



Low Probability of Attacks by Hooded Crows *Corvus cornix* L., 1758 (Passeriformes: Corvidae) during the Nest-attendance Period: A Pilot Study

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Abstract: We monitored 15 nests of hooded crows *Corvus cornix* while simultaneously recording the activity of birds at their nests and the number and activity of people in the vicinity of nests, to examine (1) how often crows attack people during the nest attendance period, (2) whether people and their activity close to crows' nests increase the probability of attacks and (3) whether people around nests increase the probability of crows' vocalisation. In total, we conducted 130 hours of observation, during which we recorded the presence and behaviour of nearly 30,000 people close to the crows' nests. Despite intensive human activities in the vicinity of crows' nests, we did not record aggression toward humans or pet animals, indicating that attacks are rare before fledglings leave their nests. In addition, vocalisation by crows was affected by the number of conspecifics in the nest vicinity but not by the human presence or activities.

Key words: human-wildlife conflict, urban ornithology, urban ecosystems, corvids

Introduction

Urbanisation presents one of the most intense forms of human-caused environmental change, affecting community structure, population dynamics and its genetic constitution, as well as the morphology and behaviour of organisms (SHOCHAT et al. 2006). Urban communities are characterised by lower diversity, compared to non-urban ecosystems, often dominated by a small number of species that may reach high abundances (CROOKS et al. 2004, MCKINNEY 2008, MORELLI et al. 2016). In addition, animal spe-

cies that successfully colonise cities are typically those that have behavioural, physiological and morphological flexibility allowing them to overcome common stressors in urban environments, such as pollution, noise and infectious diseases (LOWRY et al. 2013, WAUTERS & MARTINOLLI 2018).

Human-wildlife conflicts are common in urban environments and could be provoked by behaviours that animals typically do not exhibit in their more natural habitats (LOWRY et al. 2013, BROOKS et al. 2020, SCHELL et al. 2021). Aggressive behaviour toward humans is arguably one of the strongest trig-

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gers of conflict with urban-dwelling species (BASAK et al. 2023). Perception of this conflict is shaped by personal negative experiences with wild animals but also by other factors, such as common beliefs, fears or media coverage (CLUCAS et al. 2011, KÖVÉR et al. 2022, BASAK et al. 2023). Thus, in order to understand the foundation of negative attitudes toward potentially aggressive species, it is important to determine the real probability of aggressive behaviour and the specific context in which it happens.

The hooded crow *Corvus cornix* L., 1758 is a successful urban coloniser, experiencing population increase throughout European cities since the 1960s (VUORISALO et al. 2003, MAZGAJSKI et al. 2008, VREZEC 2010). Such a population rise is a consequence of increased anthropogenic food sources, the lack of crows' predators and low level of persecution in urban habitats as well as the birds' intelligence and their ecological flexibility allowing them to adjust to highly altered urban environments (VUORISALO et al. 2003, KÖVÉR et al. 2015). However, increased population densities of urban crows lead to frequent conflict with humans, mainly due to noisy vocalisation, pollution by faeces and the spread of human waste (POKORNY et al. 2014). In addition, crows may physically attack humans while taking care of the young (VUORISALO et al. 2003, POKORNY et al. 2014), which, along with negative media coverage on the topic, even more strengthens the aversion of people toward them. Two questionnaire-based studies reported that 5–10 % of participants had personally experienced attacks by crows in Europe (ŠPUR et al. 2016, KÖVÉR et al. 2022). Nevertheless, information on the incidence of these attacks close to the crows' nests is lacking in the literature. In addition, it is not well documented at which nesting stage crows attack people and whether human activities provoke aggression or vocalisation of crows.

In this study, we examined in several cities in Serbia whether crows attack people before fledglings leave their nests. There is a lack of detailed and quantitative research on the conflict between humans and crows in Serbia. However, a brief search of media content published during the last decade revealed dozens of articles about the human–crow conflict (e.g., STANKOVIĆ 2019, S. K. 2020, J. M. M. 2021). Although the analysis of media reporting on crows was out of the scope in this study, it became evident that human–crow conflicts occur regularly in urban environments. Furthermore, the media content typically lacks a scientific background, leading to sensationalist reporting on instances of conflict. Consequently, the coverage tends to be unreliable, devoid of context and predominantly negative to-

ward crows. Therefore, by employing by a network of volunteers who observed crows' nests, we aimed to examine (1) how often crows attack people during the nest attendance period, (2) whether people and their activity close to crows' nests increase the probability of attacks, and (3) whether people around nests increase the probability of crows' vocalisation.

Materials and Methods

The study took place in four cities in Serbia – Belgrade, Novi Sad, Šabac and Čačak (Fig. 1), in April and May 2021. Members of the Bird Protection and Study Society of Serbia and students of the University of Belgrade participated in the study. We announced the study through social networks and emails, whereas students were informed in their classes or using the Google Classroom platform. All participants, in total 18 of them, were included in the study on a voluntary basis. The data collection protocol was straightforward and contained several tables, which volunteers filled out while observing nests. In addition, all volunteers obtained training (online and in the field) prior to onset of the study.

The history of colonisation of urban habitats by the hooded crow has not been studied in Serbia. Literary data from the mid-20th Century indicate that hooded crows typically bred in different open and semiopen habitats (MATVEJEV 1950, 1976), whereas the colonisation process of urban environments possibly increased in the second half of the 20th Century, similar to nearby countries (e.g., VREZEC 2010, KÖVÉR et al. 2015). Currently, urban and suburban environments are considered the most significant habitat for this species (PUZOVIĆ et al. 2015). The breeding population in the Belgrade area is estimated to be around 1000–1500 breeding pairs, 500–700 pairs in Novi Sad and 79–90 pairs in Čačak (PUZOVIĆ, unpublished data), which constitutes nearly 1% of the population in Serbia (PUZOVIĆ et al. 2015). Bird tolerance to humans differs among urban and rural habitats and increases with latitude (DIAZ et al. 2013). Nevertheless, the breeding range of hooded crows in Serbia is continuous (PUZOVIĆ et al. 2015, KELLER et al. 2020), with the study cities within a relatively short distance of each other (up to 100 km). The agricultural landscape intersected by an extensive network of settlements dominates the area between the cities with no natural barriers in between. For these reasons, we considered that the behaviour of crows would not significantly differ among cities, given the small geographical distance and ecological uniformity of the urban environments in the studied areas.

Hooded crows are typically solitary breeders with pairs being territorial during breeding season (LOMAN 1985). Their nests are usually placed high in the canopy of deciduous or conifer trees and may be reused in subsequent years (ZDUNIAK & KUCZYŃSKI 2003, KÖVÉR et al. 2015, MCIIVOR & HEALY 2017). At the end of March 2021, we searched for active crow nests – a nest was considered active if, during consecutive visits, we noticed a crow within the nest and (or) crows were repeatedly visiting the nest, indicating feeding of the partner or offspring. The most important criterion for including nests in research was the possibility of conflict among nesting crows and people. Therefore, we did not consider crow nests in private properties but within public city parks, green areas or sidewalk trees, with noticeable pedestrian traffic close to the nest trees. We observed 15 nests: 12 nests in Belgrade and one nest in Novi Sad, Šabac and Čačak each. A detailed description of study locations is provided in Table 1. Each nest was observed 3–6 times throughout the study period, with subsequent visits to the same nest occurring 6–19 days apart. To reduce the possibility of disturbing nesting crows during the study, observers were placed around 30 m away from the nest tree. Once an observer noticed that a nest was no longer active, i.e. no crows were present in or adjacent to the nest or no crows were flying in (out) of the nest during an observation session, observation of that nest was ceased.

Nests were observed during daylight, from 7 to 19 h, within two-hour blocks (e.g. 7–9, 9–11, 11–13, etc.), which were typically alternated in subsequent observations of the same nest. E.g., if a nest was observed 7–9 during one visit, it was observed in another time window (e.g. 13–15) during the next visit. However, not all observers could follow the suggested protocol; thus, some nests were observed more than once in a given two-hour period. Two-hour blocks were further divided in 24 five-minute intervals, for which we recorded the following information: (1) the number of crows within a 30 m radius from the nest tree; (2) the number of visible nestlings or fledglings within a 30 m radius from the nest tree and their position – at nest, beside nest, on the nest tree, on another tree, on the ground, other; (3) the number of crows' calls within a 30 m radius from the nest tree; (4) the position of vocalising crows – at nest, beside nest, on the nest tree, on another tree, on the ground, other; (5) the number of aggressive behaviours of crows directed toward people within a 5 m and 30 m radius from the nest tree, described as – following people, swooping people without physical contact, swooping people with

physical contact accomplished through bill, claws or wings; (6) the number of people within a 5 m and 30 m radius from the nest tree, their activity – standing/sitting, walking, jogging, playing/sports, riding scooter/bicycle/motorcycle, approaching fledglings, and their gaze – directed toward crow/nest or not; (7) noise produced by people within a 5 m and 30 m radius from the nest tree – present or absent; and (8) the number of cats and dogs within a 5 m and 30 m radius from the nest tree.

Vocalisation by crows was assessed using a zero-inflated generalised linear mixed model with negative binomial distribution. Prior to analysis, we assessed collinearity among predictors using the Pearson coefficient of correlation (ZUUR et al. 2009). As the number of people within the 5 m radius from the nest tree and the total number of people within a five-minute interval were highly correlated ($r_{\text{Pearson}} = 0.814$, $p < 0.001$), we included only the number of people within the 5 m radius as a variable in our models. In the first model, the response variable was the number of crows' calls per five-minute interval, whereas the predictors were the number of people within the 5 m radius from the nest tree, the number of pets, noise generated by people and the total number of crows (the last three variables refer to the entire area within the 30 m radius from the nest tree). To account for the nest and date variability other than that covered by the model's predictors, the date of observation nested within the nest ID was set as a random factor. The second model was similar to the first one but in order to account for variability in the number of crows within the study area, i.e. to assess the influence of predictors on the per-capita rate of vocalisation, we also specified an offset variable as the number of crows recorded per the five-minute interval (ZUUR et al. 2009). To validate the model, we plotted the scaled residuals (HARTIG 2022). The analysis was conducted using R v4.3.0. (R CORE TEAM 2023) using packages glmmTBM (BROOKS et al. 2017) and DHARMA (HARTIG 2022).

Results

We observed 15 nests for 130 hours – three nests were observed for a total of six hours each (three two-hour blocks/nest), seven nests for a total of eight h/nest, two nests for a total of 10 h/nest and three nests for a total of 12 h/nest. All nests were actively attended by crows during the study period, although nestlings were rarely notified (in 155 out of 1560 five-minute intervals), as nests were placed high in the canopy. A fledgling outside the nest was observed only once, at the moment it left the nest during an

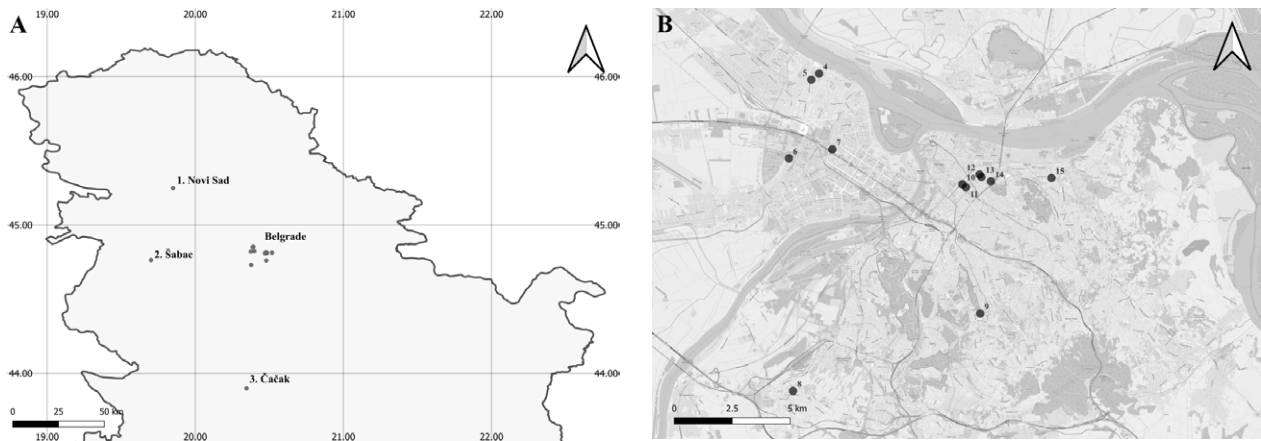


Fig. 1. Maps with study locations of observed nests. A. Three nests in Novi Sad, Šabac and Čačak; B. Twelve nests in Belgrade. The nest numbering corresponds to the numbering in Table 1.

observation session. The average number of crows within a five-minute interval was 1.30, ranging 0–11. We recorded activity of 2634 people in the vicinity of nests: 5937 within the 5 m radius from the nest tree and 23697 within the 5–30 m radius. The average number of people per five-minute interval was 18.85 (range 0–107). The most common activity of people was walking: 15013 individuals, followed by standing/sitting: 8000, playing/sports: 4865, riding a scooter/bicycle/motorcycle: 1240, whereas the least common was jogging: 516 individuals. Passers-by rarely paid attention to the birds, only in 21 five-minute intervals they looked toward the crows' nests. During the study period, we recorded 563 dogs up to 5 m from the nest trees, 1654 dogs were present 5–30 m from the nest trees, whereas stray cats were rarely observed, 100 in total.

We did not record any aggressive behaviours of crows, whose nests we observed, directed toward people. In addition, crows rarely vocalised during observations – within 191 five-minute intervals we notified 570 crows' calls. The total number of crows' calls was positively affected by the number of crows within a five-minute interval, whereas per-capita rates of vocalisation were negatively affected by the number of crows within a five-minute interval. No other variables included in GLMMs had a significant effect on the incidence of crows' vocalisation (Tables 2 and 3).

Discussion

The recent development of cities, characterised by rapid human population growth and spatial expansion of built-up areas, leads to frequent human-wildlife conflicts in urban environments (GASTON 2010, SOULSBURY & WHITE 2015). Populations of

various crow species have been increasing in cities throughout the world (MARZLUFF et al. 2001, WILSON et al. 2015, BENMAZOUZ et al. 2021), where they are often considered nuisance animals (CLUCAS et al. 2011, POKORNY et al. 2014). Negative experiences with crows may include contamination of public areas by feces, spread of human waste, loud vocalisation, property damage or attacks on humans and their pets (KUROSAWA et al. 2003, Špur et al. 2016, KÖVÉR et al. 2022). In a study conducted in Slovenia, 9.2% of participants, out of 1042 who filled out a questionnaire, reported that they had personally experienced attacks by crows, whereas 14.7% heard about attacks from other people (Špur et al. 2016). Similarly, 5% of inhabitants of several Hungarian cities (out of 1740 individuals who participated in a survey) reported they had personal experiences with crow attacks, while 12.3% heard about attacks from others (KÖVÉR et al. 2022).

The nesting crows we observed did not attack people. In addition, none of the human activities we aimed to identify as triggers of attacks did not provoke a reaction from birds. Studies on Australian magpies *Gymnorhina tibicen* found that rapid movements of humans through magpie territories, such as cycling or jogging, often elicit attacks by birds. These studies also imply that attacks are more severe, occasionally causing physical injuries, if intruders approach closer to a nest tree (JONES 1980, WARNE & JONES 2003). In our study, a substantial number of people passed through the study areas, with more than 500 individuals jogging or cycling less than 5 m from the nest trees, but with no effects on the birds' behaviour. In addition, the number of people and their pets (or stray animals) within the study area did not affect the vocalisation of crows, which in general rarely occurred. Nevertheless, the

Table 1. Description of the study locations. The site numeration corresponds to the numeration of nests in Fig. 1.

Study location	Description
1. Novi Sad	Single tree on the sidewalk of a busy street. Extensive grassland and residential buildings are nearby.
2. Šabac	Extensive green area at the Sava River. It consists of open grasslands with scattered deciduous trees, intersected by walking and bicycle trails.
3. Čačak	Residential city area with a conifer tree line along the street. Townhouses and small buildings are placed on one side of the street, whereas a parking lot is on the other.
4. Belgrade – Zemun	Parking lot with high deciduous trees surrounded by residential buildings.
5. Belgrade – Zemun	Green area between buildings, with grassland and a high cover of deciduous trees.
6. Belgrade – Bežanijska kosa	Residential city area with a tree line along the street. Small buildings are placed on one side of the street, whereas extensive grassland with scattered trees is on the other.
7. Belgrade – Studentski grad	Park within the Belgrade University dormitory, consisting of grassland intersected by walking trails, with a high cover of deciduous trees.
8. Belgrade – Železnik	The backyard of a sports complex, with grassland, a high cover of deciduous and conifer trees, a parking lot, and buildings.
9. Belgrade – Banjica	Park with extensive pavement, surrounded by a high cover of deciduous trees and tall residential buildings.
10/11. Belgrade – Tašmajdan (2 nests)	Park in the city centre, with a high tree cover of conifers and deciduous trees, extensive areas of maintained grasslands with decorative flowers, intersected by walking trails. It contains children’s playgrounds, a dog run, and a water fountain. As a spatial cultural-historical unit, it is under state protection.
12. Belgrade – Proforska kolonija	Green area between buildings, with grassland and a high cover of deciduous trees.
13. Belgrade – Proforska kolonija	Park adjacent to the city centre with extensive pavement, grassland, and scattered deciduous trees. It contains a children’s playground.
14. Belgrade – Oslobodioci Beograda	Park adjacent to the city centre, with a high tree cover of conifers and deciduous trees, shrubs, maintained grasslands, and decorative flowers.
15. Belgrade – Karaburma	Park in a residential area, with a paved children’s playground, and high deciduous trees, surrounded by buildings.

Table 2. Coefficient estimates for predictors included in the mixed effect model examining the total number of crows’ calls per five-minute intervals: the number of people within the 5 m radius from the nest tree, the number of animals (cats and dogs), noise generated by people (present or absent), and the total number of crows within the area. Significant effects are highlighted in bold.

Predictor	Coefficient estimate	Standard error	P-value
Number of people	-0.0387	0.0224	0.0845
Number of animals	0.0046	0.0434	0.9178
Noise	0.1888	0.2468	0.4444
Number of crows	0.2014	0.0734	0.0061

Table 3. Coefficient estimates for predictors included in the mixed effect model examining per-capita rates of crows’ calls per five-minute intervals: the number of people within the 5 m radius from the nest tree, the number of animals (cats and dogs), noise generated by people (present or absent), and the total number of crows within the area. Significant effects are highlighted in bold.

Predictor	Coefficient estimate	Standard error	P-value
Number of people	-0.0369	0.0221	0.0949
Number of animals	-0.0002	0.0434	0.9955
Noise	0.1561	0.2423	0.5195
Number of crows	-0.1293	0.0628	0.0395

crows' vocalisation was affected by the total number of crows within the study area – while the total number of calls increased with the number of crows, it was the opposite for per-capita rates of vocalisation. The reason for such an observation may be related to the defence of breeding territories, as on many occasions we observed members of a breeding pair chasing conspecific intruders, which was often accompanied by loud vocalisation. Thus, it seemed that at this stage of the breeding season, while still being at their nests, crows were more concerned about protecting the nest against conspecifics than about human passers-by.

One of the limitations of our study is that it included a small number of nests and thus did not account for intraspecific variability in birds' behaviour (CARRETE & TELLA 2010). In addition, our protocol was not designed to measure the frequency of different call types. As crows use different types of vocalisations depending on social or environmental context (e.g. mating calls, mobbing calls, alarm calls) (CRAMP & PERRINS 1994), distinguishing among calls would provide better insight into the reaction of birds to different types of environmental stimuli, including those caused by humans. Nevertheless, recording of such sophisticated behavioural information would require substantial training of volunteers, which is challenging in volunteer-based science studies.

In spite of its limitations, however, our study indicates that the probability of crow attacks is most likely low while birds are at their nests and that future research should extend to the period after fledglings leave the nests. In addition, we used volunteer-derived data to examine a topic that is mainly under-represented in citizen science programs on avian urban ecology. Although this research covered a small number of nests, developed protocols can be successfully applied by non-professional ornithologists and citizen volunteers, and thus be easily incorporated into broadscale studies that would improve our coexistence with urban corvids.

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References

- BASAK S. M., ROSTOVSKAYA E., BIRKS J. & WIERZBOWSKA I. A. 2023. Perceptions and attitudes to understand human-wildlife conflict in an urban landscape – A systematic review. *Ecological Indicators* 151: 110319.
- BENMAZOUZ I., JOKIMÄKI J., LENGYEL S., JUHÁSZ L., KAISANLAHTI-JOKIMÄKI M. L., KARDOS G., PALÁDI P. & KÖVÉR L. 2021. Corvids in urban environments: A systematic global literature review. *Animals* 11 (11): 3226.
- BROOKS J., KAYS R. & HARE B. 2020. Coyotes living near cities are bolder: implications for dog evolution and human-wildlife conflict. *Behaviour* 157 (3–4): 289–313.
- BROOKS M., KRISTENSEN K., VAN BENTHEM K. J., MAGNUSSON A., BERG C. W., NIELSEN A., SKAUG H. J., MAECHLER M. & BOLKER B. M. 2017. glmmTMB Balances Speed and Flexibility Among Packages for Zero-inflated Generalized Linear Mixed Modeling. *The R Journal* 9 (2): 378–400.
- CARRETE M. & TELLA J. L. 2010. Individual consistency in flight initiation distances in burrowing owls: a new hypothesis on disturbance-induced habitat selection. *Biology Letters* 6 (2): 167–170.
- CLUCAS B., MARZLUFF J. M., KÜBLER S. & MEFFERT P. 2011. New directions in urban avian ecology: Reciprocal connections between birds and humans in cities. In: ENDLICHER W. (Ed.): *Perspectives of Urban Ecology*. Berlin, Germany: Springer-Verlag. pp 167–195.
- CRAMP S. & PERRINS C. M. 1994. *Handbook of the Birds of Europe the Middle East and North Africa. The Birds of the Western Palearctic*, vol. VIII. Oxford, UK: Oxford University Press.
- CROOKS K. R., SUAREZ A. V. & BOLGER D. T. 2004. Avian assemblages along a gradient of urbanization in a highly fragmented landscape. *Biological Conservation* 115 (3): 451–462.
- DÍAZ M., MÖLLER A. P., FLENSTED-JENSEN E., GRIM T., IBÁÑEZ-Álamo J. D., JOKIMÄKI J., MARKÓ G. & TRYJANOWSKI P. 2013. The geography of fear: a latitudinal gradient in anti-predator escape distances of birds across Europe. *PLoS one* 8(5): p. e64634.
- GASTON K. J. 2010. *Urbanisation*. In: GASTON K. J. (Ed.): *Urban ecology*. Cambridge, UK: Cambridge University Press. Pp. 10–34.
- Hartig F. 2022. DHARMA: Residual Diagnostics for Hierarchical (Multi-Level/Mixed) Regression Models. R package version 0.4.6. <http://florianhartig.github.io/DHARMA/>.
- J. M. M. 2021. Najezda agresivnih vrana napadi ptica sve češći u centru Beograda: upozoravaju stručnjaci, ali upozoravaju i vrane, i to ovako! <https://www.blic.rs/vesti/beograd/najezda-agresivnih-vrana-napadi-ptica-sve-cesci-u-centru-beograda-upozoravaju/qvznxgx>, accessed on 20 August 2024.
- JONES L., DARROCH R. K., GILDING J. & BENNETT D. H. 1980. A review of seasonal and ecological factors in Australian magpie *Gymnorhina tibicen* attacks on people. *Bird Behavior* 2 (2): 113–117.
- KELLER V., HERRANDO S., VORIŠEK P., FRANCH M., KIPSON M., MILANESI P., MARTÍ D., ANTON M., KLVANOVÁ A. & KALYAKIN M.V. 2020. *European breeding bird atlas 2: Distribution, abundance and change*. Cerdanyola del Vallès, Spain: Lynx Edicions.
- KÖVÉR L., GYÜRE P., BALOGH P., HUETTMANN F., LENGYEL S. &

- JUHÁSZ L. 2015. Recent colonisation and nest site selection of the Hooded Crow (*Corvus corone cornix* L.) in an urban environment. *Landscape and Urban Planning* 133: 78–86.
- KÖVÉR L., PALÁDI P., BENMAZOUZ I., Šorgo A., Špur N., JUHÁSZ L., CZINE P., BALOGH P. & LENGYEL S. 2022. Is the Hitchcock story really true? Public opinion on hooded crows in cities as input to management. *Animals* 12 (9): 1207.
- KUROSAWA R., KANAI Y., MATSUDA M. & OKUYAMA M. 2003. Conflict between humans and crows in greater Tokyo-garbage management as a possible solution. *Global Environmental Research – English Edition* 7 (2): 139–147.
- LOMAN J. 1985. Social organization in a population of the Hooded Crow. *Ardea* 73:61–75.
- LOWRY H., LILL A. & WONG B. B. 2013. Behavioural responses of wildlife to urban environments. *Biological Reviews* 88 (3): 537–549.
- MARZLUFF J. M., MCGOWAN K. J., DONNELLY R. & KNIGHT R. L. 2001. Causes and consequences of expanding American Crow populations. In: MARZLUFF J. M., BOWMAN R. & DONNELLY R. (Eds.): *Avian ecology and conservation in an urbanizing world*. New York, USA: Springer Science & Business Media, pp. 331–363.
- MATVEJEV S. D. 1950. *Distribution and life of birds in Serbia*. Belgrade, Serbia: The Serbian Academy of Sciences and Arts, Monographs, Vol. 3.
- MATVEJEV S. D. 1976. *Survey of the Balkan Peninsula bird fauna, Part I*. Belgrade, Serbia: The Serbian Academy of Sciences and Arts, Monographs, Vol. 46.
- MAZGAJSKI T. D., ŽMIHORSKI M., HALBA R. & WOŹNIAK A. 2008. Long-term population trends of corvids wintering in urban parks in central Poland. *Polish Journal of Ecology* 56 (3): 521–526.
- MCIVOR G. E. & HEALY S. D. 2017. Nest site selection and patterns of nest re-use in the Hooded Crow *Corvus cornix*. *Bird Study* 64 (3): 374–385.
- MCKINNEY M. L. 2008. Effects of urbanization on species richness: a review of plants and animals. *Urban Ecosystems* 11: 161–176.
- MORELLI F., BENEDETTI Y., IBÁÑEZ-Álamo J. D., JOKIMÄKI J., MÄND R., TRYJANOWSKI P. & MÖLLER A. P. 2016. Evidence of evolutionary homogenization of bird communities in urban environments across Europe. *Global Ecology and Biogeography* 25 (11): 1284–1293.
- POKORNY B., FLAJŠMAN K. & JELENKO I. 2014. The importance and impacts of crows, with emphasis on Hooded Crow (*Corvus cornix*), in the (sub)urban environment. *Acta Silvae et Ligni* 103: 47–60.
- PUZOVIĆ S., RADIŠIĆ D., RUŽIĆ M., RAJKOVIĆ D., RADAKOVIĆ M., PANTOVIĆ U., JANKOVIĆ M., STOJNIĆ N., ŠČIBAN M., TUCAKOV M., GERGELJ J., SEKULIĆ N., AGOŠTON A. & RAKOVIĆ M. 2015. *Birds of Serbia: Breeding population estimates and trends for the period 2008–2013*. Novi Sad, Serbia: Bird Protection and Study Society of Serbia, and Department of Biology and Ecology, Faculty of Sciences, University of Novi Sad.
- R CORE TEAM. 2023. *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. <http://www.R-project.org/>.
- SCHELL C. J., STANTON L. A., YOUNG J. K., ANGELONI L. M., LAMBERT J. E., BRECK S. W. & MURRAY M. H. 2021. The evolutionary consequences of human–wildlife conflict in cities. *Evolutionary Applications* 14 (1): 178–197.
- SOULSBURY C. D. & WHITE P. C. 2015. Human–wildlife interactions in urban areas: a review of conflicts, benefits and opportunities. *Wildlife Research* 42 (7): 541–553.
- SHOCHAT E., WARREN P. S., FAETH S. H., MCINTYRE N. E. & HOPE D. 2006. From patterns to emerging processes in mechanistic urban ecology. *Trends in Ecology & Evolution* 21 (4): 186–191.
- S. K. 2020. “Ljudi, vrane napadaju kao lude...” Beograđani na mukama, stručnjaci kažu da je sve to normalno, evo kako da se odbranite. <https://www.blic.rs/vesti/beograd/ljudi-vrane-napadaju-kao-lude-beogradjani-na-mukama-strucnjacikazu-da-je-sve-to/xw90ct1>, accessed on 20 August 2024.
- ŠPUR N., POKORNY B. & Šorgo A. 2016. Attitudes toward and acceptability of management strategies for a population of Hooded Crows (*Corvus cornix*) in Slovenia. *Anthrozoös* 29 (4): 669–682.
- STANKOVIĆ L. 2019. Pažnja, vrane napadaju. Sada je sezona kada se ustremljuju na ljude, a u ovim slučajevima moraćete kod lekara. <https://www.blic.rs/vesti/beograd/paznja-vrane-napadaju-sada-je-sezona-kada-se-ustremljuju-na-ljude-a-u-ovim/78nvlqf>, accessed on 20 August 2024.
- VREZEC A. 2010. Historical occurrence of the Hooded/Carrion Crow (*Corvus cornix/corone*) in urban areas of Europe with emphasis on Slovenia. *Annales, Series Historia Naturalis* 20: 131–140.
- VUORISALO T., ANDERSSON H., HUGG T., LAHTINEN R., LAAKSONEN H. & LEHIKONEN E. 2003. Urban development from an avian perspective: Causes of hooded crow (*Corvus corone cornix*) urbanisation in two Finnish cities. *Landscape Urban Planning* 62 (2): 69–87.
- WARNE R. M. & JONES D. N. 2003. Evidence for target specificity in attacks by Australian Magpies on humans. *Wildlife Research* 30 (3): 265–267.
- WAUTERS L. A. & MARTINOLI A. 2018. Urban Biological Invasions: When vertebrates come to town. In: Ossola A. & Niemelä J. (Eds.): *Urban biodiversity: from research to practice*. London, UK: Routledge Studies in Urban Ecology, pp 87–100.
- WILSON R. F., SARIM D. & RAHMAN S. 2015. Factors influencing the distribution of the invasive house crow (*Corvus splendens*) in rural and urban landscapes. *Urban Ecosystems* 18: 1389–1400.
- ZDUNIAK P. & KUCZYŃSKI L. 2003. Breeding biology of the Hooded Crow *Corvus corone cornix* in Warta river valley (W Poland). *Acta Ornithologica* 38 (2): 143–150.
- ZUUR A. F., IENO E. N., WALKER N. J., SAVELIEV A. A. & SMITH G. M. 2009. *Mixed effects models and extensions in ecology with R*. New York, USA: Springer.

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