

Use of raptors on the urban population of crows and pigeons

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Master's thesis / Diplomski rad

2024

Degree Grantor / Ustanova koja je dodijelila akademski / stručni stupanj: **University of Zagreb, Faculty of Veterinary Medicine / Sveučilište u Zagrebu, Veterinarski fakultet**

Permanent link / Trajna poveznica: <https://um.nsk.hr/um:nbn:hr:178:385675>

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THE UNIVERSITY OF ZAGREB
FACULTY OF VETERINARY MEDICINE

INTEGRATED UNDERGRADUATE AND GRADUATE UNIVERSITY STUDY
PROGRAMME *VETERINARY MEDICINE*

Master's Thesis

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Use of raptors on the urban population of crows and pigeons

Zagreb, 2024

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The paper contains 40 pages, 17 figures, 5 tables, 102 references.

ACKNOWLEDGMENTS

I would like to thank my mentor, professor Konjević for being such a nice mentor to me. I respect him the most and I truly appreciate his work and ideas on the world, the people and life in general. I learned a lot during those last years working with him and I sincerely hope there won't be an end to this collaboration. Listening to all his jokes and how life should be lived enlightens me.

I would like to thank Branimir Reindl for working on this project with me. I learned a lot from him about birds, and current project in Croatia.

I would like to thank my family. My father and my mother to allow me to accomplish my dream. My brother to be my only smart and kind brother. My sisters, Fara, Sahouly and Laina to always listen to all my worries and always be there for me.

I would like to thank my friends: Zoé for basically be my first roommate, to go through hard times together but always there for each other. Eunhee to be my best partner in class from day one, and outdoor partner to talk about class and life. I will miss those times. Val Naas to always be the sun in my life, your hard work and motivation was truly an inspiration for me. I would like to thank all my classmates for going through all this together. Everyone I met during those last 6 years are incredible women who will achieve, I hope, the best for themselves and for the world.

I would like to thank my boyfriend Fran for being with me at the worst and best time of my life. You make my personal life peaceful and bright. Ja volim te.

I would like to say thank you to the association Hrabre Njuške to be a foster for many cute Croatian cats. Gucci Gang, Boi, Push, Puff, Ginger, Witch ... they will always be in my heart for all the comfort they brought to me during the study.

I would like to say thank you to the exotic clinic of the Faculty of Veterinary Medicine for those time volunteering and to help me learn Croatian.

Lastly, I would like to say thank you to the Faculty of Veterinary Medicine in Zagreb. Without these 6 hard, happiest and saddest years of my life, I would have never met the person I love the most and would never be in Croatia.

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1. INTRODUCTION

Pigeons (*Columba livia*) and crows (*Corvus* spp.) represent, according to various literature, increasing pests in urban environments, posing an ecological and public health challenge. These birds, especially crows, can also be a threat to urban wildlife biodiversity. Their expanding populations in densely populated areas create a certain level of public health concerns. According to modern literature, pigeons are primarily characterized, as "offense" that "pollutes" human used landscapes. Furthermore, they are often described as "rats with wings" neatly summarizing fear that is present in the society regarding their role as potential source and vector of various pathogens. Indeed, their droppings are known to contain a variety of infectious and frequently, zoonotic microorganisms, including bacteria, fungi, and viruses, which can be a potential risk to humans, particularly immunocompromised ones. Over 110 diseases are known to be transmitted by pigeons to humans through different ways of transmission, including pigeon meat or inhalation of dust. Furthermore, the presence of feathers and nesting materials such as branches increase the risk of fire, particularly when they encounter heated bulbs or electrical wires. These materials are highly flammable and can easily propagate the fire. In addition to posing a public health hazard, bird droppings significantly contribute to the time-consuming cleaning of buildings and their maintenance. These socioeconomic and public health threats make pigeons a real urban problem.

Corvids, especially crows, are another problematic group of birds in urban areas. Their highly social and intelligent behavior makes them adept to exploiting urban resources and very resistant to human control programs. Crows are further known for their aggressive behavior towards humans and pets, as well as their predation on smaller bird species, such as the European sparrow (*Passer domesticus*). Their loud vocalizations and tendency to scatter waste contribute to noise pollution and littering in the cities. Therefore, even though one may argue that increasing the number of species in cities is positive in a way of increasing biodiversity, it can have opposite effect through reducing the number of other, more vulnerable species, and in fact reducing the overall biodiversity. The dominance of aggressive and very adaptable species like pigeons and crows can lead to a homogenization of urban wildlife, consequently diminishing the ecological variety that supports a healthy urban ecosystem.

Given these factors, it is essential to explore and implement effective management strategies that mitigate the negative impacts of these species while balancing the needs of urban biodiversity. Bird control strategies are multiple and are infinite due to human creativity. The

most common method of control is the application of physical barriers such as nets, spikes and slops placed on areas where birds are considered as pests. The other control strategy that we will analyze in this study is falconry. The aim of this study is to identify the efficacy of the trained raptor on the urban population of pigeons and crows in a specific facility in Zagreb, and to analyze potential habituation of pigeons and crows to raptors.

2. OVERVIEW OF THE CURRENT KNOWLEDGE

2.1. Pigeons and crows' urban population

Pigeons have been the first domesticated bird, 5000 years ago in southwestern Asia (SOSSINSKA, 1982). Urban pigeons are mostly referred to as feral pigeons (*Columba livia* f. *urbana*). They are descendants of domesticated pigeons, which in turn originate from wild rock pigeons (*Columba livia*). Domesticated pigeons were a valuable companion to humans throughout history and among others, they symbolize peace in various cultures. Beyond their symbolic role, pigeons had a crucial function in diplomacy and communication between



Figure 1. Rock dove. Source: <https://indiabiodiversity.org/species/show/239937>.

countries, serving as reliable messengers. Pigeons were domesticated and selectively bred to make them excellent long distance flying messengers, particularly during ancient postal systems and when wars occurred. Additionally, pigeons were hunted for sport and are competing in races, as recreation. After the Great Depression and Second World

War, the price of pigeons decreased which made them more affordable also as food delicacy for human consumption. However, since chickens are growing faster and bigger in size, the interest and popularity of pigeon farming declined. Once the farms were closed, pigeons were released in nature, but also to the cities. From this time, they became feral in urban areas and were not considered as pests, with no negative approach towards them. Until the twentieth century, thoughts changed, and they were reported as spreaders of diseases. Authorities put a ban on pigeon feeding, and some pigeons became victims of human actions like poisoning, electrocution, etc.

In Europe, two urban pigeon species are recognized: the rock pigeon (*Columba livia*) and the common wood pigeon (*Columba palumbus*). Rock pigeon, also called rock dove and common pigeon, is the most common pigeon in cities. *Columba livia* is composed of nine subspecies. Wild *Columba livia* is living in natural cliffside habitats (LARSON et al., 1999;

STRINGHAM et al., 2012). *Columba livia* f. *urbana* is the urban form of the rock pigeon, also called feral pigeon, that is dependent on human population and present worldwide. *C. l. livia* is the most frequent subspecies in Europe. Rock pigeon is recognized by two black bars on the dorsal part of the wing (Fig. 1). They have several color patterns due to their domesticated ancestors. Generally, the pigeon body is blue gray in color, with some iridescent green or purple areas on the wings and the neck. They have adapted to humans in urban environments. Pigeons are adapted to buildings, abandoned houses and bridges for nesting, and streets for feeding (GOODWIN, 1954, 1960; GOMPERTZ, 1957; MURTON and WESTWOOD, 1966). It is said that pigeon population depends on the food provided by humans on purpose or accidentally (MURTON and WRIGHT, 2013). This adaptation to urban environment has resulted in rock pigeons thriving alongside human structures and food abundance. Numbers show that rock dove is the least concerned species among birds in Europe, according to IUCN. There are around 17 to 28 millions of wild and feral rock pigeons in Europe. The common wood pigeon is the second pigeon found in cities.

Originally a wild pigeon, the wood pigeon lives in forests, but lately, their numbers in cities are increasing. This pigeon is heavier, and more territorial compared to rock pigeon. Wood pigeons are identified by their white patch on neck and wings. Both bird species are living in large groups outside of the breeding period, although this period is shorter in wood pigeons. Their common predators in cities are domesticated cats, raptors such as Eurasian sparrowhawk (*Accipiter nisus*) and Eurasian goshawk (*Artus gentillus*). The nests of wood pigeons are also vulnerable to crows who tend to eat the eggs and chicks.

Table 1 Pathogenic organisms identified in feral pigeon populations

| |
|---|
| Viruses |
| Western equine encephalomyelitis (WEE) ²³ |
| Rubella ^{24,25} |
| St. Louis Encephalitis ^{23,26} |
| West Nile virus (WNV) ^{21,22,24} |
| Influenza ²⁴ |
| Bacteria |
| <i>Clostridium perfringens</i> ¹² |
| <i>Listeria monocytogenes</i> ²⁷ |
| <i>Salmonella enterica</i> serovar Anatum ²⁸ |
| serovar Anatum var. 15 ¹⁵ |
| serovar Derby ²⁸ |
| serovar Arizonae ²⁹ |
| serovar 1,4,12:27: g ₁ [m],t,e,n,x ²⁹ |
| serovar Java ³⁰ |
| serogroup E ²¹ |
| serovar Enteritidis ³⁰ |
| serovar Kiambu ¹¹ |
| serovar Typhimurium ^{12,16,29-33} |
| serovar Typhimurium Typ 690 ²⁵ |
| serovar var. Copenhagen ^{25,28} |
| <i>Yersinia</i> spp. ²⁵ |
| <i>Campylobacter jejuni</i> ^{13,14,16,17,31,34} |
| <i>Campylobacter coli</i> ^{13,17} |
| <i>Escherichia coli</i> (STEC, VTEC) ³⁵⁻³⁷ |
| <i>Coxiella burnetii</i> ^{24,25,38,39} |
| <i>Chlamydia psittaci</i> ^{8,24,25,30,32-34,38-55} |
| Fungi |
| <i>Allescheria boydii</i> ⁵⁶ |
| <i>Aspergillus</i> spp. ^{56,57} |
| <i>Candida albicans</i> ^{59,60,63} |
| <i>Candida glabrata</i> ^{59,60,63} |
| <i>Torulopsis (Candida) glabrata</i> ²⁹ |
| <i>Candida guilliermondii</i> ^{59,60,62,63} |
| <i>Candida humicola</i> ⁶³ |
| <i>Candida intermedia</i> ⁶² |

| |
|---|
| <i>Candida krusei</i> ^{56,59,60,62,63} |
| <i>Candida lambica</i> ⁶³ |
| <i>Candida lipolytica</i> ⁶³ |
| <i>Candida lusitanae</i> ^{60,62} |
| <i>Candida parapsilosis</i> ^{62,63} |
| <i>Candida pseudotropicalis</i> ^{60,62} |
| <i>Candida rugosa</i> ^{60,62,63} |
| <i>Candida tropicalis</i> ^{59,60,62,63} |
| <i>Candida zeylanoides</i> ⁶³ |
| <i>Chrysosporium</i> spp. ⁵⁶ |
| <i>Cryptococcus albidus</i> ⁶²⁻⁶⁴ |
| <i>Cryptococcus laurentii</i> ^{62,63,65} |
| <i>Cryptococcus neoformans</i> ^{29,58,62,63,66-76} |
| <i>Cryptococcus terreus</i> ⁶² |
| <i>Cryptococcus uniguttulatus</i> ⁶⁵ |
| <i>Debaryomyces hansenii</i> ⁶⁵ |
| <i>Geotrichum</i> spp. ^{59,63} |
| <i>Geotrichum candidum</i> ⁵⁶ |
| <i>Histoplasma capsulatum</i> ⁷⁷ |
| <i>Hansenula anomala</i> ⁶³ |
| <i>Kloeckera apiculata</i> ⁶³ |
| <i>Paecilomyces</i> spp. ⁵⁶ |
| <i>Pichia membranaefaciens</i> ⁶² |
| <i>Rhizopus</i> spp. ⁵⁶ |
| <i>Rhodotorula</i> spp. ⁵⁶ |
| <i>Rhodotorula glutinis</i> ⁶³ |
| <i>Rhodotorula rubra</i> ^{29,62,63} |
| <i>Saccharomyces cerevisiae</i> ^{62,63} |
| <i>Saccharomyces oleaginosus</i> ⁶² |
| <i>Saccharomyces telluris</i> ^{59,60,62} |
| <i>Scopulariopsis</i> spp. ⁵⁶ |
| <i>Streptomyces</i> spp. ⁵⁶ |
| <i>Torulopsis candida</i> ^{62,63} |
| <i>Trichosporon beigellii</i> ⁶³ |
| <i>Trichosporon capitatum</i> ⁶³ |
| <i>Trichosporon cutaneum</i> ^{56,62,63} |
| <i>Trichosporon pullulans</i> ⁶³ |
| Protozoas |
| <i>Toxoplasma gondii</i> ^{30,78,79} |
| Total 60 pathogens as designated by genus and species. |

Figure 2. Pathogenic organism identified in feral pigeon populations. Source: HAAG-WACKERNAGEL and MOCH (2004)

In the Eastern part of Europe, one of the most common members of the Corvidae family



Figure 3. Hooded crow (*Corvus cornix*) next to Sava River. Photo: A. Buet.

that have successfully integrated into urban environments is the hooded crow (*Corvus cornix*). They are easily recognized due to two-toned body plumage made of ashy gray and glossy black wings, head and round-shaped tail (Fig. 3). There are 4 subspecies of hooded crow (GILL et al., 2022). Their diet is very similar to that of a common raven (*Corvus corax*), being a constant scavenger and eating plants and small animals. Similar to the raven, the crow is very intelligent. The population of

the hooded crow in Europe is estimated to 14 to 34 million of individuals and is declared by the IUCN as the least concern (LC) species.

2.2 Health hazard

Pigeons are considered as a potential risk factor for human and animal health. They are carriers of various pathogens such as parasites, fungi, bacteria and viruses. Over the years, scientific research on the transmission of zoonotic diseases from urban pigeons to humans evolved significantly. HAAG-WACKERNAGEL and MOCH (2004) published a comprehensive study regarding zoonotic diseases transmitted from urban pigeons to humans in the period from 1941 to 2003. A total of 60 zoonotic pathogens were identified within urban pigeon populations (Fig. 2). It included 5 different viruses, 9 bacteria, 45 fungi and one protozoa. Five pathogens have been reported as zoonotic: *Salmonella enterica*, *Chlamydophila psittaci*, *Histoplasma capsulatum*, *Aspergillus* spp., *Candida parapsilosis*, *Cryptococcus neoformans* and *Toxoplasma* spp. are presented in the table with the way of transmission (Fig. 4) (HAAG-WACKERNAGEL and MOCH, 2004).

More recent studies have identified over 110 pathogens in pigeon population (MIA et al., 2022). Even though this study used samples from domestic pigeons, it clearly shows the ability of pigeons to carry a wide range of zoonotic pathogens. Given that domestic and urban pigeon shares a common ancestor, pathogens found in domestic pigeons may contaminate urban pigeons as well, increasing the potential risk for human health.

Table 2 Association between human practice and illness contracted from feral pigeons

| Pathogen | Number of illnesses ^a | Description of contact |
|--------------------------------|----------------------------------|---|
| <i>Salmonella enterica</i> | 1 | Environmental exposure ¹¹ |
| <i>Chlamydomphila psittaci</i> | 29 ^b | Environmental exposure ^{41,42,44,45,80-82} |
| | 10 | Handling a sick or dead pigeon ^{40,47,82-84} |
| | 8 | Pigeon feeding ^{42,82,83,85,86} |
| <i>Histoplasma capsulatum</i> | 23 | Environmental exposure ³ |
| | 68 | Exposure in a hospital setting ⁷⁷ |
| <i>Aspergillus</i> spp. | 13 (13) | Exposure in a hospital setting ⁸⁷⁻⁹⁰ |
| <i>Candida parapsilosis</i> | 12 (12) | Exposure in a hospital setting ⁹¹ |
| <i>Cryptococcus neoformans</i> | 5 (2) | Environmental exposure ^{67,92-95} |
| | 5 (4) | Exposure in a hospital setting ^{75,96} |
| | 1 (1) | Wound inflicted by a pigeon ⁹⁷ |
| <i>Toxoplasma</i> | 1 | Environmental exposure ⁷⁸ |
| Total cases | 176 | |

^a Number of patients who were immunoincompetent.
^b Additional cases are reported, but not enumerated^{39,98} (Haag-Wackernagel, unpublished).

Figure 4. Association between human practice and illness contracted from feral pigeons. Source: HAAG-WACKERNAGEL and MOCH (2004).

This risk is increasing due to the constant interactions with pigeons, like feeding, cleaning of their droppings and nest removal. Contaminated dust and feces are the common source of infection to humans. Immunocompromised patients are especially at risk and should be well educated in order to contraction of pathogens pigeons. *Cryptococcus neoformans* infection in immunocompromised patients and immunocompetent ones, as elderly or young child, have been reported (BUCHANAN and MURPHY, 1998). Pigeon itself is not an amplifier host of *C. neoformans*, a fungal pathogen, but its droppings are the optimal environment for the growth of the fungi (KAPLAN, 1973). The survival of *Cryptococcus neoformans* depends on high acidity of pigeon droppings (JINKS and YEE, 1968; ABEGG et al., 2006). The nest of pigeons and soil contaminated by pigeon carcasses are common places to find *C. neoformans* (BUCHANAN and MURPHY, 1998; GHADERI et al., 2019). Contrary to that, *Histoplasma* and *Chlamydia* infection in humans is not related to weaker immune system.

Humans are infected by *Cryptococcus*, *Chlamydomphila* and *Histoplasma* mainly via inhalation of contaminated dry excreta, ocular discharge and milk crop of pigeons (BALSAMO et al., 2017). Although pigeons are recognized public health hazard to humans, they are also a

source of infection to other animals. Cryptococcosis can be transmitted to terrestrial and aquatic mammals, like dolphins (MORGAN et al., 2024).

Moreover, feral pigeons serve as carrier of ectoparasites. According to HAAG-WACKERNAGEL (2005), the most important ectoparasites of feral pigeons are the pigeon tick, *Argas reflexus*, and the red blood mite, *Dermanyssus gallinae*. Both arachnid parasites can migrate into human living space when they lose their natural hosts. Red blood mite bites are generally irritating but harmless, while pigeon ticks can pose serious health risks to individuals with certain predispositions. IgE-mediated (type I) allergy can be developed after repeated bites from *A. reflexus*, which in extreme situations may lead to a life-threatening anaphylactic reaction (BESSOT et al., 1997; SIRIANNI et al., 2000; HILGER et al., 2005; QUERCIA et al., 2005). Allergic reaction to tick bites is caused by the proteins secreted by the tick's salivary gland (BESSOT et al., 1997; SIRIANNI et al., 2000; QUERCIA et al., 2005). In case of parasitic infections or to prevent those anaphylactic cases, pigeons should be removed, nests cleared out and disinfection applied on the environment of pigeon-breeding sites.

Food borne diseases from pigeon meat are not common when compared to the frequency of infection from common food-borne pathogen from milk or eggs (Fig. 5). One important case of *Salmonella enterica* has been reported after the consumption of feral or domesticated pigeons in 1933 but nothing has been documented since then (HAAG-WACKERNAGEL and MOCH, 2004). Pigeon population may carry many food-borne pathogens including *Campylobacter*. The prevalence of the *Campylobacter* species in pigeons is up to 24 %. It is followed by *Escherichia coli* with the prevalence of 18% (MIA et al., 2022). Furthermore, antimicrobial resistance has been reported in rearing pigeons. 23.8 % *E. coli* and 54.54 % *Salmonella* spp. were reported as multidrug-resistant bacteria in pigeons in Bangladesh (KARIM et al., 2020). However, food-borne diseases originating from pigeons are relatively low.

Moreover, viral zoonotic pathogens are also present in pigeon population. According to the study published by MIA et al. in 2022, the total prevalence of viral zoonotic pathogens from pigeons concluded to be most elevated from all zoonotic pathogens with 21%. Newcastle disease is the most common virus identified in pigeons, with 27% prevalence (MIA et al., 2022). Succeeds Coronaviruses with 25% and avian influenza with 21% of prevalence (MIA et al., 2022). Avian influenza is currently one of the most important pandemics worldwide in all bird species.

Table 3 PubMed references returned for outbreaks per food commodity

| | | | |
|-----------|-----|-----------|----|
| Milk | 168 | Goat | 18 |
| Egg | 112 | Juice | 18 |
| Fish | 96 | Hamburger | 16 |
| Vegetable | 96 | Horse | 14 |
| Shellfish | 92 | Rabbit | 11 |
| Fruit | 79 | Wild boar | 10 |
| Chicken | 79 | Deer | 6 |
| Cheese | 73 | Duck | 5 |
| Beef | 66 | Pigeon | 0 |
| Dairy | 64 | Alligator | 0 |
| Pork | 48 | Snake | 0 |
| Turkey | 37 | Ostrich | 0 |

Searched on October 22, 2003 at www.ncbi.nlm.nih.gov/entrez/query.fcgi. Search terms were 'commodity and food and outbreak and human'.

Figure 5. Outbreaks per food commodity. Source: HAAG-WACKERNAGEL and MOCH (2004).

On the other side, crows (*Corvidae*) are also known for their importance as hosts and transmitters of many zoonotic pathogens. In the feces of those birds, scavengers of sick animals and highly present in human dense areas, zoonotic bacterial pathogens and parasitic are present. 9 different species of bacteria from the family *Enterobacteriaceae* and few protozoan parasites. *Cryptosporidium*, *Blastocystis*, *Cyclopsora*, *Salmonella*, *Shigella* and *Kluyvera* are the zoonotic pathogens found in fecal samples of crows (LEE et al., 2008). A significant amount of the parasite *Cryptosporidium* spp. has been found in crows feces (LEE et al., 2008). Crows play an important role in the transmission of parasites, especially when birds are feeding from the ground, or may eat items contaminated with droppings from another infected animals, such as rats or fishes (ANGUS, 1983). Furthermore, infection of humans from *Cryptosporidium* spp. commonly originates from water sources contaminated by sick animals (FARIZAWATI et al., 2005).

Crows and pigeons are also sources of vector-borne diseases. Mosquitoes potentially transmit West Nile virus (WNV) in crows' population and be a public health risk to humans. Crows have been associated with increased human cases of WNV in New York States (EIDSON et al., 2001). This could suggest the use of monitoring dead crows as a simple warning system for potential outbreaks. Furthermore, in winter, crow-to-crow transmission of

WNV has been observed when mosquitoes are not active (DAWSON et al., 2007). Crows may play an important role in maintaining the virus throughout seasons. WNV has been detected in crow feces which is the main transmission among their own species (DAWSON et al., 2007). Crows may become infected after scavenging infected house sparrows (*Passer domesticus*) with WNV, indicating potential cross-species transmission of the virus (KOMAR et al., 2003). WNV-positive lice (*Philopterus* spp.) were found on infected crows, which may play a role in transmitting the virus between birds (DAWSON et al., 2007). Ticks are important in vectors of zoonotic diseases, including emerging zoonotic diseases. From ticks sampled from urban crows, 2 main tick-borne pathogens were identified in the tick and in the bird. *Rickettsia* spp. and *Anaplasma phagocytophilum* DNA was found in ticks and bird tissues (SÁNDOR et al., 2017). It highlights the importance of tick host in urban population of crows and their potential risk to human health.

In general, crow and pigeon populations are a potential risk to public health, with different pathogens. Immunocompromised patients, older people and children are the most at risk. Society must understand and know the health risks of having high concentrations of pigeons and crows in urban areas. Avoiding manipulation of dead birds and cleaning of droppings without sanitary protection must be explained to people in order to decrease risk of infection.

2.3 Other species of birds

Other species of birds are susceptible to both pigeons and crows growing populations in different manners. Pigeon population pose health risks not only to humans but also to other bird species. *Chlamydia psittaci* is bacterial pathogen mainly infecting birds. More than 450 bird species are susceptible to this microorganism, and is present worldwide (ANDERSEN and VANROMPAY, 2008; BALSAMO et al., 2017). Since birds are shedding *C. psittaci* through feces, urine, ocular secretions, and crop milk for Columbiformes only, spreading of the disease between other bird species is easily accomplished (BROOKS, 2021). Another very common disease transmitted between birds is *Trichomonas gallinae*, especially from the feral pigeon (AMIN et al. 2014). Columbidae are the main host for this parasite, and are responsible for their worldwide spread (HARMON et al., 1987). This parasite may affect many bird families and cause severe infections in bustards (SILVANOSE et al., 1998), psittacine birds (BAKER, 1996; MCKEON et al., 1997), fowl (MCDUGALD, 2000) and passerine birds (COUSQUER, 2005). Although, the main problem is the infection of bird of prey (diurnal and nocturnal) after the ingestion of contaminated birds with the flagellated

protozoan, such as doves, feral pigeons, carcasses of bird (WORK and HALE, 1996; BOAL et al., 1998; ERWIN et al., 2000; KRONE et al., 2005). In the wildlife rescue centers, raptors are found in poor condition due to *Trichomonas* infection of oropharyngeal mucosa. Untreated it commonly end up fatal. It is a recent problem to all those bird of prey which are losing their natural habitat and their historical prey resources. Birds of prey tend to change their diet from small wild mammals to feral pigeons in the rural areas (DUDEK et al., 2018). Feral pigeons tend to be an excellent prey for urban birds of prey due to its high concentration in cities but they also are the main source of infection.

Crows have a negative impact on prey species productivity, especially nest success and brood size (MADDEN et al., 2015). Contrary to common belief, hooded crow's impact on prey bird populations is less significant than often assumed (ZDUNIAK et al., 2008). Crows have a small negative impact and five times more for productivity than for abundance. The impact is smaller than other predators. Hooded crows are the main nest predator of many bird species, mostly water birds. They are one of the influences on bird clutches (WITKOWSKI, 1983; CADIOU, 1999; GRANT et al., 1999; GREEN and YURLOV, 1999; VOLPONI, 1999; OPERMANIS et al., 2001). Furthermore, it was reported that crows occasionally catch birds in flight such as the Common Swift (*Apus apus*) (CAMOLESE et al., 2003) and the European Starling (*Sturnus vulgaris*) (EDHOLM, 1979). In the study published by ZDUNIAK et al. in 2008, they observed the diet of nestling hooded crow diet. It consists mostly of insects, fish, plants and potentially avian prey. During the breeding season, the percentage of samples with eggshells and feathers ranged from 4% to 10% and from 0% to 4% were found in stomach of adult crows (PICOZZI, 1975).

2.4 Infrastructures damage

Pigeon excreta could lead to severe damage of public properties over time, often buildings, bridge structures. Yearly, a single pigeon may produce up to 12 kg of excreta (KÖSTERS et al., 1991; STOCK and HAAG-WACKERNAGEL, 2014) that mess up breeding sites, building facades, monuments, pavements, sidewalks, and other public areas and, potentially deface and deteriorate calcareous stone (DEL MONTE and SABBIONI, 1986; DELL'OMO, 1996). Pigeons destroy vegetation while looking for food (HAAG-WACKERNAGEL, 1995). The pigeon droppings contain salts, phosphoric, nitric, and uric acids, which make it acidic. Low pH-excreta may cause great impact to various building materials. It is well known that pigeon excreta cause chemical reactions on wood (LEUCCI et al., 2013), architectural metals (SPENNEMANN and LOOK, 2006; SPENNEMANN and

WATSON, 2018) and monumental stones (MURTON et al., 1972). Uric acid is the component in the excreta, which is responsible for decaying sandstone, limestone, marble, metals and composite roofs (SPENNEMANN and WATSON, 2017). In the review published by SPENNEMANN and WATSON (2017), the different diet in the rock dove (the wild progenitor of the feral pigeon) and the feral pigeon are described. It indicates that the human-based diet of urban pigeons most likely causes the feral pigeon excreta to be more acidic than the rock dove excreta. Moreover, the low quality of human food significantly increases the fecal output and/or uric acid volumes. Although, few number of studies have been published on the topic of feral pigeon diet before pH measurement. Pigeons defecate during various activities, including nesting (long-term), roosting (medium-term), and perching (short-term). Pigeons are perching more than any other bird species, on high-elevated spots. Feral pigeons tends to defecate before flight (CARO, 2005), potentially for fit-for-flight hypothesis (VAN DER VEEN and SIVARS, 2000). Consequently, even brief perching locations like window ledges, cornices can accumulate significant excrement despite intermittent pigeon presence. Pigeon excreta deposits cause majority of damage during the first two weeks. After this period, bird excreta dissolves or desiccates, and superficial accumulation make buildings look dirty for months (SPENNEMANN et al., 2017).

A study made by HAAG-WACKERNAGEL and GEIGENFEIND (2008) was performed in order to build ideal structures with features, which will prohibit pigeons from nest, sleep and perch. For instance, 4 cm is the maximum ledge width a pigeon is not able to sit. The inclination of smooth construction material such as tinfoil, glass or plastic must be 25° in order to repulse pigeons, for medium rough materials (wood, plane concrete) it is 35°, and for rough materials (sandstone, rough concrete) at least 50°. Even though new buildings are often designed to prevent pigeons from nesting, breeding, and roosting, feral pigeons tend to select older buildings, particularly those built before 1936 (SACCHI et al., 2002). Additionally, pigeons often build nests using small branches and random debris, which can clog gutters, drainage systems and other systems, causing water damage to the property or potentially start or propagate a fire.

2.5 Potential measures to mitigate

Several measures can be applied to remove pigeons and crows, which are considered pests in the urban environment, in order to mitigate the damage that they cause. Easy cheap eco-friendly and humane DIY can be made by people but are commonly less effective. Shiny objects such as hanging CDs and aluminum foil are visual disturbance for pigeons. Noisy

sounds are also a method to repulse pigeons due to their sensitivity to sounds. Building modifications can easily be achieved in order to prevent pigeons landing and build nests. Slops with different inclinations and angled boards on ledges can easily be placed. Placing decoy of predators can scared pigeons for a certain amount of time. Moving the decoy occasionally may be effective for a longer period.

According to some study, pigeons may be able to see in color and ultra-violet spectrums in order to forage, signaling and sex recognition (JACOBS, 1992). This means visual control strategies can disturb those birds or mimic danger with varying color spectrums. Decoys (HARRIS and DAVIES, 1998), moving lights and objects, lasers (BLACKWELL et al., 2002), threatening images and reflective items are all great visual disturbances for pigeons. Although, visual deterrents are limited to a specific amount of time, due to habituation by pigeons (HUTTON and DOBSON, 1993; HUTTON, 2005). HARRIS et al. (2016) have observed that visual deterrents were not as useful as habitat modification with bird spikes. Bird spikes scared off nearly 70% of the pigeon population index whereas the deterrents were only 45% effective.

Professional bird control is a better option to get rid of pigeons in bigger areas, residential, commercial buildings or monuments. Each method provided by the professional has benefits, but each place is unique and requires specific solution according to it. Some of the control method aims to reduce pigeon population density through increase mortality (HAAG-WACKERNAGEL, 2008; GIUNCHI et al., 2012), decreasing natality (GIUNCHI et al., 2007a, b; HAAG-WACKERNAGEL, 2008; DOBEIC et al., 2011) or through resource management modifying behaviour (HAAG-WACKERNAGEL, 1995; GIUNCHI et al., 2007a, b; HAAG-WACKERNAGEL, 2008). Nowadays, it is increasingly controversial to use lethal measures to remove pigeons (TREVES and NOUGHTON-TREVES, 2005). Non-lethal measures are usually physical barrier, visual, auditory and tactile senses. Habitat modifications can be achieved with placement of physical barrier such as spikes, slides, restrictions of entrance dimensions, to prevent building of ideal roosting and nesting sites. Bird spikes (SEAMANS et al., 2007), sprung wires (HUTTON, 2005), bird netting (HUTTON and DOBSON, 1993) are anti-perching devices.

The use of gel repellents to discourage pigeons from occupying buildings is an effective method. Although, it has a local effect, it is very efficient for strictly limited area (GAGLIARDO et al., 2020). Gel repellents are not suitable for a program which aimed to reduce the carrying capacity of urban environment by lowering nest and roost sites availability

in a large-scale pigeon management. This method is excellent to prevent the roosting of birds, and its effect does not diminish through time. Multi cues gel products are composed of olfactory stimuli (citronellal and peppermint) and visual (reflect UV light). Citronellal works mainly as insect repellent, while peppermint is mostly for birds. Birds usually avoid those gel dishes due to irritation caused by the odour on their olfactory and trigeminal system (MASON et al., 1989; MASON, 1990; AVERY et al., 1996; DAY et al., 2003; ORR-WALKER et al., 2012). Furthermore, new generation of gel repellent are highly viscous but not sticky enough to glue feathers, representing a harmless method.

Falconry is the practice of using training raptors, such as hawks or falcons, to control urban bird populations in their natural state and habitat. This method is based on the natural hunting instincts of raptors to disperse and reduce the numbers of these birds in specific area, creating fear in them. Falconry is a very demanding for the falconer, mostly time consuming, and requires a lot of care and effort. Everything about the raptor must be taken into consideration: food, rest time and reproduction. Raptors go through molting, and it has negative impact on the bird flight (ZUBEROGOITIA et al., 2018). It is essential for falconers to manage the delicate balance between fitness and correct weight prior hunting or bird controlling, so the bird of prey shows its natural hunting instincts. When the weight is too high, they may not come back, and if it is too low, they won't fly well or become ill. Furthermore, while flying on premises, falconers must be alert and aware of the surroundings in order to prevent birds of prey to hunt on domestic animals.

To sum up, there is no one and only method to decrease the urban population of pigeons and crows in some specific areas. A combination of methods is required to have great overall efficiency.

2.6 Harris's hawk description

Harris's hawk (*Parabuteo unicinctus*) is a medium-sized raptor native to the continent of America. The Harris's hawk is easy to identify thanks to its contrasting plumage (Fig. 6). Its body is primarily dark brown, almost black, while its shoulders and thighs display a rich chestnut-red or rusty color. The reddish-brown upper wing covers and legs give a distinctive, two-tone appearance. The tail is dark with a confident white band at the base. Additionally, with its yellow talons and bright yellow facial skin around the eyes and beak, it makes the Harris's hawk unique among raptors. It has a wingspan ranging up to 120 cm and a body length

of 46 to 59 cm. Adults typically weigh between 700 to 1,200 grams. Females are generally larger and heavier than males, as is common among birds of prey.

In falconry, Harris's hawk is considered as broadwings birds as eagles, and buzzards. This category of bird of prey vary tremendously in size and hunting ability. Broadwings require a significant space to fly safely and tend to soar and glide. Nowadays, the Harris's hawk is the most popular for most falconers. They are chosen for their calm temperament and ease to train them.

Unlike most raptor species, Harris's hawks are highly social and hunt cooperatively in small groups, as a family group. The hunting group goal is to be more effective. For that purpose, Harris's hawk accepts working dogs, and falconers as members of their 'hunting family'. Additionally, to this social hunting behavior, their sharp eyesight, agility, and high trainability,



Figure 6. Harris's hawk prior to releasing at study site. Photo: B. Reindl.

makes them very effective in falconry, particularly for pest control in urban environments. Harris's hawks are responsive in busy city environments. Their cooperative hunting instincts contribute to an effective flushing out pest birds, such as pigeons and crows, from complex urban areas. In falconry-based pest control programs, Harris's hawks are deployed to patrol problem areas, as they are perceived as a direct predatory threat and their presence alone often deters pest birds.

3. HYPOTHESIS AND AIMS OF RESEARCH

The hypothesis of this research is that the frequent use of raptors will lead to habituation of pigeons and crows, and with time will lead to shorter periods of efficiency.

Aim:

- 1.1. To analyze effect of ouster of pigeons and crows using raptors
- 1.2. To compare return of target species after repeated ousting
- 1.3. To evaluate the potential of raptors in control of urban pigeons and crows,

4. MATERIALS AND METHODS

4.1. Location and study design

The study took place in one large industry site in Dumovec, Zagrebačka county in Croatia. The factory Valipile is an industry producing one-day-old chicks, with the storage of their food and the mixture production of the food on the site. For this study we used Harris's hawks (two birds) to ouster pigeons and crows from the factory area. Study was divided in three phases. In the first phase a regular, undisturbed behavior of pigeons was monitored. This phase lasted for eight days. In the second and third phase raptors were used in different intervals. In the second phase raptors were used four times (2 x 2) with varying intervals. There was 5 days interval between first and second and third and fourth use of raptors. Between second and third use was a period of three days. Third phase started five days after the second one. It also included four ousting. Intervals between first and second, and third and fourth one was one day, while interval between second and third was seven days. This approach offered us insight into the behavior of birds regarding the presence and absence of raptors, as well as potential habituation to their use. Presence of pigeons and crows was monitored non-invasively using the phototraps (cameras) (Fig. 7). The Ethical Committee of the Veterinary Faculty University of Zagreb approved the study (Class: 640-01/24-02/03, No. 251-61-01/139-24-54).



Figure 7. Image taken by the camera, pigeons are sitting on the electric wire, just outside of the factory yard.

4.2 Phototraps and observation

Three cameras were placed in the area near grain tanks. Two cameras were placed on



Figure 8. Reolink Go Plus camera. Photo: I. Madi.

the outer fence facing each other, in order to cover the majority of the studied area. Remaining third camera was installed on one pillar of the grain tank, in direction of the outer fence. In this study, two cameras were Reolink Go Plus models, and one was Scout Guard, model Boly BG590-24mHD (on pillar). Reolink Go Plus (Fig. 8) is a portable camera powered by battery and recharged via solar panel. Resolution is 2K Super HD with IR LED range of up to 10 meters. It uses advanced AI technology, which enables distinguishing of humans and vehicles from other objects in the

protected area. In case of detection, it sends push notifications

to the

smartphone. PIR sensibility is set at normal, with 3 MP resolution.

Scout Guard, model Boly BG590-24mHD is PIR camera (Fig. 9) that uses sensor of 0.7 s and covers a total range of 30 m. Maximum image resolution is 24 MP. Setting a smaller area of detection results in reduction of unnecessary images. Night mode is enabled by invisible 44 pcs black IR LED. Images obtained by this camera are extracted via memory card.

Obtained images were recorded during morning period (8.00 and 10.00 a.m.), midday (1.00 and 3.00 p.m.), and afternoon (4.00 and 6.00 p.m.)



Figure 9. Scout Guard, model Boly Guard BG590-24mHD. Photo: M. Bujanić

4.3 Use of Harris's hawk for removal of problematic species

Two Harris's hawks were used in this study. At the beginning of the study birds were adapted to the object. In brief, in this phase birds get used to the facility, the presence of trucks and other vehicles, people and in general, the noise in the production plant. This adaptation is carried out over several days in such a way that the same food and "walking" are performed on gloves through the whole area.

After a few days, the birds started to fly at the study area and live prey is offered for them to boost experience and gain safety in a new environment and circumstances. Such approach results in calm birds during the free flight and hunting the present pigeons and crows. Free flights of birds within the yard of the production plant at different times (time of day) and with different weather conditions (from sunny hot days to rainy cool days accompanied by moderate wind) are implemented after adaptation stage. Birds were used eight times in this study, with different intervals. Each time, one of hawks was released to ouster pigeons. Birds were allowed to catch pigeon, which was taken from the bird and replaced by alternative food. After a period of time a short break was made and another bird was used instead of the first one. Allowing birds to catch pigeons results in increased fear and insecurity among them, enhancing the effects of the raptors presence.

4.4 Analysis of data

All data were analyzed in the Excel program. Descriptive statistics included maximum and minimum number of pigeons and crows, as well as average and median values, according to hours and phases of the study.

5. RESULTS

Presence of pigeons at study site during the first phase of the research is presented in the Figure 11.

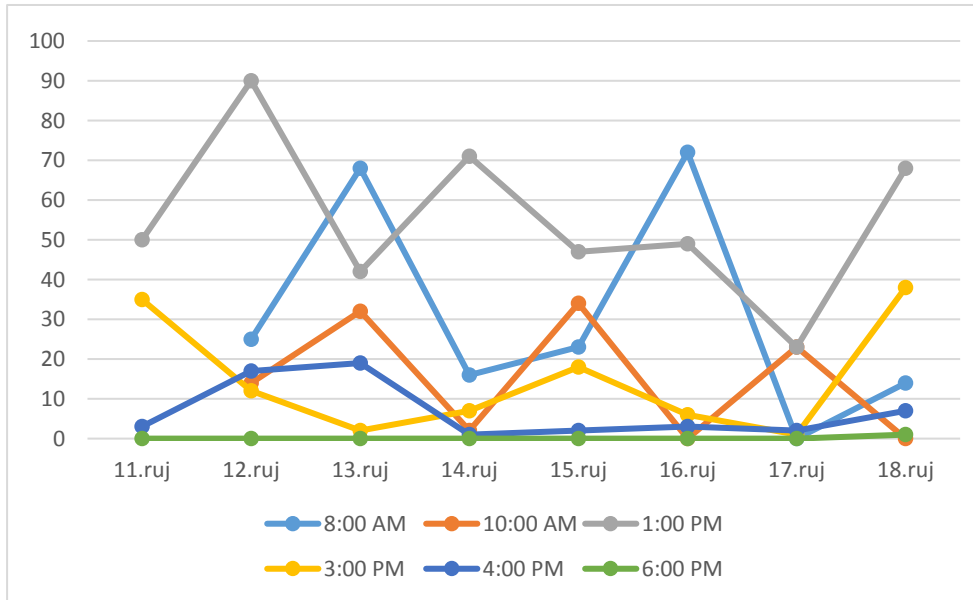


Figure 11. Presence of pigeons at study site during the first phase of research.

Table 1. Data on presence of pigeons at study site during the first phase of the research.

| | 8.00 am | 10.00 am | 1.00 pm | 3.00 pm | 4.00 pm | 6.00 pm |
|---------|---------|----------|---------|---------|---------|---------|
| minimum | 0 | 0 | 23 | 1 | 1 | 0 |
| maximum | 72 | 34 | 90 | 38 | 19 | 1 |
| average | 31.14 | 15 | 55 | 14.87 | 6.75 | 0.12 |
| median | 23 | 14 | 49.5 | 9.5 | 3 | 0 |

Table 1 shows that highest number of pigeons are present in the period at 1.00 p.m. (max. 90, med. 49.5). Followed by 8.00 a.m. (max. 72, med. 23), 10.00 a.m. (max. 34, med. 14) and 3.00 p.m. (max. 38, med. 9.5). Lowest number of pigeons was observed at 4.00 p.m. (max. 19, med. 3) and 6.00 p.m. (max. 1, med. 0). According to the days, number of pigeons shows variations, but highest observed number was 169, and lowest 49.

Presence of pigeons at study site during the first part of the second phase of research is presented in the Figure 12.

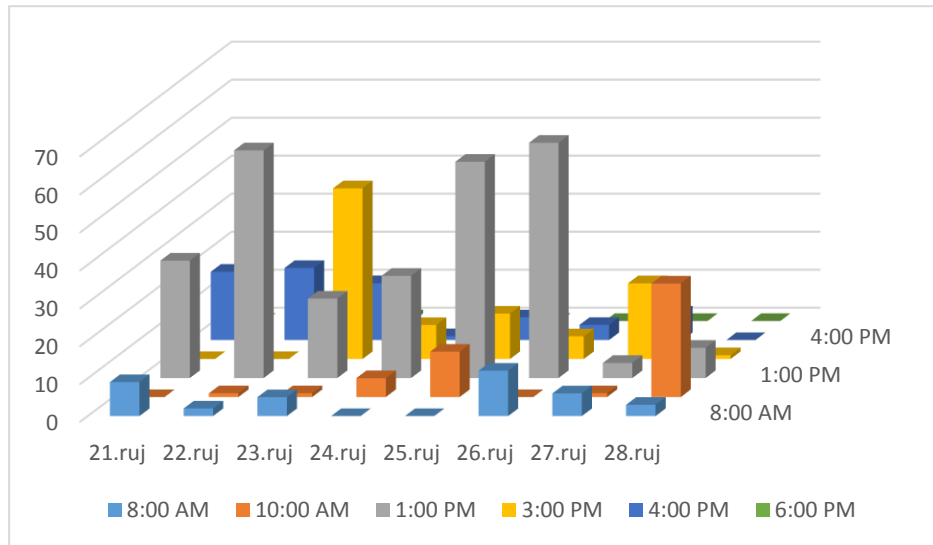


Figure 12. Presence of pigeons at study site during the first part of the second phase of research.

During the first part of the second phase of the research hawk was present on 21st and 27th of September, with a five days break between two visits. On the first day with hawk 58 pigeons were recorded at the study site. Next day there was 82 pigeons. Maximum number of pigeons recorded in this phase per day was 88, lowest number was recorded third day after the hawk use. During the day when hawk was used for the second time, 38 pigeons were recorded. A day before we have recorded 84, and day after hawk flight 42 pigeons.

Presence of pigeons at study site during the second part of the second phase of research is presented in the Figure 13.

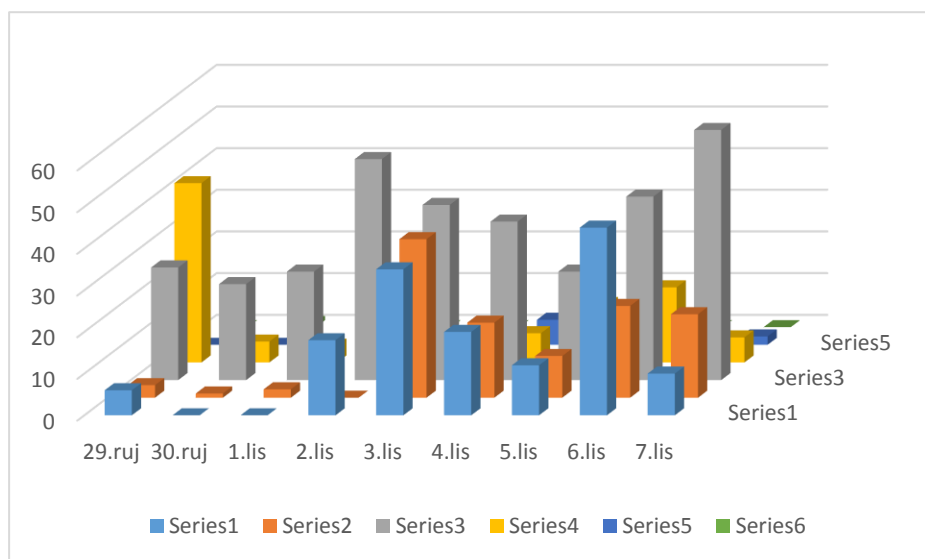


Figure 13. Presence of pigeons at study site during the second part of the second phase of research.

During the second part of the second phase of research hawk was used on 1st and 7th October. During the hawks flight we have recorded 32 and 98 (day before there was 121, and day after 116) pigeons respectively. Maximum number of observed pigeons was 124, and minimum 30 individuals. Data on presence of pigeons during this phase is presented in the Table 2.

Table 2. Data on presence of pigeons at study site during the first part of the second phase of the research.

| | 8.00 am | 10.00 am | 1.00 pm | 3.00 pm | 4.00 pm | 6.00 pm |
|---------|---------|----------|---------|---------|---------|---------|
| minimum | 0 | 0 | 4 | 0 | 0 | 0 |
| maximum | 45 | 38 | 62 | 45 | 19 | 1 |
| average | 7.38 | 7.23 | 42 | 12.46 | 3 | 0 |
| median | 5 | 1 | 42 | 6 | 3 | 0 |

From the Table 2 it is visible that highest number of pigeons was observed again at 1.00 p.m. (max. 62, median 42). Followed by 3.00 p.m. (max. 45, med. 6), 8.00 a.m. (max45, med. 5). At 10.00 a.m. total number of pigeons during whole second phase was 164, and at 4.00 p.m. 90.

Presence of pigeons at the study site during the days with hawk activity is presented in the Figure 14.

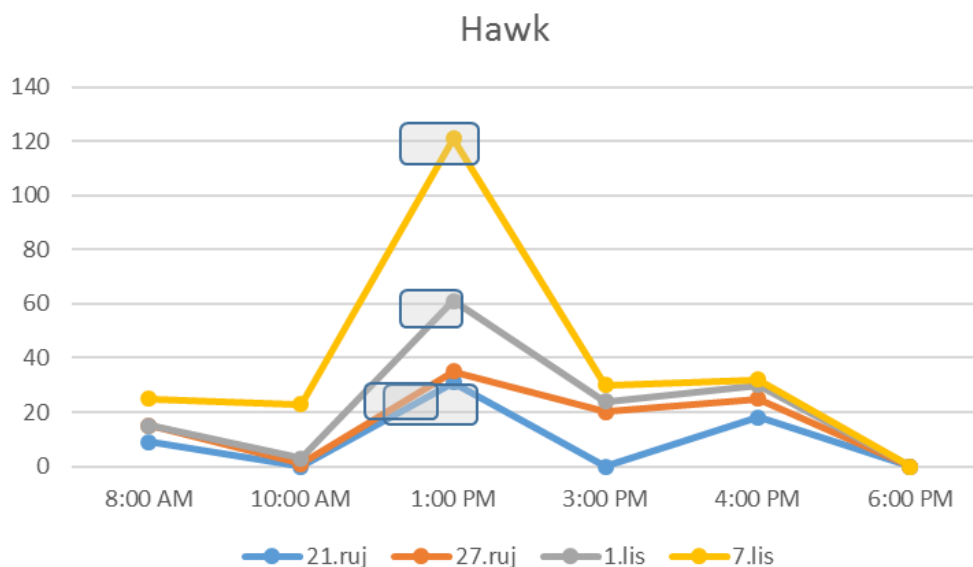


Figure 14. Presence of pigeons on days when hawk was used. Grey rectangles indicate time when hawk was used.

In this phase of research hawk was used four times, and each day after its flight, a sharp decline in pigeon numbers at study site was observed. This decline is especially pronounced in the last use of the hawk (October 7th).

In the third phase of research a rainy weather postponed second part of the third phase, which is presented separately here.

Presence of pigeons at the study site during the third phase of research is presented in the Figure 15.

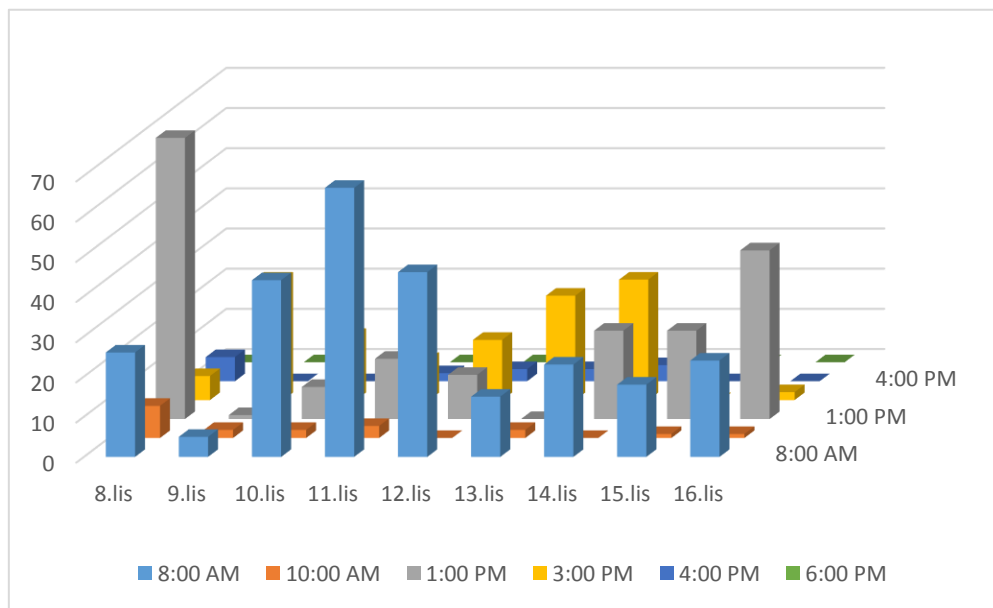


Figure 15. Presence of pigeons at study site during the first part of the third phase of research.

According to days, highest number of pigeons was observed on October 8th (N=116), and lowest on October 15th (N=31). Hawk was used five days after the end of the second phase, two times with one day break (October 13th and 15th). Total number of pigeons recorded during the first use of hawk in this phase was 46 (a day before 75, and day after 79). Second flight was after one day break and a total of 31 pigeons was recorded (a day before 79, day after 69).

Table 3. Data on presence of pigeons at study site during the first part of the third phase of research.

| | 8.00 am | 10.00 am | 1.00 pm | 3.00 pm | 4.00 pm | 6.00 pm |
|---------|---------|----------|---------|---------|---------|---------|
| minimum | 5 | 0 | 0 | 0 | 0 | 0 |
| maximum | 67 | 8 | 70 | 30 | 6 | 0 |
| average | 29.77 | 2.11 | 21.22 | 15 | 2 | 0 |
| median | 24 | 2 | 15 | 15 | 2 | 0 |

In this phase of the research highest number of pigeons was observed at 8.00 a.m. (N=268), followed by 1.00 p.m. (N=191). Highest number in one day was observed 1.00 p.m. (N=70), followed with 8.00 a.m. (N=67). Minimum number of pigeons was observed at 6.00 p.m. Highest median value was 24, calculated for 8.00 a.m.

Presence of pigeons at the study site during the second part of the third phase of research is presented in the Figure 15.

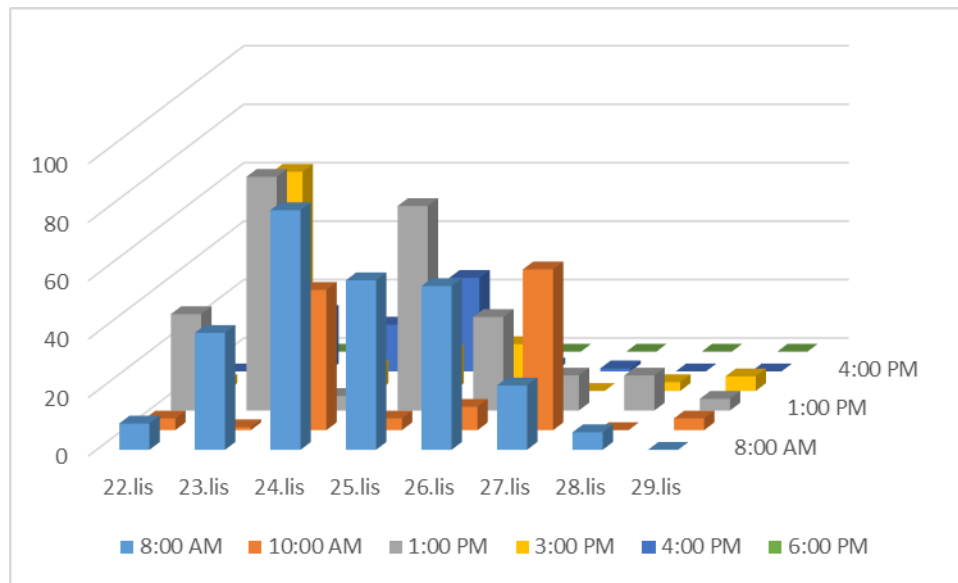


Figure 16. Presence of pigeons at study site during the second part of the third phase of research.

According to the days, highest number of pigeons during the second part of the third phase was observed on October 23rd (N=216), and lowest on the October 29th (N=13). Hawk was used two times, with a one day break. On October 23rd we have observed 216 pigeons (day before 49, day after 159), and on October 25th we have observed 178 pigeons (a day before 159, day after 114).

Table 4. Data on presence of pigeons at study site during the second part of the third phase of research.

| | 8.00 am | 10.00 am | 1.00 pm | 3.00 pm | 4.00 pm | 6.00 pm |
|---------|---------|----------|---------|---------|---------|---------|
| minimum | 0 | 0 | 4 | 0 | 0 | 0 |
| maximum | 82 | 55 | 80 | 75 | 32 | 0 |
| average | 34.12 | 15.5 | 31 | 15.37 | 8.87 | 0 |
| median | 31 | 4 | 22 | 6.5 | 1.5 | 0 |

In this part of the research highest number of pigeons was observed at 8.00 a.m. (max. 82, med. 31), followed by 1.00 p.m. (max. 80, med. 22). No pigeons were observed at 6.00 p.m.

Presence of pigeons at the study site during the days with hawk activity is presented in the Figure 17.

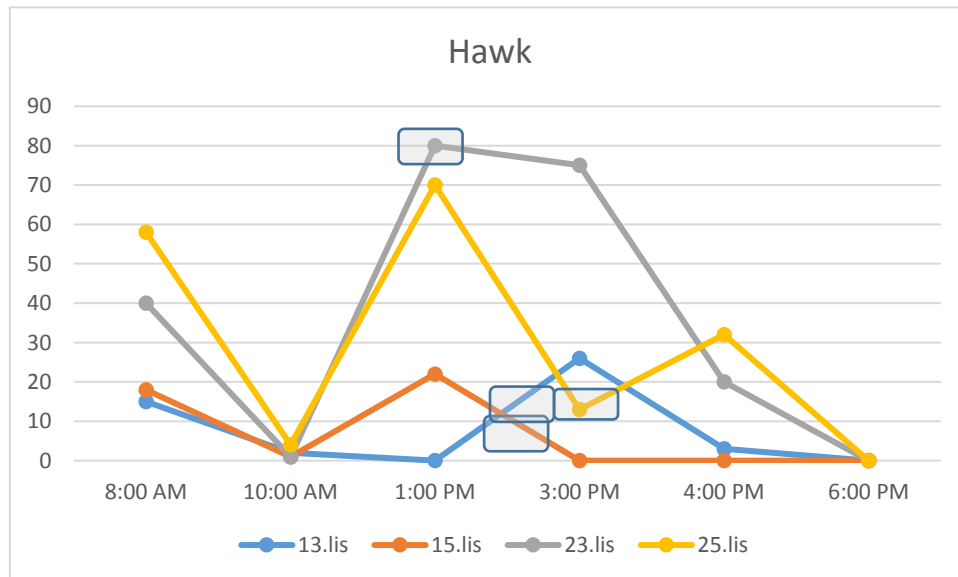


Figure 17. Presence of pigeons on days when hawk was used. Grey rectangles indicate time when hawk was used.

In the third phase of research hawk was used four times. When compared with Fig. 14, higher presence of pigeons is visible at 8.00 a.m., and use of hawk is less efficient in pigeon removal from the study site. Presence of crows is depicted in Table 5.

Table 5. Data on presence of crows at the study site.

| | 8.00 am | 10.00 am | 1.00 pm | 3.00 pm | 4.00 pm | 6.00 pm |
|---------|---------|----------|---------|---------|---------|---------|
| minimum | 0 | 0 | 0 | 0 | 0 | 0 |
| maximum | 8 | 4 | 6 | 5 | 3 | 5 |
| average | 4 | 2 | 1.5 | 0 | 0 | 0 |

Numbers of crows at the study site were in general very low. By the end of the research they left the study area.

6. DISCUSSION

In order to survive in the urban environment, pigeons need sheltered roosting and safe nesting places, constant availability of food and water, and low predation risks (DOBEIC et al., 2011). Usually, industrial areas, particularly food production factories (including food for both humans and animals), provide adequate conditions for pigeons. Since their presence can cause various problems, there are several methods that can be used to “fight” pigeons and crows. Those methods can be used solely or simultaneously (TEFFO et al., 2022). Use of falconry is relatively old method which is primarily based on the creation of so called “landscape of fear” (LAUNDRÉ et al., 2001). Therefore, it is not expected to remove pigeons from certain location by hunting them, but rather to ouster them and provoke insecurity. This is important since predation and fear of being attacked by predator represents a strong selective force for preys’ habitat selection (BLUMSTEIN and FERNÁNDEZ-JURICIC, 2010). On the other hand, since it is not expected that trained raptors will reduce birds’ populations, it is questioned whether their frequent use without additional methods, can cause habituation in targeted birds.

Prior to the use of raptors, daily presence of pigeons at study site was monitored (first phase of study). It was observed that highest number of pigeons was present at 1.00 p.m., followed by presence at 8.00 a.m., 10.00 a.m. and 3.00 p.m. Lowest number of pigeons was observed at 4.00 and 6.00 p.m. Such presence of pigeons over the major part of the day implicate sufficient availability of food at study site (RYAN, 2011). Observed diurnal presence of pigeons at study site is in accordance with results reported by ROSE et al. (2006). In fact, results of this study are comparable to summer time in this study. Data obtained for October are more comparable with the ROSE et al. (2006) study, with the exception of presence at 10.00 a.m. when we recorded lower number of pigeons. Regarding the total numbers of pigeons in this study, it was observed that numbers in September were lower compared to October. This is probably due to the higher activity of trucks that have transported harvested corn, and by that higher availability of food on the roads within the facility. Also, autumn is the period when pigeons have to accumulate body fat and increase mass in order to survive the winter, so they spend more time foraging (HAAG, 1984). It is also believed that lower number of pigeons after 4.00 p.m. is because they went to nests due to the approaching night. In this study raptors were used eight times in two phases, one with larger break between raptors visits, and the other one with one day break between flight.

During the second phase of the study hawk was released four times. Between first and second and third and fourth flight a five days break was implemented, while between second and third flight there was a 3 days break. During 5 days break period an average number of pigeons was 76.6 and 97.4 respectively, while during the 3 days break period the average number was 50. Third break period (N=97.4) was already in October, indicating higher presence of pigeons on study site during the October. After each hawk's flight during this phase, a sharp decline in pigeons number at study site was observed. However, number of pigeons returned to "normal" already next day, or day after.

During the third phase of the study, raptors were used also four times. In this phase, there was only one-day break between first and second, and third and fourth flight. Pause between second and third flight was one week. This phase was marked with high numbers of pigeons. The highest number of pigeons was observed at 8.00 a.m., followed by 1.00 p.m. In the first part of this phase hawks have induced decline in pigeon numbers during the flight day, while in second part this decline was observed only a day after. Increasing number of pigeons also characterizes this phase after hawk's flights, or just a minor decline. Also, number of pigeons at site have declined as study approached the end of October.

Number of crows at the study site was in general very low. Unlike pigeons, who were stationed in the backside of the factory, crows were present also in the front part. However, until the end of the research they left the study site. They reacted better to raptors, flying immediately away (within five minutes), but this may be also a result of their low numbers and consequent insecurity.

Since pigeons are facing various terrestrial and aerial predators, in order to survive they have developed various visual discriminative abilities and memory capacities (AUST and HUBER, 2006; STEPHAN et al., 2012). Furthermore, it is reported urban wildlife exhibit behavioral flexibility as a tool to cope with human mediated environment (SOL et al., 2013). CARLEN et al. (2021) reported that flight initiation distance in birds has decreased with urbanization. They have finally concluded that pigeons are responding to anthropogenic stressors through adaptive changes. This implicate potential of habituation of pigeons to repeated stimuli. Indeed, HARRIS et al. (2020) have reported that there is no significant difference in the pigeon numbers between the control, audio and raptor scare groups, following artificial audio and visual raptor presence. In this study, a habituation of pigeons to use of raptors was also observed. In fact, at the beginning pigeons fly away from study site immediately as they saw falconer (even without the bird), but with duration of the study they started to return quickly after hawk left the area. It was also seen in the third phase that pigeons

started to use safety distance, and fly away only to avoid being attacked by the hawk. Therefore it can be concluded that use of trained raptors to control urban population of pigeons, in open habitat, is not sufficient alone, especially if it is not done every day. This is on the other hand related to several problems like necessity to have more raptors and the fact that frequent use of raptors may lead to some losses, which can be quite expensive. To avoid habituation and increase efficiency of bird control, falconry should be combined with other methods. TEFFO et al. (2022) have analyzed potentials of mist-netting, trapping and falconry. They have concluded that most effective method is mist-netting, followed by trapping and falconry. Despite observed differences in efficacy of these methods, TEFFO et al. (2022) suggest using of combination of these methods. In Canada, HECK and SCHWARTZE (2020) suggest to combine falconry with shooting. It is also possible to use sticky-glue, repellents, etc.

Main limitations of this study were prolonged periods of rainy and foggy weather. In those conditions, cameras were not able to use solar charging, making recording of data impossible. Moreover, it is difficult or even impossible to use raptors during such periods, strong winds or when molting (BURGER, 1983). This study is one of rare studies that show interactions of trained raptors and pigeons at the open area of factory site and close to the human settlements. Later was important due to the limitations in raptor use, enabling pigeons to use safety zone. It can be also concluded that frequent use of raptor is more important than variations in its presence at the study site.

7. CONCLUSIONS

- Hypothesis was confirmed, and use of raptors led to habituation of pigeons. In the case of crows data are not that reliable due to small population of crows at the study site
- Use of trained raptors to ouster pigeons, but increased availability of food and habituation have resulted in lower efficacy during the study
- With duration of the study a reduction in time for pigeon return was observed, even in some attempts number increased after hawk left the study area
- Falconry alone is efficient in pigeon control only for short period of time.
- In order to increase efficacy of bird control program several methods should be used simultaneously

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9. SUMMARY

Use of raptors on the urban population of crows and pigeons

Anja France Noelle Renée Buet

The population of pigeons (*Columba livia*) and crows (*Corvus* spp.) is overrepresented in urban areas. Both species are considered as pests. Crows are extremely intelligent and have a role in reducing the population of smaller bird species. Secondly, crows and pigeons are responsible for the damages and contamination of buildings, monuments, etc. Furthermore, both are recorded to carry pathogens and therefore pose public health and ecological concerns. Therefore, the aim of the study was to analyze and observe the effect of using trained raptors on the population of urban crows and pigeons. The study took place in the factory Valipile in Dumovec, Zagrebačka county, Croatia. The study was divided in three phases. Phase one was the monitoring of undisturbed pigeons and crows in the area, for eight days. In phase two, raptors (Harris's hawks) were released for four times (2 x 2) with varying intervals. There was 5 days interval between two raptors flights. Third phase started five days after the second one and included four ousterings. Intervals between first and second, and third and fourth one was one day, while interval between second and third was seven days. Presence of pigeons and crows was monitored non-invasively using three phototraps: two Reolink Go Plus models, and one Scout Guard, model Boly BG590-24mHD. In the first phase, we observed high numbers of pigeons in the morning until midday (8 a.m. to 1 p.m.). Pigeons were more present at the factory in October, probably due to arrival of the harvested corn and their preparations for winter. During the second phase of the study, after each hawks' flight a sharp decline in pigeon numbers were observed but the following day pigeons returned in "normal" numbers. In the first part of the third phase, hawks have induced decline in pigeon numbers during the flight day, while in second part this decline was observed only a day after. Number of crows at the study site was in general very low. Unlike pigeons, crows reacted better to raptors, flying immediately away as soon as the raptors were visible, but this may be also a result of their low numbers and consequent insecurity, or their previous experience with wild raptors. The results of the study point to the habituation of pigeons to the presence of raptors. Falconry alone is not efficient enough for bird control for a longer period of time and should be aided with other methods of bird control.

Key words: pigeon, crow, raptor, bird control, habituation

10. SAŽETAK

Primjena ptica grabljivica na urbanim populacijama vrana i golubova

Anja France Noelle Renée Buet

Golubovi (*Columba livia*) i vrane (*Corvus* spp.) su sve prisutniji u urbanim sredinama. Obje vrste smatraju se štetočinama. Vrane su izuzetno inteligentne i imaju negativan utjecaj na brojnost manjih vrsta ptica. Pored toga, vrane i golubovi odgovorni su za oštećenja i onečišćenja zgrada, spomenika, i sl. Nadalje, zabilježeno je da obje vrste prenose uzročnike bolesti te stoga predstavljaju problem za javno zdravstvo i okoliš. Cilj ovoga istraživanja bio je analizirati učinak upotrebe treniranih ptica grabljivica na urbane vrane i golubove. Studija je provedena u tvornici Valipile u Dumovcu, Zagrebačka županija, Hrvatska. Istraživanje je podijeljeno u tri faze. Prva faza bila je praćenje golubova i vrana na tom području bez prisutnosti grabljivica tijekom osam dana. U drugoj fazi, grabljivice (Harrisovi jastrebovi) puštene su četiri puta (2 x 2) u različitim intervalima. Razmak između dva leta grabljivice bio je 5 dana. Treća faza započela je pet dana nakon druge, a uključivala je četiri istjerivanja. Razmak između prvog i drugog, te trećeg i četvrtog istjerivanja bio je jedan dan, dok je razmak između drugog i trećeg bio sedam dana. Prisutnost golubova i vrana praćena je neinvazivno pomoću tri fotozamke: dvije modela Reolink Go Plus i jedne Scout Guard, model Boly BG590-24mHD. U prvoj fazi uočena je velika brojnost golubova u jutarnjim satima do podneva (od 8 do 13 sati). Golubovi su u listopadu bili brojniji u tvornici, vjerojatno zbog dovoza kukuruza i pojačane pripreme ptica za zimu. Tijekom druge faze studije, nakon svakog leta jastrebova primijećen je nagli pad broja golubova, ali su se sljedeći dan vratili u "normalnom" broju. U prvom dijelu treće faze jastrebovi su uzrokovali pad broja golubova tijekom dana leta, dok je u drugom dijelu taj pad uočen samo dan nakon. Broj vrana na mjestu istraživanja općenito je bio vrlo nizak. Za razliku od golubova, vrane su bolje reagirale na grabljivice te su odmah odletjele, no to može biti rezultat njihove male brojnosti i posljedične nesigurnosti ili prethodnog iskustva s divljim grabljivicama. Rezultati istraživanja ukazuju na navikavanje golubova na prisutnost grabljivica. Samo sokolarenje nije dostatno učinkovito za dugotrajniju kontrolu brojnosti ptica i potrebno ga je potpomoći drugim metodama kontrole.

Ključne riječi: golubovi, vrane, ptice grabljivice, kontrola brojnosti ptica, navikavanje

11. CURRICULUM VITAE

I, Anja France Noelle Renée BUET, was born on the 27th of January 1999 on Reunion Island, a French island. Since I was young, I have always wanted to be a veterinarian. I first started to volunteer two weeks during my highschool, in Moholoholo wildlife rehabilitation center in Hoedspruit, South Africa. This first international adventure allowed me to meet different people coming from the entire world and be certain of my will to work with animals.

In 2018, I started my study in the faculty of Veterinary Medicine in Zagreb, in the international program. Between each year of study, I have been volunteering to a couple of clinics.

I completed 5 weeks of internship in the clinic of shelter in Reunion Island. In that clinic, I learned to do my first surgeries such as sterilization and castration. From this incredible veterinarian mentor from Belgium, I became independent for those surgeries. The next summer, I turned myself to wildlife rescue hospital, first in Faune Alfort, in the Veterinary school of Maison-Alfort, in Paris and then in South Africa, in Johannesburg Wildlife Veterinarian Hospital. It was in Paris where I have been working the most with feral pigeons. They were the most numbered patients in the clinic. Feral pigeons are the easiest wild animals to work with. Then, in South Africa, I mostly worked with many cape turtle doves and speckled pigeons. Those internships were very resourceful, full of knowledge, and experience. Working with birds and bats was a positive surprise, I adored it.

During the study, I was able to earn some laboratory experience by working at the Physiology and Radiobiology department with assist. Prof. Lana Pađen on one project. From this experience, I learned how to be precise in a laboratory, to follow instructions and to work with many laboratory instruments. The project was based on the identification of fatty acid in wolf tissues.

In my 6th year, I volunteered throughout the year at the exotic clinic of the Faculty of Veterinary Medicine of Zagreb and at the Goldi clinic for two months. Recently, I was part of a TNR project at the shelter Dumovec in Croatia, for one week. 205 cats were neutered.