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Testing different isolation distances in woodpecker territory mapping in Central Hungary

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Abstract Woodpeckers as cavity excavators are crucial in forest ecosystems, therefore, it is important to study their ecological needs, specifically at the territory scale, using mapping methodologies, of which there are uncertainties considering detection probabilities and the distances of the territory centres in different species and habitats. We studied the effects of the number of visits and isolation distance on detected woodpecker territories in the 1,000 ha forest mosaic of the Peszér forest in Central Hungary. We made territory mapping in 2020 along existing trails and forest roads on the present woodpecker species as Black, Eurasian Green, Great Spotted, Middle Spotted, Lesser Spotted Woodpecker and Eurasian Wryneck. We found a very low detection probability for single territories during one visit, while with the increasing number of visits it is more unlikely to overlook territories. Considering the isolation distances, by lowering the distance, more territories can be registered, which suggests that researchers should take great care choosing the proper distance for a given species whilst avoiding the over- or underestimation of territories.

This paper has an actuality as BirdLife Hungary announced the Eurasian Green Woodpecker as the Bird of the Year in 2022, for drawing attention to this species' habitat preferences and conservation.

Keywords: woodpecker ecology, territory mapping, transect surveys, isolation distances, detection probabilities

Összefoglalás A harkályok, mint odúkészítő fajok meghatározó szerepet töltenek be az erdei ökoszisztémákban, így ökológiai vizsgálataik természetvédelmi szempontból kiemelt jelentőséggel bírnak. Fontos élőhely preferenciájuk, azon belül territórium használatuk tanulmányozása különböző térképezési módszerekkel. Ezek esetében a territóriumok ráfordítás-függő észlelési valószínűsége, illetve a territórium központok távolságának tekintetében a különböző fajoknál és élőhelyeknél az irodalomban tapasztalhatók bizonytalanságok. Az 1000 hektáros Natura 2000-es, középmagyarországi Peszéri erdő mozaikjában vizsgáltuk a bejárások számának és a territóriumok izolációs távolságának a territóriumok észlelésére gyakorolt hatását. A vizsgált területen 2020 tavaszán a meglévő ösvények és erdei utak mentén végeztünk territórium térképezést az előforduló harkályfajokon, mint a fekete harkály, a zöld küllő, a nagy, közép, kis fakopáncs és a nyaktekercs. A territóriumok észlelésének egy bejárás során nagyon alacsony a valószínűsége, ám a bejárások számát növelve a territóriumok nem észlelésének valószínűsége lecsökken. Az izolációs távolság csökkentésével több terület regisztrálható, ez azt sugallja, hogy a kutatóknak nagy gondot kell fordítani az adott faj megfelelő izolációs távolságának megválasztására, elkerülve a területek túl- vagy alulbecslését.

Ennek a cikknek az aktualitása, hogy a Magyar Madártani és Természetvédelmi Egyesület a zöld küllőt jelölte ki a 2022-es év madarának, rávilágítva annak élőhely használatára és természetvédelmi jelentőségére.

Kulcsszavak: harkályok ökológiája, territórium térképezés, transzekt adatgyűjtések, izolációs távolságok, észlelési valószínűség

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Introduction

Woodpeckers, as major cavity-excavator species have a crucial role in forest ecosystems (Robles & Pasinelli 2014). These species provide nesting opportunities for numerous cavity-dwelling species (Bai *et al.* 2005). Woodpeckers can be examples of umbrella species since, through their protection, it is possible to support other species (Roberge *et al.* 2008, Edman *et al.* 2011, Lammertink 2014, Robles & Pasinelli 2014). For these conservation purposes, it is important to study their ecological needs, specifically their use of available space at the territory scale.

By definition, the territory is "any defended area" that can be used for years, and can be determined by the positions of individuals, showing territorial behaviour, e.g. territorial calls and drumming in woodpeckers (Tomasevic & Marzluff 2018a). In general, territory mapping is a group of methods, dedicated to scaling large areas in a reasonable time counting the individuals and identifying their geographical positions, measuring their abundance and having a deeper knowledge of the habitat utilization of the focal species. In the process, researchers can cover whole areas of forests in a systematic manner (Weißmair & Pühringer 2015), move on transects (Kumar *et al.* 2014, Gerdzhikov *et al.* 2018), visit only designated plots (Gjerde *et al.* 2005). The number of visits per season can also differ from study to study from only one visit (Gerdzhikov *et al.* 2018) to three (Verschuyl *et al.* 2021) or more (Kopij 2017, Miller *et al.* 2018). With the increasing number of visits, the probability to record all existing territories also increases, as there are studies with eight visits or more (Koivula & Schmiegelow 2007). To increase the chance of finding the maximum number of territories of the focal species, one can use playback recordings in a systematic design, using playback stations at equal distances and recording the presence of territories through the mapping bouts (Gjerde *et al.* 2005, Stachura-Skierczyńska & Kosiński 2014, Figarski 2017, Verschuyl *et al.* 2021). According to Kosiński *et al.* (2004), with the playback method, up to 80% of all territories can be found during one visit. However, playbacks can also make individuals erroneously crowded, and modify their distribution (Bocca *et al.* 2007).

In the planning of territory mapping, one should consider carefully the particular scientific questions, the characteristics of the terrain, the manpower that can be used and the time that can be afforded by the observers.

In territory mapping, researchers on the field register the date and even the number of the given visit in the row and take great care of the direction of movements of the birds, to minimise the chance of double counts. Territories can be delimited by e.g. the minimum convex polygon method, drawing a convex polygon around a cluster of encounters of a particular bird species, made in different mapping bouts, by excluding any other encounters from bouts that have one included point in the cluster (Remeš 2003, Duca *et al.* 2006). In addition, a territory can be regarded as occupied when two independent observations of at least one territorial bird in a limited area were made during the same breeding period (Tjernberg *et al.* 1993, Salvati *et al.* 2001). The size of this limited area as well as the minimum distance between individuals of different territories is still not well-defined in the literature. It would be helpful to use particular isolation distances, and only consider points in the same territory, if their pairwise distance is lesser than the chosen isolation distance.

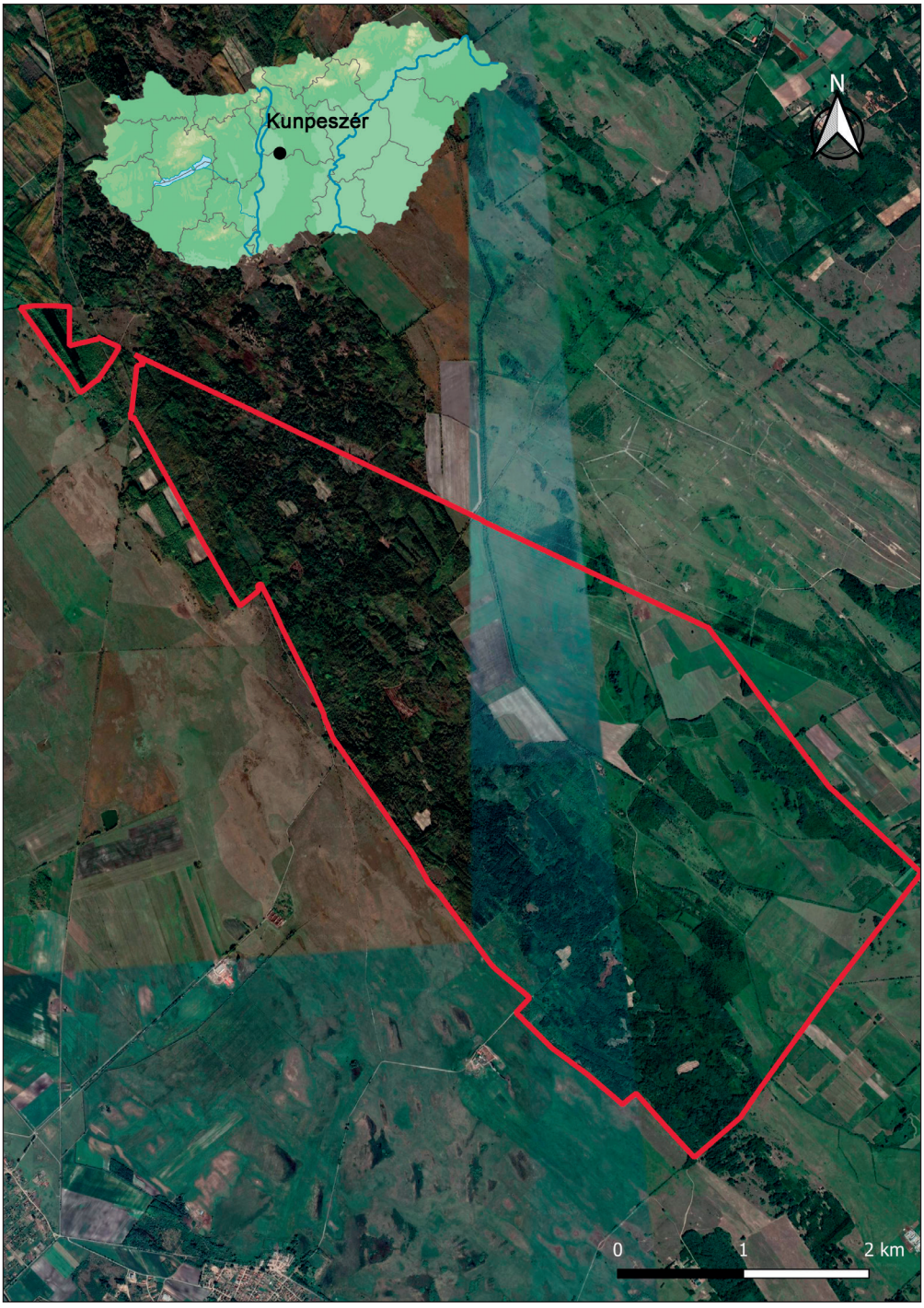


Figure 1. Aerial photograph of the study area with its geographical position in Hungary
1. ábra A vizsgált terület légifotója és földrajzi helyzete Magyarországon

In this paper, we tested how different isolation distances can affect the number of territories in various woodpecker species, with special considerations on the number of visits and detection probabilities. In this way, we aimed to quantify the comparability of the results of surveys with different efforts allocated. Through these efforts, we aimed to share solutions/suggestions on processing/interpreting data on woodpecker territories.

Material and Methods

Study area

The Peszér Forest (HUKN20002), located in Central Hungary, is a part of the Natura 2000 network, covering approximately 1,628 hectares. The total cover of forests is 1,080 hectares, while the rest of the area is covered with high conservation value grasslands. In addition to the forest stands dominated by alien tree species representing low conservation value, the study area hosts some semi-natural forest stands representing unique conservation value. The most typical of the latter is the Euro-Siberian forest steppes dominated by *Quercus robur*, which are found in a mosaic distribution (covering a total of approx. 200 ha), the mixed hardwood forests characterised by the dominant *Fraxinus angustifolia* mixing with *Quercus robur* and *Ulmus minor* (12 hectares) and the Pannonian sand thickets dominated by *Populus alba* and *Juniperus communis* (approx. 85 hectares). Also, approx. 300 hectares of uncharacteristic softwoods dominated by *Populus alba* are present.

Data collection

Data collection was carried out from 10 February to 20 May 2020, for a total of 47 days with favourable weather (rain- and windless periods). Acoustic and visual detection of woodpeckers were applied. The position and behaviour (i.e. drumming, acoustic territory defending behaviour other than drumming, feeding, flying by) of all observed specimens were recorded in ArcPad software running on a handheld device with a built-in GPS receiver.

The census routes covered all the outer forest edges and all the accessible roads and paths inside the forest, summing up to 76.9 kilometres. Due to the overall length of census routes, six census routes were assigned, each being censused at least six times throughout the data collection period (on average 7.9 times). Despite the relatively dense network of inner roads, about 40% of the habitat patches inside the forest were located more than 200 m from the nearest access route. Due to the limits of acoustic detection, it was not possible to survey the territories located there. Accordingly, the number of territories detected/calculated can be considered as a minimum number.

Data analysis

Due to the lack of individual marking (e.g. colour-ringing, attaching radio transmitters), it was not possible to identify individuals performing territorial behaviour. To locate territories

and to determine the number of those, the distance between the recorded position of individuals exhibiting territorial behaviour was taken into account. Hereinafter, the distance above which two observations were considered to belong to different territories is referred to as the isolation distance. The number of territories was calculated for isolation distances of 100, 200, 300 and 500 m. Only observations of individuals performing territorial behaviour were included in this analysis.

For calculating the distance between two points, the "Near Analysis" of ArcMap was run. In case more than two points were located close to each other (pairwise closer than the isolation distance), then all these points were considered to belong to the same territory.

Results and Discussion

During the data collection period, 238 woodpecker occurrences were recorded, and 130 of them showed territorial behaviour *(Table 1)*. The average number (± standard deviation) of observations of individuals performing territorial behaviour belonging to the same territory calculated for different isolation distances in the most visited, long transects are shown in *Table 2*. Comparing the average number of observations considering particular woodpecker species and isolation distances with the average number of censuses (7.9) it can be concluded that woodpecker territories can remain undetected during most field visits, as each visit can be regarded as an imperfect registration, where there is a ratio to record a given territory in a single visit (Bibby *et al.* 2000). According to Bibby *et al.* 2000, to confirm a territory, one needs at least two observations for a particular territory in eight or fewer visits, while in nine or more visits, three observations are required in a given area. Although the simultaneous observation of two individuals close to each other can help to find the boundaries between territories, without such encounters, the maximum distance of

Table 1. Number of territories of the different species in different isolation distances
1. táblázat A különböző fajok territóriumai az egyes izolációs távolságokon, a territoriális madarak, illetve az összes észlelés száma. A fajok fentről lefelé: fekete harkály, nagy, közép, kis fakopáncs, zöld küllő, nyaktekercs

Species	No. of territories calculated for different isolation distances				Number of records of specimens performing territorial behaviour	Total number of records
	100 m	200 m	300 m	500 m		
Black Woodpecker	23	20	18	15	29	52
Great Spotted Woodpecker	43	28	22	16	52	87
Middle Spotted Woodpecker	19	16	13	9	19	52
Lesser Spotted Woodpecker	7	7	5	4	7	24
Eurasian Green Woodpecker	12	12	10	9	12	12
Eurasian Wryneck	10	10	8	6	11	11

Table 2. The average number (± standard deviation) of observations of individuals performing territorial behaviour belonging to the same territory was calculated for different isolation distances in the most visited, long transects. In these parts, no Eurasian Wrynecks were found

2. táblázat Az adott területiumokhoz köthető észlelések átlaga és szórása a különböző izolációs távolságokon, a legtöbbször bejárt, hosszú transzekteken. Ezeken a helyszíneken nyaktekercseket nem figyeltünk meg. A fajok fentről lefelé: fekete harkály, nagy, közép, kis fakopáncs, zöld küllő

Species	Isolation distances			
	100 m	200 m	300 m	500 m
Black Woodpecker	1.10 ± 0.32	1.22 ± 0.67	1.38 ± 0.74	1.67 ± 0.82
Great Spotted Woodpecker	1.06 ± 0.24	1.36 ± 0.50	1.44 ± 0.53	1.71 ± 0.76
Middle Spotted Woodpecker	1.00 ± 0.00	1.36 ± 0.92	1.88 ± 1.36	2.80 ± 1.30
Eurasian Green Woodpecker	1.13 ± 0.35	1.14 ± 0.38	1.33 ± 0.52	1.33 ± 0.52

observations from different visits for one single territory is still undefined (Gottschalk & Huettmann 2011). In this regard, Pakkala and coworkers used a 500 m isolation distance to distinguish between Three-toed woodpecker territories (Pakkala *et al.* 2002). Also, due to this low detection probability, it is not likely that we can draw maps with expressed spatial aggregation of observations of territorial individuals which could result in unambiguous separation of territories applying the traditional transect method having been used by us.

With decreasing isolation distance from 500 m to 100 m (the extremes set in our calculations), the calculated number of territories of woodpecker species increased by 53.3%, 168.8%, 111.1%, 75.0%, 33.3% and 66.7% in the case of Black Woodpecker *(Dryocopus martius)*, Great Spotted Woodpecker *(Dendrocopos major)*, Middle Spotted Woodpecker *(Dendrocoptes medius)*, Lesser Spotted Woodpecker *(Dryobates minor)*, Eurasian Green Woodpecker *(Picus viridis)* and Eurasian Wryneck *(Jynx torquilla)*, respectively. Due to a lack of individual marking, it was not possible to directly separate territories, therefore, we were not able to determine the exact number of territories.

The estimated number of territories in our study was 15–23, 16–43, 9–19, 4–7, 9–12 and 6–10 in the case of Black Woodpecker, Great Spotted Woodpecker, Middle Spotted Woodpecker, Lesser Spotted Woodpecker, Eurasian Green Woodpecker and Eurasian Wryneck, respectively. Applying these derived data, the estimated territory density (number of territories per 1,000 ha) was 13.9–21.3, 14.8–39.8, 8.3–17.6, 3.7–6.5, 8.3–11.1 and 5.6–9.3, respectively. The densities of Great Spotted and Lesser Spotted Woodpeckers were nested in the intervals from the literature, while the densities of Black, Eurasian Green Woodpeckers, and Eurasian Wryneck were higher compared to literature intervals, besides, we found lower densities in Middle Spotted Woodpeckers (del Hoyo *et al.* 2002). Given the highly mosaical stand structure of the study site with numerous non-native plantations in the landscape, these experienced intervals can be considered reasonable, as territory size can be influenced by habitat characteristics e.g. stand and landscape structure (Tomasevic & Marzluff 2018b).

Table 3. The average probability of detecting a woodpecker territory during one visit was calculated for different isolation distances in the most visited, long transects. In these parts, no Eurasian Wrynecks were found

3. táblázat Egy territórium detektálási valószínűsége különböző fajoknál és izolációs távolságoknál a legtöbbször bejárt, hosszú transzekteken. Ezeken a helyszíneken nyaktekercseket nem figyeltünk meg. A fajok fentről lefelé: fekete harkály, nagy, közép, kis fakopáncs, zöld küllő

Species	Isolation distances			
	100 m	200 m	300 m	500 m
Black Woodpecker	6.88%	7.64%	8.59%	10.42%
Great Spotted Woodpecker	6.62%	8.52%	9.03%	10.71%
Middle Spotted Woodpecker	6.25%	8.52%	11.72%	17.50%
Eurasian Green Woodpecker	7.03%	7.14%	8.33%	8.33%

Alongside the most frequently visited, long transects (in total, 16 visits per transect throughout the whole census period), the average probability of detecting a woodpecker territory during one visit is summed up in *Table 3*.

This low detection probability (ranging between 6.25% and 17.50% across species and isolation distances) can be originated from the characteristics of the transect method. These experienced detection probabilities are way lower than the ones Bibby *et al.* (2000) published. According to them, the chance of registering a particular territory during one visit is between 0.25 and 0.33. Walking with 4 km/h speed and a maximum detection distance hypothesised to be 200 m, the surveyor spends approx. 6 minutes in the vicinity of a woodpecker territory. Other methods (e.g. point transect surveys, playing species-specific sounds) may provide much better detection probabilities. Although, because of the higher amount of time spent in the vicinity of a territory, these methods can be used for mapping territories in smaller areas or larger areas, by using a higher number of observers (Kosiński *et al.* 2004). Considering the low detection probability of woodpecker territories during one visit when applying the transect method, it can lead to serious underestimation of the number of territories with low (2–5) repetition of visits (Bibby *et al.* 2000).

Our results suggest that the number and size of territories can fairly vary in the case of different woodpecker species depending on the number of visits and the isolation distances chosen. With this in mind, researchers should take into consideration choosing parameters with great care.

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