since they did not follow a normal data distribution, we applied a transformation (log + 100) to the variables that described the availability and use of each tree species. After this transformation, a MANOVA test (Aebischer et al. 1993) comparing the available tree composition (percentage of trees of each species in each street or park) was carried out in order to determine whether Woodpigeon preferred some tree species above others for nesting (percentage of trees of each species and in each street or park with Woodpigeon nests). The Ivlev's electivity index (E)(Ivlev 1961) was also calculated for each tree species in order to facilitate the interpretation of the results for each tree species, according to the following formula:

$$E = \frac{Ui - Ai}{Ui + Ai}$$

where *Ui* and *Ai* are the proportion of used and available tree species respectively. This index discriminates between the random use (around 0), the weak to strong positive selection (up to + 1.0) and the weak to strong avoidance (down to -1.0). The values of this index for each tree species were represented in Fig. 2.

Finally, the density of nests in each street or park was calculated as the total number of nests divided by the total sampled area. The differences between the density found in the streets and the parks were analyzed using Mann-Whitney U test.

All calculation and statistics were performed using the Past software version 4.03 (Hammer et al. 2001).

RESULTS

A total of 10184 trees were revised and 1527 active nests were detected in 19 different tree species (Fig. 2). The percentage of nests located in evergreen

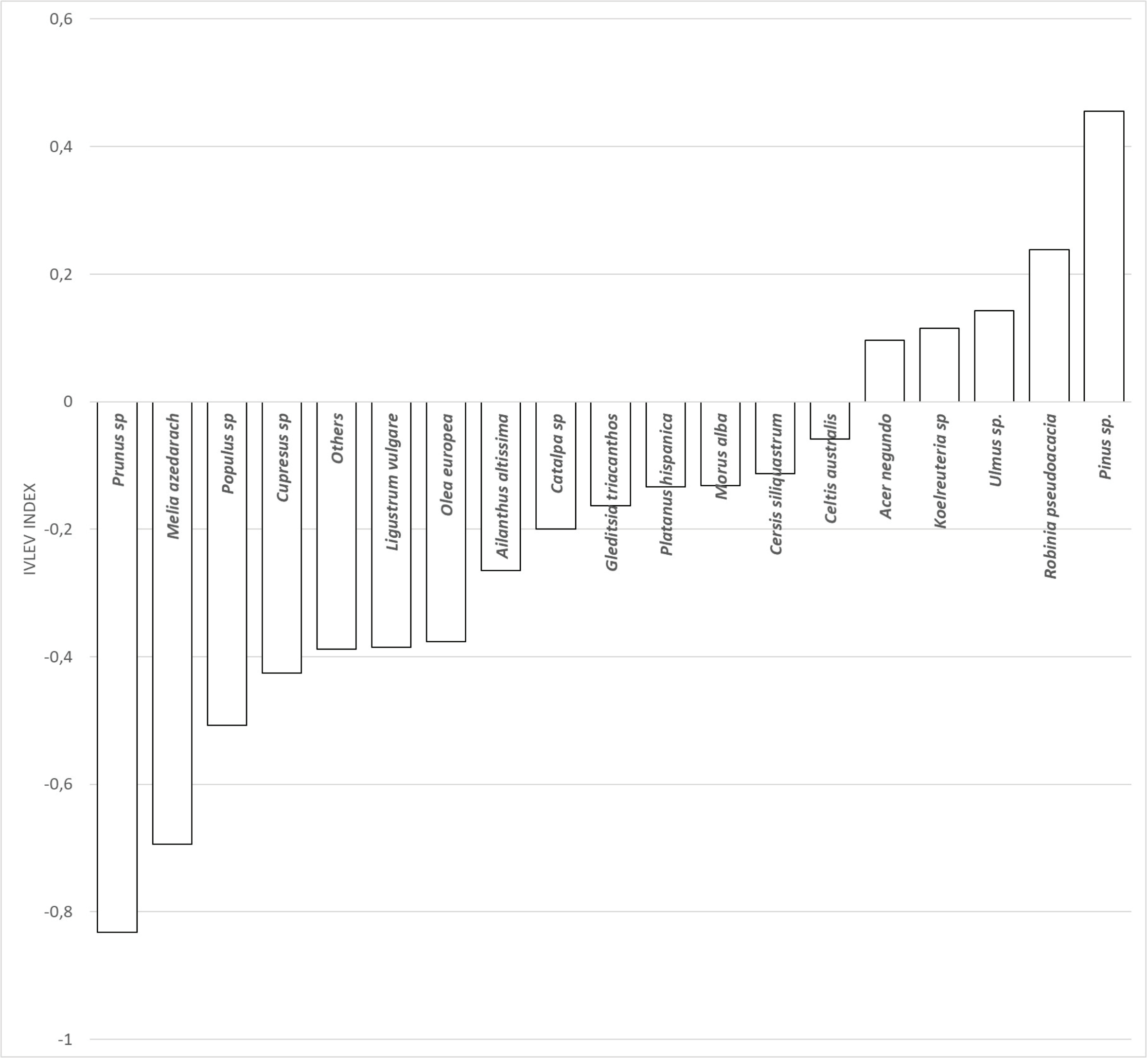

Figure 2. Selection of the different species of trees to nest.

trees was significantly higher than expected (Chi^2= 60.164, df=1, p<0.001), and the use of the different tree species was not random, showing a significant selection (Lambda = 0.67; p<0.001), positive for *Pinus* sp, *Robinia pseudoacacia, Ulmus* sp., *Koelreuteria* sp and *Acer negundo* and negative for the rest of the tree species analyzed in this work (Fig. 2).

Significant differences were also found in the density of nests location, being significantly higher in the streets (12.25 ±11.58 nest/ha) than in parks (5.69 ±3.79 nest/ha) (Z=-2,536; p<0.05) (Fig. 3).

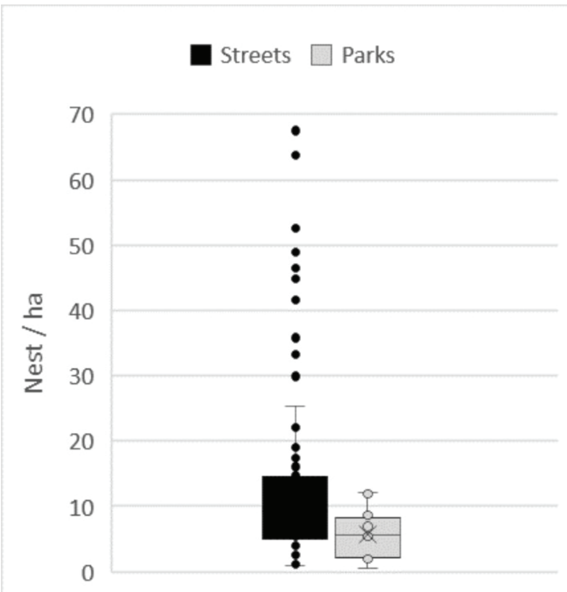

Figure 3. Nest density in streets and parks (mean, standard deviation and outliers).

DISCUSSION

Tree selection

The Woodpigeon is a bird with a great capacity for adaptation, which allows it to use a multitude of tree species to locate its nest (Hadjisterkotis & Taran 2000, Slater 2001, Hanane 2013, Sakhvon & Kover 2020) or even buildings (Fey et al. 2015). In our study, we have been able to verify how, in the city of Zaragoza, they use at least 19 different species. Most of these tree species have already been described as nesting sites for the Woodpigeon both in urban environments (Slater 2001, O hUallacháin 2014, Sakhvon & Kover 2020), and in the field (Hadjisterkotis & Taran 2000, Bogliani et al. 1992, Hanane 2013, Bendjoudi et al. 2015). However, until now it has not been analyzed whether this use was a consequence of the availability of these trees or it was caused by active selection. In our study we have been able to confirm that the choice of a tree to nest in is not random, but the Woodpigeon positively selects some species to the detriment of others. Although we found nests in both evergreen and deciduous species, the proportion of nests located in evergreen trees was significantly higher than expected. This result goes in line with that recorded in Ó hUallacháin (2014), where a positive selection of evergreen trees was suggested in urban regions of Ireland. This preference may be due to the greater protection of the nests against meteorological phenomena that evergreen species provide (Bendjoudi et al. 2015), which could be very useful in areas with high rainfall, as would be the case of Ireland, or in areas with high temperatures such as those found in our study area, where temperatures usually exceed 40 ºC. Regarding the size of the selected trees, studies carried out previously confirmed how nests tended to be located in taller trees (Hanane et al. 2013, Ó hUallacháin 2014) with thicker trunks (Hanane et al. 2013). Since this information was not recorded in the present work, it cannot be assured that this pattern does not exist in our study area. However, the fact that we found nests in both large and small tree species leads us to think that in our region it is not the main determining factor for nesting.

Nest density

The nest density we found in our study area is much higher than the previously described in the majority of studies carried out in forest environments (Bea et al. 2011, Hanane 2013), agrosystems (Bea et al. 2011, Fernández-García 2022) and urban areas (Bea et al. 2011, Sakhvon & Kover 2020, Csatho & Bozo 2022) (see Tab. 1 for details). Only the works of Varga & Juhasz (2020) in cities of Hungary or Bendjoudi et al. (2015) and Inglis et al. (2004) in an agricultural areas of Algeria and UK respectively, found comparable values. The higher density found in our work could be due, on the one hand, to the positive effect that urbanization has on the species, as previously suggested (Cramp 1972, Bea et al. 2011, Bendjoudi et al. 2015, Sakhvon & Kover 2020), and to the fact that the Woodpigeon population has already been established in Zaragoza for more than 20 years, while the other studies have been carried out in recently colonized cities (Fey et al. 2015, Sakhvon & Kover 2020) where the maximum densities have not yet been reached. There are several reasons why Woodpigeon reach higher densities in cities, but they could be summarized as i) a great availability of easily accessible food (Cramps 1972, Newhouse et al. 2008), ii) a more benevolent climate (Newhouse et al. 2008) that allows a higher percentage of second and third clutches, which are those with the greatest reproductive success (Hadjisterkotis & Taran 2000, Bengtsson 2001) and iii) a lower presence of their main predators such as the Magpie (*Pica pica*) (Tomiałojć 1980, Bengtsoon 2001, Hanane & Besnard 2013, Sakhvon & Kover 2020). This last point could also explain the significantly higher density that we have found on the streets, since Magpie are very common in most of the parks in our study area while they hardly appear on the streets traveled by vehicles. This is because, in parks, in addition to trees to nest, they find abundant food in the form of seeds, fruits and food scraps that people consume, while the streets are mostly used for walking and trees are practically the only available plants, so the food availability for corvids is much lower. However, the Woodpigeon is capable of traveling several kilometers from nesting areas to feeding areas (Slater 2001, Perea & Gutiérrez-Galán 2016), therefore, the availability of food near the nests is not as important as for corvids and they can use areas without trophic resources to nest, such as streets.

Applications to reduce the negative effect of Woodpigeon presence

The presence of the Woodpigeon in urban environments implies the appearance of conflicts with human populations associated with its excrement. In those sites where this species spends more time, such as roosts and nest areas, feces accumulate, staining parked cars and benches where people sit. To this

Table 1. Density of Woodpigeon in different habitats

Habitat	Density	Authors
Agrosystem	0.106 pairs / ha	Bea et al. (2011)
	1.2 pairs / ha	Fernández-García (2022)
	5 pairs / ha	Bendjoudi et al. (2015)
	6.95 nest/ha	Inglis et al. (2004)
Forest	0.3 pairs / ha	Bea et al. (2011)
	0.5-2.5 pairs / ha	Fernández-García (2022)
	2 nest/ha	Inglis et al. (2004)
	3.2-3.6 nest/ha	Hanane (2013)
Urban	1.12 pairs / ha	Csatho and Bozo (2022)
	1.5 pairs / ha	Bea et al. (2011)
	1.6-2.7 pairs / ha	Fernández-García (2022)
	< 2 nest/ha	Sakhvon and Kover (2020)
	5.6-12.25 nest / ha	Present study
	15-20 pairs / ha	Varga and Juhasz (2020)

damage, which could be considered minor, we must add the fact that zoonotic diseases can be transmitted through these excrements such as salmonellosis (Krawiec et al. 2015) or even high pathogenicity avian influenza H5N1 (Peters et al. 2022). Our results could be used to reduce the negative effect Woodpigeon has in urban environments, planting tree species that are less attractive to pigeons (negatively selected species) in areas of greater human use, and the most selected ones (positively selected species) in the rest of the parks areas. Thus, if planting tree species preferred by Woodpigeons next to benches or in parking lots were avoided, it would be expected that the presence of birds in those specific spots will be lower, reducing therefore the problem. Furthermore, *Pinus* sp., apart from being positively selected by Woodpigeon, it also cause problems by staining benches and cars with resin, so their use in these places would be doubly discouraged. On the contrary, the species negatively selected by Woodpigeon could be highly recommended trees to be planted next to parking lots and benches, , and in turn the problems related to the resin production would be avoided. However, species of the genus *Platanus* can cause allergic problems (Vrinceanu et al. 2021), and *Melia azedarach*, *Ailanthus altissima*, *Gleditsia triacanthos* and *Catalpa* sp. are potentially invasive species (GISD 2020), factors that should also be taken into account when choosing the tree species to be used.

Conclusion

The present work has highlighted the importance of cities for the Woodpigeon, with densities during the breeding period greater than those existing in natural environments. This situation implies that the management of this species in urban environments must be taken into account to guarantee its conservation. The preferential use of *Pinus* sp or *Acer negundo*in in park areas without benches, and planting *Prunus* sp., *Populus* sp., *Morus alba* or *Cersis siliquastrum* next to benches and vehicle parking areas could lead to a higher density of Woodpigeon in the least conflictive areas, so that their conservation would be guaranteed by reducing the negative impact on human activities.

Acknowledgements

We thank Mark den Toom, Esther Biescas and Aitziber Zufiaurre for their English review and help with the statistical analysis. The two anonymous reviewers provided valuable comments that improved the initial manuscript.

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Received: 16 May 2024
First response: 25 June 2024
Final acceptance: 15 July 2024
Published online:
Associate editor: Davide Dominoni