Use of raptors on the urban population of crows and pigeons

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LIST OF SUPPLEMENTS

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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 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.

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

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.

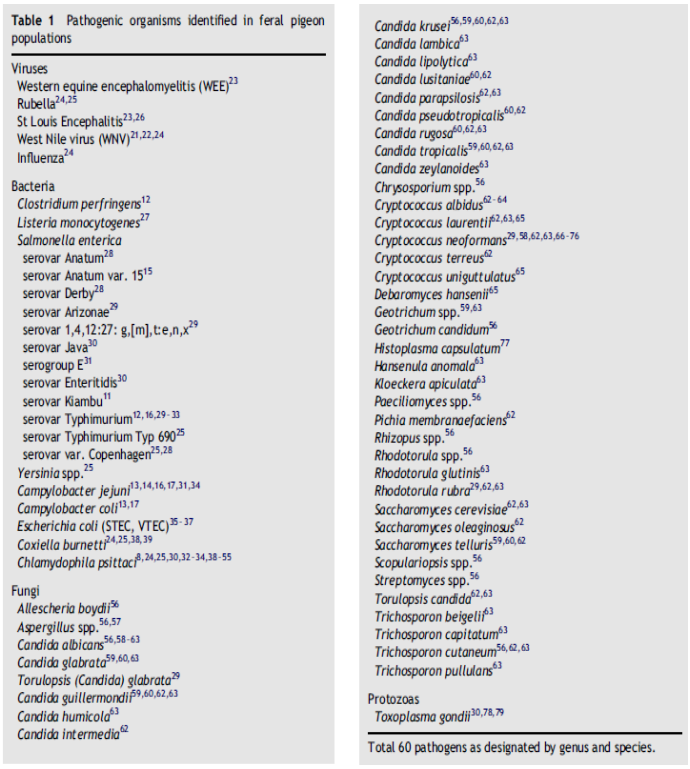

Table 1 Pathogenic organisms identified in feral pigeon populations

Viruses
- Western equine encephalomyelitis (WEE)[23]
- Rubella[24,25]
- St Louis Encephalitis[23,26]
- West Nile virus (WNV)[21,22,24]
- Influenza[24]

Bacteria
- *Clostridium perfringens*[12]
- *Listeria monocytogenes*[27]
- *Salmonella enterica*
  - serovar Anatum[28]
  - serovar Anatum var. 15[15]
  - serovar Derby[28]
  - serovar Arizonae[29]
  - serovar 1,4,12:27: g,[m],t:e,n,x[29]
  - serovar Java[30]
  - serogroup E[31]
  - serovar Enteritidis[30]
  - serovar Kiambu[11]
  - serovar Typhimurium[12,16,29-33]
  - serovar Typhimurium Typ 690[25]
  - serovar var. Copenhagen[25,28]
- *Yersinia* spp.[25]
- *Campylobacter jejuni*[13,14,16,17,31,34]
- *Campylobacter coli*[13,17]
- *Escherichia coli* (STEC, VTEC)[35-37]
- *Coxiella burnetti*[24,25,38,39]
- *Chlamydophila psittaci*[8,24,25,30,32-34,38-55]

Fungi
- *Allescheria boydii*[56]
- *Aspergillus* spp.[56,57]
- *Candida albicans*[56,58-63]
- *Candida glabrata*[59,60,63]
- *Torulopsis (Candida) glabrata*[29]
- *Candida guillermondi*[59,60,62,63]
- *Candida humicola*[63]
- *Candida intermedia*[62]
- *Candida krusei*[56,59,60,62,63]
- *Candida lambica*[63]
- *Candida lipolytica*[63]
- *Candida lusitaniae*[60,62]
- *Candida parapsilosis*[62,63]
- *Candida pseudotropicalis*[60,62]
- *Candida rugosa*[60,62,63]
- *Candida tropicalis*[59,60,62,63]
- *Candida zeylanoides*[63]
- *Chrysosporium* spp.[56]
- *Cryptococcus albidus*[62-64]
- *Cryptococcus laurentii*[62,63,65]
- *Cryptococcus neoformans*[29,58,62,63,66-76]
- *Cryptococcus terreus*[62]
- *Cryptococcus uniguttulatus*[65]
- *Debaromyces hansenii*[65]
- *Geotrichum* spp.[59,63]
- *Geotrichum candidum*[56]
- *Histoplasma capsulatum*[77]
- *Hansenula anomala*[63]
- *Kloeckera apiculata*[63]
- *Paeciliomyces* spp.[56]
- *Pichia membranaefaciens*[62]
- *Rhizopus* spp.[56]
- *Rhodotorula* spp.[56]
- *Rhodotorula glutinis*[63]
- *Rhodotorula rubra*[29,62,63]
- *Saccharomyces cerevisiae*[62,63]
- *Saccharomyces oleaginosus*[62]
- *Saccharomyces telluris*[59,60,62]
- *Scopulariopsis* spp.[56]
- *Streptomyces* spp.[56]
- *Torulopsis candida*[62,63]
- *Trichosporon beigelii*[63]
- *Trichosporon capitatum*[63]
- *Trichosporon cutaneum*[56,62,63]
- *Trichosporon pullulans*[63]

Protozoas
- *Toxoplasma gondii*[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 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.

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

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
Salmonella enterica	1	Environmental exposure[11]
Chlamydophila psittaci	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]
Histoplasma capsulatum	23	Environmental exposure[3]
	68	Exposure in a hospital setting[77]
Aspergillus spp.	13 (13)	Exposure in a hospital setting[87-90]
Candida parapsilosis	12 (12)	Exposure in a hospital setting[91]
Cryptococcus neoformans	5 (2)	Environmental exposure[67,92-95]
	5 (4)	Exposure in a hospital setting[75,96]
	1 (1)	Wound inflicted by a pigeon[97]
Toxoplasma	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 contarction 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*, *Chlamydophila* 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 *Enterobacteriacea* 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 urbans 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, oculonasal 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 (MCDOUGALD, 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 oropharingeal 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 tinplate, 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.

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

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, 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 oustering
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 oustering. 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 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 pilar). 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.

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

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.

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

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.)

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.

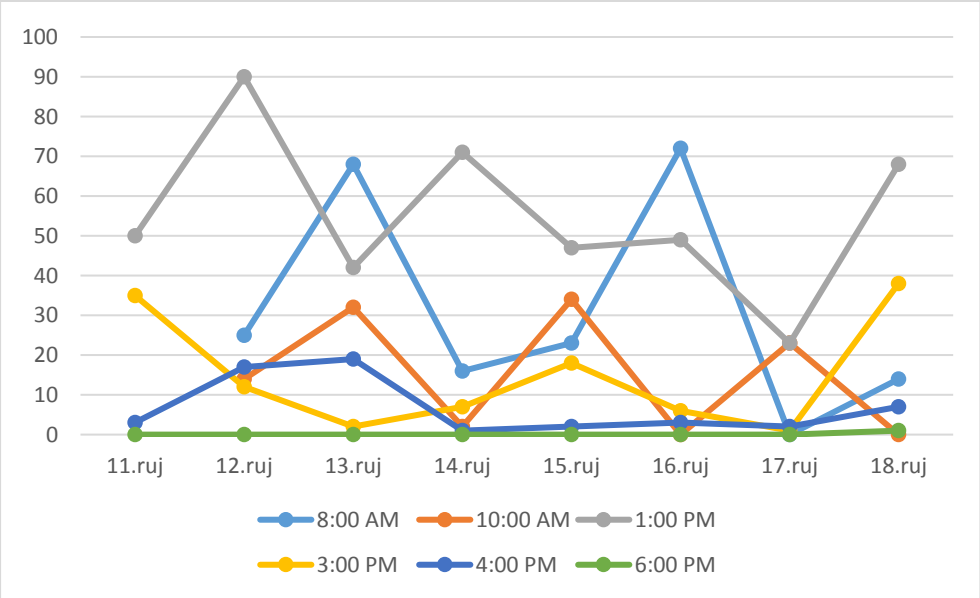

Figure 11. Presence of pigeons at study site during the first phase of research.

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.

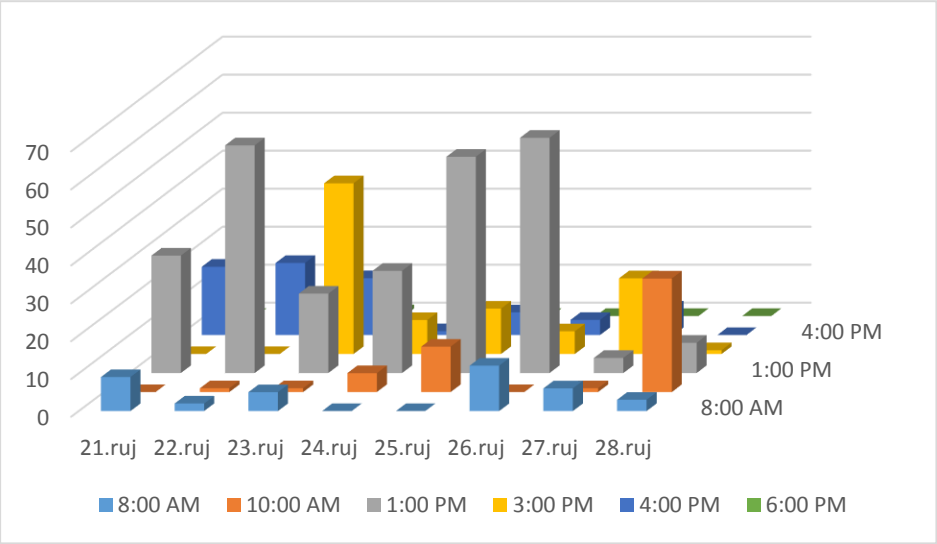

Figure 12. Presence of pigeons at study site during the first part of the second phase of research.

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.

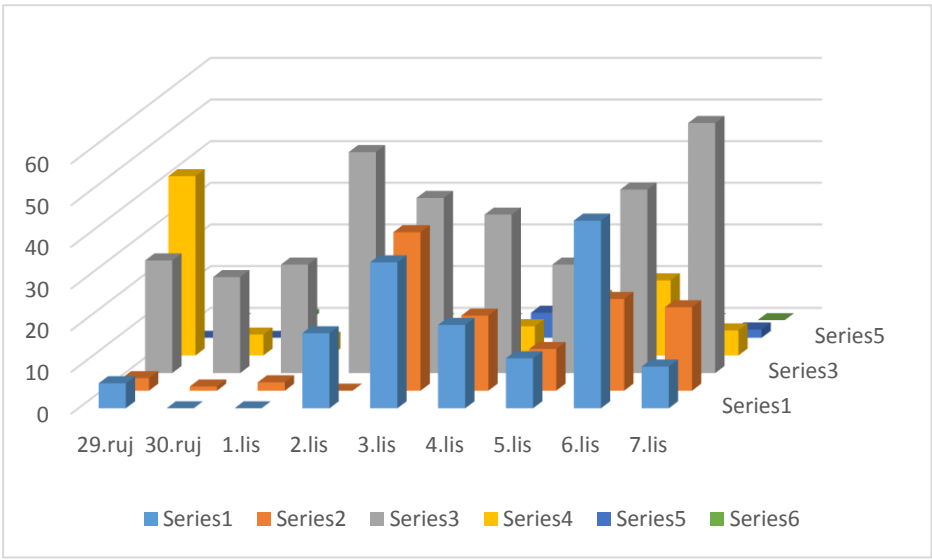

Figure 13. Presence of pigeons at study site during the second part of the second phase of research.

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.

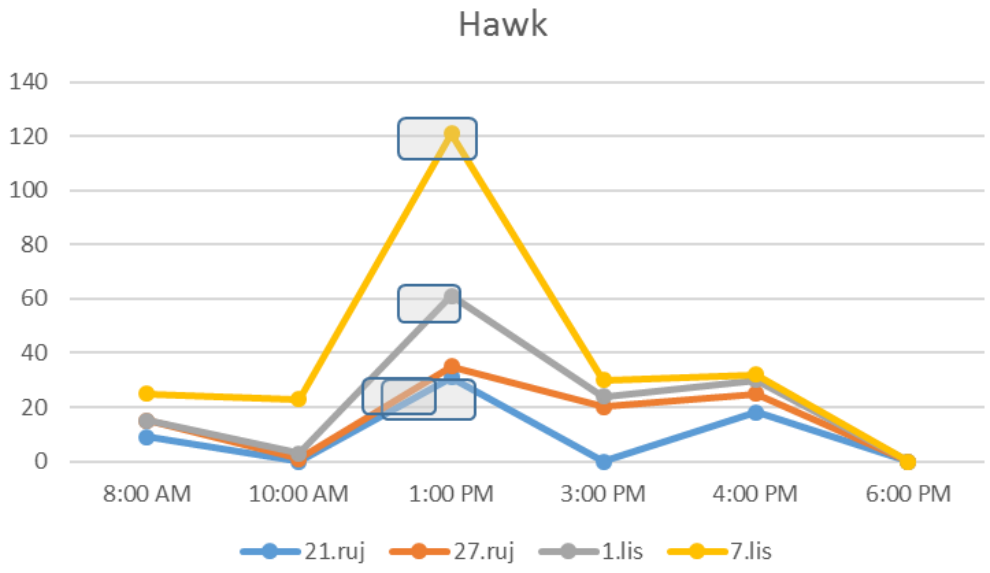

Figure 14. Presence of pigeons on days when hawk was used. Grey rectangles indicate time when hawk was used.

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.

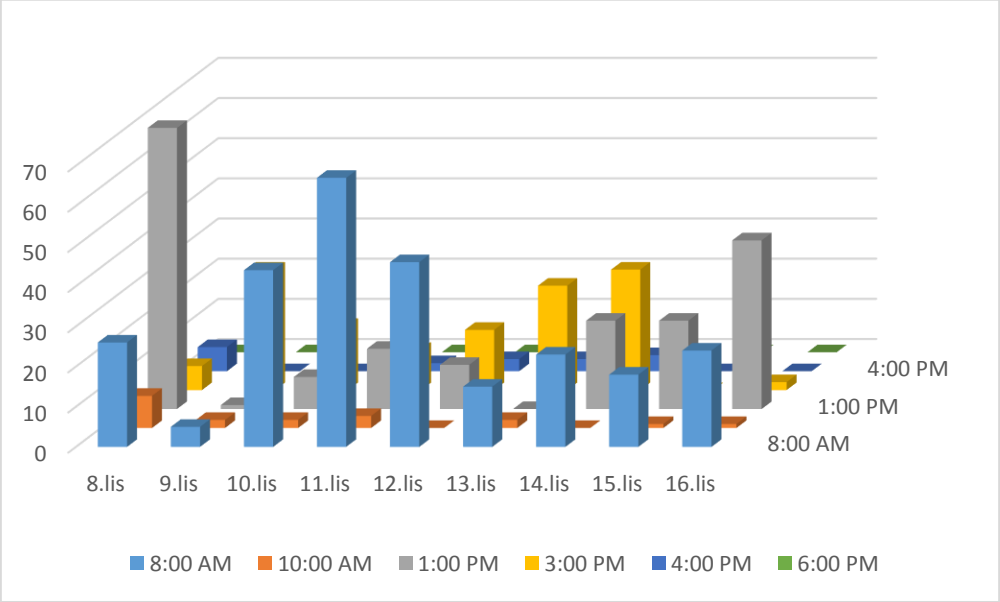

Figure 15. Presence of pigeons at study site during the first part of the third phase of research.

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.

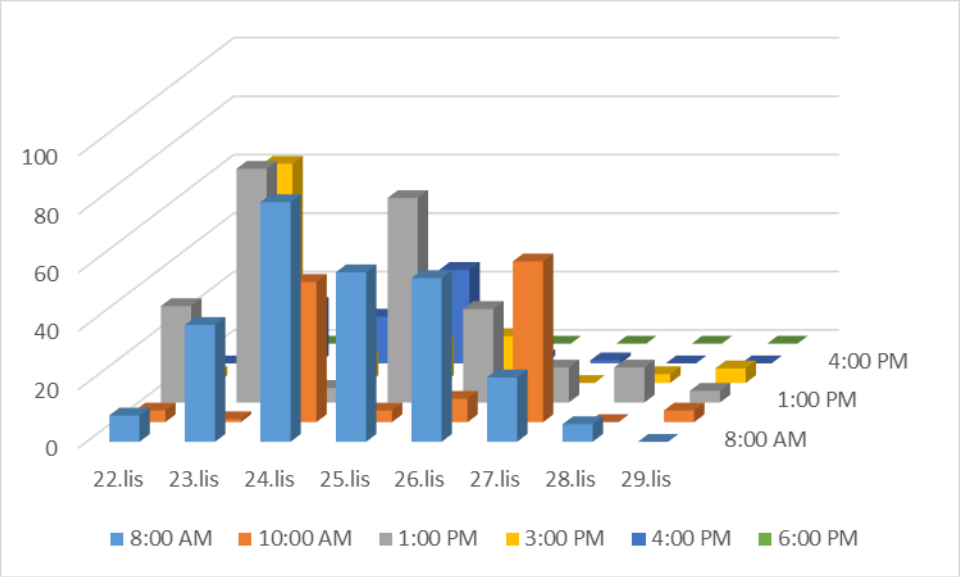

Figure 16. Presence of pigeons at study site during the second part of the third phase of research.

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.

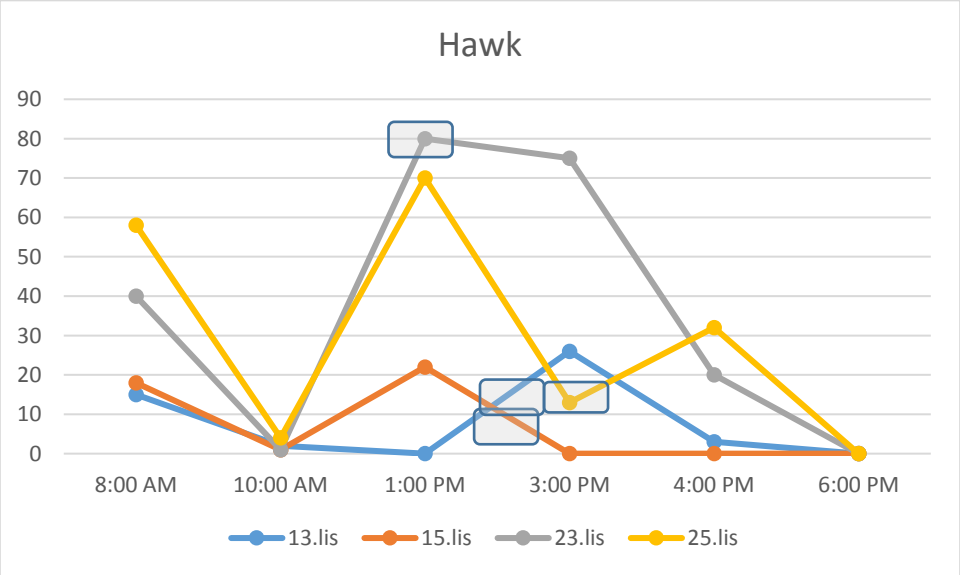

Figure 17. Presence of pigeons on days when hawk was used. Grey rectangles indicate time when hawk was used.

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 hawks' 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 firt 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 hawks 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. Their 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

8. REFERENCES

ABEGG, M.A., F. L. CELLA, J. FAGANELLO, P. VALENTE, A. SCHRANK, M. H. VAINSTEIN (2006): *Cryptococcus neoformans* and *Cryptococcus gattii* isolated from the excreta of Psittaciformes in a Southern Brazilian Zoological Garden. Mycopathologia, 161, 83–91.

AMIN, A., I. BILIC, D. LIEBHART, M. HESS (2014): Trichomonads in birds--a review. Parasitology 141, 733-747.

ANDERSEN, A. A., D. VANROMPAY (2008): Avian chlamydiosis (psittacosis, ornithosis). In: Diseases of Poultry (Saif Y. M., A. M. Fadly, J. R. Glisson, L. R. McDougald, L. K. Nolan, D. E. Swayne, eds.), 12th edition. Blackwell Publishing, Ames, Iowa, 971–986.

ANGUS, K. A. (1983): Cryptosporidiosis in Man, Domestic Animals and Birds: A Review. J. R. Soc. Med. 76, 62-70.

AUST, U., L. HUBER (2006): Picture-object recognition in pigeons: Evidence of representational insight in a visual discrimination task using a complementary information procedure. J. Exp. Psychol - Anim. Behav. Process. 32, 190–195.

AVERY, M. L., D. G. DECKER, J. S. HUMPHREY, C. C. LAUKERT (1996): Mint plant derivatives as blackbird feeding deterrents. Crop. Prot. 15, 461–464.

BAKER, J. R. (1996): Causes of mortality and morbidity in exhibition budgerigars in the United Kingdom. Vet. Rec. 139, 156 – 162.

BALSAMO G., A.M. MAXTED, J.W. MIDLA, J.M. MURPHY, R. WOHRLE, T.M. EDLING, P. H. FISH, K. FLAMMER, D. HYDE, P.K. KUTTY, M. KOBAYASHI, B. HELM, B. OIULFSTAD, B.W. RITCHIE, M. G. STOBIERSKI, T.K. EHNERT, T. N. Jr TULLY (2017): Compendium of measures to control *Chlamydia psittaci* infection among humans (Psittacosis) and pet birds (Avian Chlamydiosis). J. Avian Med. Surg. 31, 262-282.

BESSOT, J. C., M. C. KOPFERSCHMITT, F. DE BLAY, A. DIETEMANN, A. NIRRENGARTEN, N. HUTT, C. LE COZ, A. BOUZOUBA, J. SAINTE LAUDY, G. PAULI (1997): Anaphylactic shock after pigeon tick bite (*Argas reflexus*). About twelve cases (in French). Rev. Fr. Allergol. Immunol. Clin. 37, 431–437.

BLACKWELL, B. F., G. E. BERNHARDT, R. A. DOLBEER (2002): Lasers as nonlethal avian repellents. J. Wildl. Manage. 66, 250–258.

BLUMSTEIN, D. T., E. FERNÁNDEZ-JURICIC (2010): A Primer of Conservation Behavior. Sinauer Associates, Sunderland, MA.

BOAL, C.W., R.W. MANNAN, K.S. HUDELSON (1998): Trichomoniasis in Cooper's hawks from Arizona. J. Wildl. Dis. 34, 590 – 593.

BROOKS E. E. (2021): Chlamydiosis in birds (Zoonotic) (Exotic Pets). VINcyclopedia of Diseases.
https://www.vin.com/members/cms/project/defaultadv1.aspx?pid=607&id=10184971&f5=1

BUCHANAN, K. L., J. W. MURPHY (1998): What Makes *Cryptococcus neoformans* a Pathogen? Emerg. Infect. Dis. 4, 71-83.

BURGER, J. (1983): Bird control at airports. Environ. Conserv. 10, 115-124.

CADIOU, B. (1999): Attendance of breeders and prospectors reflects the duality of colonies in the Kittiwake *Rissa tridactyla*. Ibis 141, 321-326.

CAMOLESE, C., C. H. D'ANGELI, F. FRATICELLI, E. MANZO, R. SALMI (2003): A carrion crow *Corvus cornix* catch in flight a common swift *Apus apus*. Alula (Roma) 10, 103-104.

CARLEN, E. J., R. LI, K. M. WINCHELL (2021): Urbanization predicts flight initiation distance in feral pigeons (*Columba livia*) across New York City. Anim. Behav. 178, 229-245.

CARO, T.M. (2005): Antipredator defenses in birds and mammals: University of Chicago Press.

COUSQUER, G. (2005): Ingluvitis and oesophagitis in wild finches. Vet. Rec. 157, 445.

DAWSON, J. R., W. B. STONE, G. D. EBEL, D. S. YOUNG, D. S. GALINSKI, J. P. PENSABENE, M. A. FRANKE, M. EIDSON, L. D. KRAMER (2007): Crow deaths caused by West Nile virus during winter. Emerg. Infect. Dis. 13, 1912-1914.

DAY, T. D., L. R. MATTHEWS, J. R. WAAS (2003): Repellents to deter New Zealand's North Island robin Petroica australis longipes from pest control baits. Biol. Conserv. 114, 309–316.

DEL MONTE, M., C. SABBIONI (1986): Chemical and biological weathering of an historical building: Reggio Emilia Cathedral. Sci. Total Environ. 50, 165–182.

DELL'OMO, A. (1996): The role of pigeon droppings in the bio-alteration of rocks. PhD Thesis. University of Rome "La Sapienza" (in Italian).

DOBEIC, M., S. PINTARIČ, K. VLAHOVIĆ, A. DOVČ (2011): Feral pigeon (*Columba livia*) population management in Ljubljana. Vet. Arhiv 81, 285–298.

DUDEK, B. M., M. N. KOCHERT, J. G. BARNES, P. H. BLOOM, J. M. PAPP, R. W. GERHOLD, K. E. PURPLE, K.V. JACOBSON, C. R. PRESTON, C. R. VENNUM, J. W. WATSON, J. A. HEATH (2018): Prevalence and risk factors of *Trichomonas gallinae* and Trichomonosis in golden eagle (*Aquila chrysaetos*) nestlings in western north America. J. Wildl. Dis. 54, 755–764.

EDHOLM, M. (1979): Hooded crow, *Corvus corone cornix*, catching starling *Sturnus vulgaris* in flight. Var Fagelvarld 38, 106-107.

EIDSON, M., J. MILLER, L. KRAMER, B. CHERRY, Y. HAGIWARA and THE WEST NILE VIRUS BIRD MORTALITY ANALYSIS GROUP (2001): Dead crow densities and human cases of West Nile virus, New York State, 2000. Emerg. Infect. Dis. 7, 662-664.

ERWIN, K. G., C. KLOSS, J. LYLES, J. FELDERHOFF, A. M. FEDYNICH, S. E. HENKEM, J. A. ROBERSON (2000): Survival of *Trichomonas gallinae* in white winged doves carcasses. J. Wildl. Dis. 36, 551 – 554 .

FARIZAWATI, S., Y. A. LIM, R. A. AHMAD, C. T. FATIMAH, Y. SITI-NOR (2005): Contribution of cattle farms towards river contamination with *Giardia* cysts and *Cryptosporidium* oocysts in Sungai Langat Basin. Trop. Biomed. 22, 89-98.

GAGLIARDO, A., E. POLLONARA, L. VANNI, D. GIUNCHI (2020): An experimental study on the effectiveness of a gel repellent on feral pigeons. Eur. J. Wildl. Res. 66, 27.

GHADERI, Z., S. EIDI, J. RAZMYAR (2019): High Prevalence of *Cryptococcus neoformans* and isolation of other opportunistic fungi from pigeon (*Columba livia*) droppings in Northeast Iran. J. Avian Med. Surg. 33, 335-339.

GILL F., D. DONSKER, P. RASMUSSEN (2022): Crows, mudnesters, birds-of-paradise. IOC World Bird List Version 12.1. International Ornithologists' Union. Retrieved 20 March 2022.

GIUNCHI, D., N. E. BALDACCINI, G. SBRAGIA, C. SOLDATINI (2007b): On the use of pharmacological sterilisation to control feral pigeon populations. Wildl. Res. 34, 306–318.
GIUNCHI, D., Y. V. ALBORES-BARAJAS, N. E. BALDACCINI, L. VANNI, C.

SOLDATINI (2012): Feral pigeons: problems, dynamics and control methods. Integrated pest management and pest control—current and future tactics. Intech London, InTechOpen, pp. 215-240.

GIUNCHI, D., V. GAGGINI, N. E. BALDACCINI (2007a): Distance sampling as an effective method for monitoring feral pigeon (*Columba livia* f. *domestica*) urban populations. Urban Ecosyst. 10, 397–412.

GOMPERTZ, T. (1957): Some observations on the feral pigeon in London (with Addendum: two cases of polyneuritis in Feral Pigeons. Derek Goodwin), Bird Study 4, 2-13.

GOODWIN, D. (1954): Notes on Feral Pigeons. Avic. Mag. 6, 190-213.

GOODWIN, D. (1960): Comparative ecology of pigeons in inner London. Brit. Birds 53, 201-212.

GRANT, M. C., C. ORSMAN, J. EASTON, C. LODGE, M. SMITH, G. THOMPSON, S. RODWELL, N. MOORE (1999): Breeding success and causes of breeding failure of curlew *Numenius arquata* in Northern Ireland. J. Appl. Ecol. 36, 59-74.

GREEN, N., A. YURLOV (1999): Body dimensions and mass of breeding and hatched Black-tailed Godwits (*Limosa* l. *limosa*): a comparison between a West Siberian and a Dutch population. J. Ornithol. 140, 73-79.

HAAG, D. (1984): Ein Beitrag zur Ökologie der Stadttaube (*Columba livia livia*). PhD Thesis. University of Basel, Switzerland.

HAAG-WACKERNAGEL, D. (1995): Regulation of the street pigeon in Basel. Wildl. Soc. Bull. 23, 256-260.

HAAG-WACKERNAGEL, D. (2005): Parasites from feral pigeons as a health hazard for humans. Ann. Appl. Biol. 147, 203-210.

HAAG-WACKERNAGEL, D. (2008): Feral pigeon management. Available via DIALOG. www.Anatomie.unibas.ch/integrativeBiology/hag/Feral-Pigeon/Strassentauben/pigeon-management.html.

HAAG-WACKERNAGEL, D., H. MOCH (2004): Health hazards posed by feral pigeons. J. Infect. 48, 307-313.

HAAG-WACKERNAGEL, D., I. GEIGENFEIND (2008): Protecting buildings against feral pigeons. Eur. J. Wildl. Res. 54, 715-721.

HARMON, W. H., W. A. CLARK, A. C. HAWBECKER, M. STAFFORD (1987): *Trichomonas gallinae* in columbiform birds from Galapagos islands. J. Wildl. Dis. 23, 492 – 494 .

HARRIS, E., E. P. DE CROM, J. FOUCHE, A. WILSON (2020): Comparative study on the short-term effects of audio and visual raptor presence on a pigeon population, with a view towards pest control. Int. J. Pest Manage. 66, 31-39.

HARRIS, E., E. P. DE CROM, J. LABUSCHAGNE, A. WILSON (2016): Visual deterrents and physical barriers as non-lethal pigeon control on University of South Africa's Muckleneuk campus. SpringerPlus 5, 1884.

HARRIS, R. E., R. A. DAVIES (1998): Evaluation of the efficacy of products and techniques for airport bird control. Aerodrome Safety Branch Transport Canada, Ontario, 93.

HECK, N., S. SCHWARTZE (2020): Use of Falconry and Shooting as Rock Pigeon Abatement Techniques at an Electrical Converter Station in Alberta, Canada. J. Raptor Res. 54, 193–197.

HILGER, C., J. C. BESSOT, N. HUTT, F. GRIGIONI, F. DE BLAY, G. PAULI, F. HENTGES (2005): IgE-mediated anaphylaxis caused by bites of the pigeon tick Argas reflexus: cloning and expression of the major allergen Arg r l. J. Allergy Clin. Immunol. 115, 617–622.

HUTTON, R. (2005): Method statement for the control of feral pigeons. Available via DIALOG. http://www.handr.co.uk/literature/feral_pigeons.htm.

HUTTON, T. C., J. DOBSON (1993): The control of feral pigeons: an independent approach. Struct. Surv. 11, 159–167.

JACOBS, G. H. (1992): Ultraviolet vision in vertebrates. American Zoologist 32, 544-554.

JINKS, W. E., R. B. YEE (1968): Factors that determine the growth of *Cryptococcus neoformans* in avian excreta. Am. J. Epidemiol. 88, 445–450.

KAPLAN, W. (1973): Epidemiology of the principal systemic mycoses of man and lower animals and the ecology of their etiologic agents. JAVMA 163, 1043-1047.

KARIM, S. J. I., M. ISLAM, T. SIKDER, R. RUBAYA, J. HALDER, J. ALAM (2020): Multidrug-resistant Escherichia coli and Salmonella spp. isolated from pigeons. Vet. World 13, 2156–2165.

KOMAR, N., S. LANGEVIN, S. HINTEN, N. NEMETH, E. EDWARD, D. HETTLER, B. DAVIS, R. BOWEN, M. BUNNING (2003): Experimental infection of North American birds with the New York 1999 strain of West Nile virus. Emerg. Infect .Dis. 9, 311–22.

KÖSTERS, J., E.F. KALETA, G. MONREAL, O. SIEGMANN (1991): The Problem of City Pigeons (in German). Deutsch. Tierärztl. 4, 272–276.

KRONE, O., R. ALTENKAMP, N. KENNTNER (2005): Prevalence of *Trichomonas gallinae* in Northern Goshawk from Berlin area of Northeastern Germany. J. Wildl. Dis. 41, 304 – 309.

LARSON, D.W., U. MATTHES, P.E. KELLY (1999): Cliff Ecology. Cambridge University Press, Cambridge.

LAUNDRÉ, J. W., L. HERNÁNDEZ, K. B. ALTENDORF (2001): Wolves, elk, bison: reestablishing the "landscape of fear" in Yellowstone National Park, U.S.A. Can. J. Zool. 79, 1401–1409.

LEE, H. Y., A. STEPHEN, D. SUSHELA, M. MALA (2008): Detection of protozoan and bacterial pathogens of public health importance in faeces of *Corvus* spp. (large-billed crow). Trop. Biomed. 25, 134–139.

LEUCCI, G., D. MELICA, G. QUARTA (2013): The Foggia Cathedral: an in situ integrated geophysical and mechanical study on the wooden structures of the ceiling. Paper presented at the Built Heritage 2013. Monitoring Conservation Management., Milan 18–20 November 2013.

MADDEN, C. F., B. ARROYO, A. AMAR (2015): A review of the impacts of corvids on bird productivity and abundance. Ibis 157, 1-16.

MASON, J. R. (1990): Evaluation of d-pulegone as an avian repellent. J. Wildl. Manage. 54, 130–135

MASON, J. R., M. A. ADAMS, L. CLARK (1989): Anthranilate repellency to starlings: chemical correlates and sensory perception. J. Wildl. Manage. 53, 55–64.

MCDOUGALD, L. R. (2000): “ Protozoaria ”. In: Diseases of Poultry (Calnek, B. W., ed.). Iowa University State Press, Ames, Iowa, USA, pp. 924 – 926.

MCKEON, T., J. DUNSMORE, S. R. RAIDAL (1997): *Trichomonas gallinae* in budgerigars and columbid birds in Perth, Western Australia. Austr. Vet. J. 75, 652 – 655.

MIA, M. M., M. HASAN, M. R. HASNATH (2022): Global prevalence of zoonotic pathogens from pigeon birds: A systematic review and meta- analysis, Heliyon 8: E09732.

MORGAN, R. V., S. LESTER, K. ROTHROCK, J. BRISTER, G. PAVLOVSKY (2024): Cryptococcosis (Feline). VINcyclopedia of diseases.

https://www.vin.com/members/cms/project/defaultadv1.aspx?pid=607&id=4954024&f5=1

MURTON, R. K., E. N. WRIGHT (2013): The problems of birds as pests. Proceedings of a Symposium Held at the Royal Geographical Society, London, 28-29 September 1967. Elsevier, p. 181.

MURTON, R. K., N. J. WESTWOOD (1966): The foods of the Rock Dove and Feral Pigeon, Bird Study 13, 130-146.

MURTON, R., R. THEARLE, J. THOMPSON (1972): Ecological studies of the feral pigeon *Columba livia* var. *l*. Population, breeding biology and economic considerations. J. Appl. Ecol. 9, 835–874.

OPERMANIS, O., A. MEDNIS, I. BAUGA (2001): Duck nests and predators: interaction, specialization and possible management. Wildl. Biol. 7, 87-96.

ORR-WALKER, T., N. J. ADAMS, L. G. ROBERTS et al (2012): Effectiveness of the bird repellents anthraquinone and d-pulegone on an endemic New Zealand parrot, the kea (*Nestor notabilis*). Appl. Anim. Behav. Sci. 137, 80–85.

PICOZZI, N. (1975): A study of the carrion/hooded crow in northeast Scotland. Brit. Birds 68, 409-419.

QUERCIA, O., F. EMILIANI, F. G. FOSCHI, G. F. STEFANINI (2005): Anaphylactic shock to *Argas reflexus* bite. Allerg. Immunol. (Paris) 37, 66–68.

ROSE, E., P. NAGEL, D. HAAG-WACKERNAGEL (2006): Spatio-temporal use of the urban habitat by feral pigeons (*Columba livia*). Behav. Ecol. Sociobiol. 60, 242-254.

RYAN, A. C. (2011): The distribution, density, and movements of feral pigeons *Columba livia* and their relationship with people. MSc Thesis. Victoria University of Wellington, NZ.

SACCHI, R., A. GENTILLI, E. RAZZETTI, F. BARBIERI (2002): Effects of building features on density and flock distribution of feral pigeons *Columba livia* var. *domestica* in an urban environment. Can. J. Zool. 80, 48-54.

SÁNDOR, A. D., Z. KALMÁR, I. MATEI, A. M. IONICĂ, I.-D. MĂRCUŢAN (2017): Urban breeding corvids as disseminators of ticks and emerging tick-borne pathogens. Vector Borne Zoonotic Dis. 17, 152-154.

SEAMANS, T. W., S. C. BARRAS, G. E. BERNHARDT (2007): Evaluation of two perch deterrents for starlings, blackbirds and pigeons. Int. J. Pest Manage. 53, 45–51.

SILVANOSE, C. D., J. H. SAMOUR, J. L. NALDO, T. A. BAILEY (1998): Oro-pharyngeal protozoa in captive bustards: clinical and pathological considerations. Avian Pathol. 27, 226 – 230.

SIRIANNI, M. C., G. MATTIACCI, B. BARBONE, A. MARI, F. AIUTI, J. KLEINE-TEBBE (2000): Anaphylaxis after *Argas reflexus* bite. Allergy 55, 303.

SOL, D., O. LAPIEDRA, C. GONZALEZ-LAGOS (2013). Behavioural adjustments for a life in the city. Anim. Behav. 85: 1101e1112.

SOSSINSKA, R. (1982): Domestication in birds. In: Avian Biology, vol. VI (Farner, D. S., J. R. King, K. C. Parkes, eds.). Academic Press, New York, pp. 373–403.

SPENNEMANN, D. H. R., D. W. LOOK (2006): Impact of Tropical Vegetation On World War II-Era cultural resources in the Marshall Islands. Micronesian Journal of the Humanities and Social Sciences, 5(1/2), 440–462.

SPENNEMANN, D. H., M. J. WATSON (2017). Dietary habits of urban pigeons (*Columba livia*) and implications of excreta pH–a review. Eur. J. Ecol. 3, 27-41.

SPENNEMANN, D., M. PIKE, M. WATSON (2017): Behaviour of pigeon excreta on masonry Surfaces. Restoration of Buildings and Monuments 23, 15.

SPENNEMANN, D. H. R., M. J. WATSON (2018): The impact of bird excreta on the conservation of architectural metals. A review. APT Bulletin Journal of Preservation Technology 49, 19-26.

STEPHAN, C., A. WILKINSON, L. HUBER (2012): Have We Met Before? Pigeons Recognise Familiar Human Faces. Avian Biol. Res. 5,75-80.

STOCK, B., D. HAAG-WACKERNAGEL (2014): Effectiveness of gel repellents on feral pigeons. Animals 4, 1–15.

STRINGHAM, S.A., E. E. MULROY, J. XING, D. RECORD, M. W. GUERNSEY, J. T. ALDENHOVEN, E. J. OSBORNE, M. D. SHAPIRO (2012): Divergence, convergence, and the ancestry of feral populations in the domestic rock pigeon. Curr. Biol. 22, 302–308.

TEFFO, T. R., G. FUSZONECKER, K. KATONA (2022): Testing pigeon control efficiency by different methods in urban industrial areas, Hungary. Biol. Futur. 73, 87–93.

TREVES, A., L. NOUGHTON-TREVES (2005): Evaluating lethal control in the management of human-wildlife conflict. In: People and wildlife, conflict or co-existence? (Woodroffe, R., S. Thiegood, A. Rabinowitz, eds.). Cambridge University Press, New York, USA.

VAN DER VEEN, I. T., L. E. SIVARS (2000): Causes and consequences of mass loss upon predator encounter: Feeding interruption, stress or fit-for-flight. Funct. Ecol. 14, 638–644.

VOLPONI, S. (1999): Reproduction of a newly established population of the Great Cormorant in northeastern Italy. Waterbirds, 22, 263-273.

WITKOWSKI, J. (1983): Population studies of the grey-lag goose *Anser anser* breeding in the Barycz valley, Poland. Acta Ornithol. 19, 179-216.

WORK, T. M., J. HALE (1996): Causes of owl mortality in Hawaii, 1992–1994. J. Wildl. Dis. 32, 266 – 273.

ZDUNIAK, P., J. Z. KOSICKI, B. GOŁDYN (2008): Un-paint it black: Avian prey as a component of the diet of nestling Hooded Crows *Corvus cornix*. Belgian J. Zool. 138, 85-89.

ZUBEROGOITIA, I., J. ZABALA, J. E. MARTÍNEZ (2018): Moult in birds of prey: a review of current knowledge and future challenges for research. Ardeola 65,183–207.

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 firts 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 assit. 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.