Living in the concrete jungle: a review and socio-ecological perspective of urban raptor habitat quality in Europe

Brandon Mak 1 · Robert A. Francis 1 · Michael A. Chadwick 1

Accepted: 21 January 2021 / Published online: 7 February 2021
© The Author(s) 2021

Abstract

Raptors can be important components of urban ecosystems due to their role as apex predators, the presence of which may bring benefits to people. Urban environments may provide good quality habitats, and the raptors’ ability to utilize resources found here can contribute to their success. However, urban environments are socio-ecological systems and such mechanisms shaping habitats and ecological resources therein are less understood. This paper explores how raptors utilize urban resources, and the socio-ecological processes influencing their quality and availability. It begins with a systematic mapping of the literature to summarize the utility of urban resources by raptors with European distributions. Eighteen species were documented in the literature successfully exploiting novel hunting and/or nesting opportunities in both green and built-up locations of urban areas. We discuss how these may be consequential of human activities, some of which intentionally provided as subsidies, and how their utility by raptors create opportunities for human-raptor interactions further shaping public perception and decisions which potentially affect the raptors. Finally, we demonstrate these concepts by drawing on our experience from an urban peregrine falcon (*Falco peregrinus*) conservation site in London, UK. The paper concludes with a call for urban raptor conservation and research to consider social and ecological aspects together, appropriately reflecting urban environments as socio-ecological systems.

Keywords  Socio-ecological systems · Human-animal interactions · Urban wildlife · Habitat use · Urban ecology

Introduction

Birds are important components of urban biodiversity (Wiklund 1982; Bogliani et al. 1999; Quinn and Kokorev 2002; Ueta 2007; Whelan et al. 2015), among which highly-abundant and synurbic species such as the common pigeon (*Columba livia*) are perhaps the clearest examples of birds that thrive in urban environments. Urban bird communities can also include raptors, which provide a suite of important ecosystem services. Raptor scavenging activity reduces the risk of disease transmission, bringing potential savings in healthcare costs (Markandya et al. 2008). Interactions with birds not only positively shape healthy human relationships and support human wellbeing (Wolch 1998; Fuller et al. 2007; Dallimer et al. 2012; Clayton and Myers 2015; Cox et al. 2017), but also the wellbeing of nature—charismatic raptors are often used as flagship species to attract resources in support of conservation programs (Clayton and Myers 2015; Donázar et al. 2016; Arent et al. 2018). The landscape of fear created by raptor predation limits prey activity and density (Abramsky et al. 1996; Preisser et al. 2005; Laundré et al. 2010; Kross 2012; Atkins et al. 2017). This form of natural pest control may be desirable to reduce maintenance costs associated with, for example, corrosive pigeon excrement (Solonen 2008; Pagel et al. 2018). These apex predators act as sentinels, indicating the health of an ecosystem through their relationship with other organisms. The absence of this group can lead to trophic cascades when food webs are modified as a result of altered predation pressure, evident in the density of synurbic or pest species found in cities (Mueller et al. 2016; Donázar et al. 2016).

Raptors historically cohabited alongside humans in towns and cities since the Medieval period (Donázar et al. 2016;
Bildstein and Therrien 2018) and their increasing use of current urban environments follows their global recovery from substantial population declines, despite urban environments traditionally considered by some to be poor quality, degraded habitats (Brown 1977; Bildstein et al. 1998; Thiollay 2006), partly due to the risk of chemical toxicity in the food chain (Hofer et al. 2010; Kekkonen et al. 2012; Elliott et al. 2015). However, higher raptor productivity here — although a simplistic measure that overlooks post-fledging survival — can indicate urban environments to be of better quality than less developed surrounding habitats (Newton 1998; Chace and Walsh 2006; Solonen 2008; Cooke et al. 2018; Kettel et al. 2018). The greater productivity has been attributed to their ability to exploit urban prey (Chace and Walsh 2006; Chamberlain et al. 2009; Jokimäki et al. 2016; Kettel et al. 2018), resulting in earlier or bigger clutches (Rutkowski et al. 2006; Solonen 2008), or higher fledging rates (Salvati et al. 2002; Rutkowski et al. 2006). The urban raptors’ choice of nest sites may also confer reproductive advantages (Chace and Walsh 2006; Papp 2011; Dykstra 2018; James Reynolds et al. 2019) and while typically novel or anthropogenic in nature, these sites can be more numerous and diverse with urbanisation (Mainwaring 2015).

Suitable nest sites and prey availability are typically considered to be the key determinants of successful raptor populations in urban environments (Solonen 2008; Newton 2010; Mannan and Steidl 2018), but urban ecosystems are socio-ecological systems (Francis and Chadwick 2013) and people can also influence raptor feeding and nesting opportunities. Some examples include religious practices subsidizing the diets of the thriving black kite (Milvus migrans) communities in Delhi, India, with food offerings (Kumar et al. 2019), pest control measures limiting the availability of rodents for red-tailed hawks (Buteo jamaicensis) in Philadelphia, USA (Hunold 2017), and sympathetic citizens protecting wild animals’ safe use of their breeding territories (Gullo et al. 1998; OtterWatch 2017; Hunold 2017; Darke 2017; Crowley et al. 2019). Given the roles raptors play, it is important to facilitate their conservation by appreciating the full range of resources and mechanisms supporting the needs of urban raptor populations. However, there is a gap in our understanding of the socio-ecological processes as these tend to be neglected in urban raptor research to date, apart from studies reporting antagonistic interactions such as aggression towards humans or illegal persecution of raptors (Galeotti 1994; Papp 2011; Cianchetti-Benedetti et al. 2016; Kunca and Yosef 2016). This is in line with a bias towards the exploration of human-wildlife conflict across wider literature despite socio-ecological processes encompassing more than antagonistic relationships (Gullo et al. 1998; Soulsbury and White 2015). Urban avian studies in general also tend to cover a broad range of species without a particular focus on raptors, while there is a geographical bias towards North American populations for urban raptor research (Bird et al. 1996; Poppleton 2016; Boal and

---

**Fig. 1** Foci of published urban raptor studies in Europe, with number of studies per country in brackets.
Dykstra 2018; Kettel et al. 2018). In this review, we ask: What urban resources do raptors in Europe use and how may their availability and quality (as indicated by the raptors’ productivity) be linked to socio-ecological mechanisms? To answer this, we use a systematic literature search to map the extent of our knowledge on the ecological requirements of urban raptors in Europe. We then demonstrate how socio-ecological processes may underpin the availability and quality of urban raptor habitat in our case study of urban peregrine falcon (Falco peregrinus) conservation in London, UK.

Fig. 2 Urban raptor nest habitats and types from literature reviewed. Open and cavity nests are found in trees in and out of green spaces, with different levels of human influence expected at each type of habitat. Raptors colonize buildings/structures with cavities/surfaces that are inherent or provided by people (e.g., nestboxes). Dotted lines indicate locations of tree nestboxes. Lineweights are commensurate with number of studies.
Fig. 3  Main diet components of urban raptors from literature reviewed. Most species feed primarily on prey types they specialize in hunting (black bars) but some have populations switching to non-traditional prey types (red bars).
Methods

Conceptual framework

This study takes a two-step approach utilizing a systematic mapping of literature and case study to answer our research question. The systematic mapping approach will first (1) highlight the raptor species that have been researched in urban environments, and then (2) outline their use of habitat components within the urban landscape to meet nesting and dietary needs. As human activity is likely to influence urban wildlife and their use of resources within these socio-ecological ecosystems (Hunold 2017; Khoo and Lee 2020), we will relate the urban raptors’ ecological resource use with the ecological and human dimension from within and without the reviewed literature. Secondly, everyday human-animal interactions may be key to some of these socio-ecological processes, in which human and nonhuman activity perpetuate feedback loops that influence the success of urban wildlife (Gullo et al. 1998; Belaire et al. 2016; Cianchetti-Benedetti et al. 2016; Hunold 2017; Crowley et al. 2019). Thus, we will explore the dynamics between human-raptor interactions and the quality of available resources through our case study of urban peregrine conservation at Charing Cross Hospital in London, UK.

Systematic mapping

While ‘raptors’ can be a specialized term used to describe Accipitriformes, Cathartiformes and Falconiformes, we use the term in a broader sense which includes Strigiformes as their nocturnal counterparts (sensu Chace and Walsh 2006; Campbell and Lack 2011; Boal and Dykstra 2018). We then identified 51 raptor species occurring in Europe as described in Voous and Thomson (1960) (see full list of species in Appendix 1 Table 1). For each species, we searched for literature on Web of Science (Core Collection) and Google Scholar using the terms ‘urban’ and the Latin binomial of the species (e.g. urban AND Falco peregrinus) as the topic. All records were considered, from the earliest articles incorporated in the databases (1900–2019). Our definition of urban raptors broadly includes species that utilize or dwell in urban environments (Fischer et al. 2015). We did not filter studies based on a singular definition of ‘urban’ and adopted the term as defined by the author(s) of each study which included both the built-up and green spaces contained within their study limits. Each study was scrutinized for (1) focal species, (2) topics covered and (3) study sites. Topics were categorized as ‘population’, ‘habitat’, ‘feeding/hunting’, ‘reproduction’ or ‘others’ to relate the raptors’ activities to their use of habitat features. Where more than one species/topic was discussed in an individual study, the article was counted twice. See Appendix 2 Table 2 for a full breakdown of topics covered. These studies were then used to summarize current knowledge of habitat use by raptors in urban environments.

Case study

To understand how raptor habitat may be intertwined with socio-ecological processes over time, we conducted qualitative research using a combination of online resources and field observations/surveys (Hunold 2017). We identified the presence of peregrine falcons nesting at Charing Cross Hospital and the group Fulham and Barnes Peregrines, or FaB Peregrines, which cares for them, through an internet search. FaB Peregrines is one of, but connected to a wider network of, many amateur naturalist groups in London engaging in such activities. Commentary on FaB Peregrines’ conservation-focused activities and the peregrines’ lives alongside online interaction with and amongst the public, albeit curated by their page owners, can be found on their social media pages (FaB Peregrines 2020a, b) which provided raw material needed for our qualitative analysis. We canvassed Facebook posts of the 2018 and ongoing 2019 breeding seasons and every blog entry, with the latter documenting activity since 2007. This allowed us to construct a timeline of the site, the group and the peregrines’ activities.

Once we were familiar with the key events prior to the ongoing breeding season through our review of the social

Fig. 4 Opaque film was fitted to Charing Cross hospital windows close to the nest to prevent the sight of people alarming the female peregrine. Photo: FaB Peregrines Facebook
media data, we concurrently conducted qualitative research in person on new events as they occurred and to reflect on past ones. To do so, we contacted FaB Peregrines to identify ourselves and express our research interests. We then joined the group as volunteers for their Fledgiewatch activities (when the group is most active) during the latter part of the 2019 breeding season (July and August) at Margravine Cemetery beside the hospital to conduct our field research. Field data collection involved unstructured interviews with the FaB Peregrines leader and two key members who provided information filling gaps in recent and older social media records (see Appendix 3). The interview process typically began with general questions about the peregrines’ and group’s recent activities occurring between our visits which we usually first learned of through their Facebook posts. This then led to spontaneous conversations on topics about the site and peregrines that we followed up with questions to seek their opinions on, whenever we felt their relevance to our research. We also observed spontaneous interactions between the group, other birders and non-birding members of the public which included hospital staff and visitors, a pigeon fancier and passersby who visited during Fledgiewatch while we were on site. While these interactions included people from a broad demographic range, the core members were of white British nationality (the most populous group in the Hammersmith and Fulham borough), and middle-aged or older (above the median age of 32 years among residents of the borough (ONS 2011)). We joined the group on site 2–4 days per week, lasting up to 4 h each time at a ‘regular spot’ in the cemetery from where we watched the peregrines. To encourage participants to speak and act freely, we tried to build rapport and appear less conspicuous as newcomers by (1) adopting the position of volunteer-first, researcher-second, (2) choosing unstructured interviews and (3) recording field notes from memory only at the end of each session. All raw material from social media, interview data and observations were manually coded according to the activity of humans or peregrines, together with participants’ sentiments towards the activity, which we organized in NVIVO 12 software (QSR International 2018). Data was collected under ethical approval from King’s College London (project reference: MRS-18/19–13,499).

Results

Raptors occurring in the urban environment

A total of 112 studies met the criteria for this review, with 18 species reported in urban environments across Europe (Fig. 1). These are the Bonelli’s eagle (Hieraaetus fasciatus), booted eagle (Hieraaetus pennatus), common buzzard (Buteo buteo), red kite (Milvus milvus), black kite (Milvus migrans), white-tailed Eagle (Haliaeëtus albicilla), northern goshawk (Accipiter gentilis, hereafter goshawk), sparrowhawk (Accipiter nisus), peregrine falcon (Falco peregrinus, hereafter peregrine), hobby (Falco subbuteo), common kestrel (Falco tinnunculus), lesser kestrel (Falco naumanni), barn owl (Tyto alba), Ural owl (Strix uralensis), tawny owl (Strix aluco), scops owl (Otus scops), long-eared owl (Asio otus), and little owl (Athene noctua). More European raptor species with urban populations are likely to exist beyond the English language publications considered in this review or have not been the focus of research. In the studies we reviewed, the following topics were discussed: population (33 studies), habitat (29 studies), feeding/hunting (56 studies), reproduction (23 studies), and others (15 studies) (refer to Appendix 2 Table 2 for a full breakdown of studies).

Nest sites Of 112 papers incorporated in the systematic mapping exercise, 40 contained information on raptor nesting sites. Twenty-one papers recorded 7 raptor species nesting in trees found in green space (urban woodland, parks, cemeteries, gardens and allotments) or beside streets, while 20 recorded 7 raptor species nesting within anthropogenic structures (e.g. monuments, rooftops, building openings, chimneys, attics, wall cracks, flowerpots, nestbox/trays; summarized in Fig. 2). Both types of sites support the breeding requirements of open and cavity nesters. In trees, open nests were predominantly used by hawk species (goshawks, sparrowhawks, red kites), while cavities – both naturally-occurring and those provided by nestboxes – were occupied by owls (tawny, scops, long-eared and little owls). Similarly, cavities in anthropogenic structures were mainly used by owls (barn, scops, little and tawny owls), both spontaneously and encouraged, while open nests here were mostly used by peregrines. Some cavity nesters (little, scops and tawny owls) were more flexible, occupying holes in trees and human structures.

These nesting opportunities highlighted by the raptors’ site selection may be attributed to a combination of factors: the presence of other urban dwelling species, nesting ecology of the raptors, human activity and urban planning policies. Breeding birds in urban areas increase nesting opportunity for raptors by building nests which the raptors may later occupy. Common kestrels, long-eared and scops owls are some raptors observed in the literature usurping corvid or passerine nests in trees and buildings (Marchesi and Sergio 2005; Dziemian et al. 2012; Lövy and Riegert 2013; Sumasgutner et al. 2014b). Further nesting opportunities arise as a consequence of human activity, most clearly through the placement of nestboxes in buildings and trees (Fig. 2), but also indirectly through historical building preservation and citizens’ biophilic tendencies. For example, the densest common kestrel population in Europe is attracted by the high nest availability within Vienna’s urban core of historical architecture and window planters of residential blocks (Sumasgutner et al. 2014b). Similarly, peregrines, common
kestrels, lesser kestrels, barn owls and scops owls tend to be found breeding in towers of churches and cathedrals which have architectural features supporting the raptors’ needs (Tella et al. 1996; Negro et al. 2000; Taylor 2003; Marchesi and Sergio 2005; Drewitt and Dixon 2008; Sumasgutner et al. 2014b). Imprinted offspring raised at these sites may subsequently seek out similar nest sites of their own post-fledging, in a perpetual selection of these habitat types (Larson 2004; Sielicki and Sielicki 2009). The consequential inflation of nesting opportunities owing to the ecology of urban commensal avifauna and human preferences is particularly beneficial to falcons and owls since they do not construct nests, opportunistically occupying suitable sites in the landscape instead (Newton 2010). Incidentally, qualities of anthropogenic nests may be superior to more natural ones. Human-made materials are likely to better withstand degradation from natural processes (e.g. entrance enlargement by ring-necked parakeets (Psittacula krameri) (Orchan et al. 2013)), remaining viable for longer periods. Higher elevations typical of urban nests also make them less accessible to terrestrial predators (Tella et al. 1996; Negro et al. 2000; Charter et al. 2007) or recognizable (Fargallo et al. 2005; Drewitt and Dixon 2008; Sumasgutner et al. 2014b). Additionally, nestboxes can be designed to increase reproductive success by limiting egg-rolling (Bird et al. 2018) and predation (Bailey and Bonter 2017). Finally, urban raptor site selection may be influenced by policies targeting human wellbeing. Urban green spaces designated for recreational use are unlikely to experience intensive disturbance and can provide refugia for wildlife (Khoo and Lee 2020). Raptors may be drawn to urban woodlands where nesting conditions are more stable compared to rural sites which may be used for forestry (Solonen 2008), while owls may select urban parks sheltering them from external noise pollution (Fröhlich and Ciach 2018, 2019).

The greatest number of studies, and species recorded therein, occurred in parks (15 studies, 7 species) and within spontaneously colonized anthropogenic structures (12 studies, 7 species) (Fig. 2). While indicating the sites’ importance to breeding raptors, it potentially reflects a bias in sampling effort arising from their accessibility to the researchers and public as most of the studies required either physical inspection of the nest sites or for observations to be made from accessible locations (Rutz 2008; Sumasgutner et al. 2014b; Fröhlich and Ciach 2019). Raptors nesting around areas highly frequented by people, whether they are in green spaces or “out of place”, are likely to draw citizens’ attention (Philo and Wolch 1998; Khoo and Lee 2020), making them vulnerable to human disturbance (Chace and Walsh 2006; Sorace and Gustin 2010). However, their lower aggression suggests human-raptor interactions, while prevalent, are tolerable for the birds (Rutz 2003a; Dravecký and Obuch 2009; Papp 2011). This coexistence may be due to the tendency for regular users of green space to be more sensitive towards the nonhuman inhabitants of such areas (Clayton and Myers 2015). Additionally, the prevalence of raptors allowed to remain in anthropogenic sites – building openings, monuments or flowerpots unintended for nesting, where raptors culturally do not belong – as opposed to being flushed out by people, together with the provision of nestboxes, suggest that the collective extension of goodwill from citizens, or at least their indifference towards the raptors, is potentially driving the availability of suitable nest sites (Mainwaring 2015; Hulold 2017; James Reynolds et al. 2019). Such a link between public sentiment towards urban avifauna in general and providing for them is already evident in the popularity of household nestboxes (Gastone et al. 2005). Actions that encourage raptor persistence in human spaces will reinforce opportunities for interactions across species (Clayton and Myers 2015; Bélaire et al. 2015, 2016). These in turn reconnect urban citizens with nature, as we undergo an extinction of experience whereby succeeding human generations grow up in a world lacking particular species, communities or ecological conditions (Soga and Gastone 2016). Such interactions are crucial for engendering public support for broader urban biodiversity conservation (Miller 2005; Soga and Gastone 2016; James Reynolds et al. 2019). Therefore, urban raptor persistence requires their nest sites to be ecologically suitable and for their presence to be culturally accepted (Johnson 2014), which we will demonstrate in our case study.

**Foraging sites** Urban raptors forage inside green spaces (8 studies, 7 species) and outside of it (8 studies, 5 species). Green spaces include cemeteries, ruins, gardens and playing fields which are analogous to natural open hunting grounds commonly used by barn owls, tawny owls, long-eared owls and little owls (Goszczyński et al. 1993; Salvati et al. 2002; Kitowski and Grzywaczewski 2010; Szép et al. 2018). Even in built-up areas, raptors do not need to spend much time finding prey, reflecting the ease at which they can hunt (Rutz 2006). A number of factors may contribute to their use of such sites and the accessibility of prey.

Buildings provide vantage points (or perches) from which prey can be easily spotted, while concealing raptors on the move from their targets. This element of surprise leads to significantly greater hunting success (Rutz 2004, 2006) and is evident in the adoption of perch-hunting techniques among raptors which do not traditionally hunt this way (Kühler et al. 2005; Mikula et al. 2013; Time 2016). Artificial illumination can help raptors locate their prey at night, while allowing the predators to remain hidden (Negro et al. 2000; Rejt 2001; Vrezec 2001; Rutz 2006; Johnson 2014). The consistent hunting opportunities associated with these features may lead to their adoption within the raptors’ habits. Lesser kestrels cease hunting and roost only after building lights are turned off (Negro et al. 2000), which highlights how raptor activity can become intertwined with ours when human activities or preferences strongly influence their prey communities. Artificial illumination attracts assemblages of bats, insects and
birds (Negro et al. 2000; Rejt 2001; Vrezec 2001; Rutz 2006), similarly with garden birdfeeders and skyscraper greenery attracting songbirds (Cannon et al. 2005; Fuller et al. 2008; Belcher et al. 2018), and consequently their predators. This may underlie common kestrels’ preference for nesting in buildings close to green backyards, where they can prey on visiting songbirds (Sumasgutner et al. 2014b). Furthermore, our idealisations of nature, manifesting in routine grass trimming, make hidden prey more accessible for the raptors hunting in green recreational spaces such as playing fields (Kitowski and Grzywaczewski 2010). However, human food subsidies can contribute to the use of urban environments even amongst non-resident raptors. For example, a substantial portion of red Kites in Reading, UK are supported by sympathetic individuals feeding them in private gardens (Orros and Fellowes 2015). This is in line with general bird feeding being one of the most popular forms of human-wildlife interactions in urban environments, benefitting humans and birdlife (Fuller et al. 2008), as may religious practices that leave food offerings consumed by wild raptors (Kumar et al. 2019). Raptors may also be foraging where human food waste is consistently available (Kübler et al. 2005). The viability of urban foraging sites however requires tolerance for the inconveniences accompanying their usage, especially in areas highly frequented by people. Discarded food and prey remains may be deemed unsightly while the sight of prey being killed and dismembered can be disturbing to onlookers increasingly unaccustomed to such processes (Miller 2005; Rutz et al. 2006a). Additionally, the act of feeding wild raptors, regardless of its benefits may come with social or legal ramifications that need to be overcome by individuals (Jones and Howard 2006; Jones and Reynolds 2008). Therefore, like their nest sites, raptor feeding opportunities can be entangled with human activities and once apparent their availability may be influenced by social norms.

Prey Urban raptors consume various types of prey. Of 112 papers, 22 recorded mammals as the primary prey (5 species), 22 recorded mainly birds (7 species) and 5 found mainly insects (3 species) (Fig. 3). Three species had multiple dominant prey types, including ones not traditionally taken, while one species was recorded primarily consuming non-traditional prey (Fig. 3). Their dietary breadths are narrow and skew towards the abundant commensal species available in cities (Manganaro et al. 2001; Rutz et al. 2006a). Among them are common urban dwelling birds which have become an important component of their diets, taken even by species specialized in hunting other types of prey (Fig. 3). The literature we reviewed indicate that among urban raptors which have birds as their numerically dominant prey, house sparrows (Passer domesticus) are the most frequently taken among common kestrels, comprising 13.1–73.9% of diets (Yalden 1980; Salvati et al. 1999; Piattella et al. 1999; Kübler et al. 2005); 53% for hobbies, (Fiuczynski and Soemmer 2000); 22.1% for sparrowhawks (Frimer 1989a); and 25.4–88.7% for tawny owls (Goszczyński et al. 1993; Gryz and Krauze-Gryz 2019). Similarly, feral pigeons (Columba livia domestica) are the most frequent avian prey in some populations of tawny owls, forming 18.1% of their diets (Galeotti et al. 1991); 36.4% for goshawks (Rutz 2004); and 30.4–80% for peregrines (Rejt 2001; Serra et al. 2001; Leonard and Mannino 2007; Drewitt and Dixon 2008; Johnson 2014).

These commensal avian prey supplies are more stable throughout the year, with their availability fluctuating less than other prey types (Goszczyński et al. 1993; Riegert et al. 2007b; Solonen and Ursin 2008; Riegert and Fuchs 2011), and can provide alternatives in the absence of traditional prey (Zalewski 1994; Dravecký and Obuch 2009; Kreiderits et al. 2016). However, their predation of urban birds may not be benign. These prey may be not be optimal, considering their lower nutritional value (Liker et al. 2008; Sumasgutner et al. 2014a; López 2017) and difficulty of capture for maladapted or inexperienced raptors (Krone et al. 2005; Kunca et al. 2015). Furthermore, they may carry disease (Krone et al. 2005; Kunca et al. 2015) or contain heavy metals (Hofer et al. 2010; Kekkonen et al. 2012). Diurnal raptors preying on rodents, especially rats, face reduced prey availability due to their nocturnal activity combined with suppression from effective pest control measures which also expose raptors to secondary poisoning risks (Sumasgutner et al. 2014a; Hunold 2017; Lohr 2018). These have fitness costs on breeding raptors, and can turn habitats into population sinks (Sumasgutner et al. 2014a). Raptor predation takes on a social dimension when their lethality becomes apparent. Negative sentiment can be provoked by the raptors’ indiscriminate predation on financially or culturally valuable animals. Depredation of ornamental fish and house sparrows, which are in decline, are some examples we found in the literature reviewed that may be unpopular or escalate conflict (Bell et al. 2010; Mester and Mérő TO 2018). While their ability to control feral pigeon populations may bring welcomed benefits to some (Solonen 2008; Pagel et al. 2018), their inability to discern feral and racing pigeons has become contentious among others, leading to much attention on the subject (Rutz et al. 2006a; UK Raptor Working Group 2019). Similarly, synurbic species provide many urban citizens most of their daily contact with nature which they may become attached to (Bell et al. 2010; Francis and Chadwick 2013; Crowley et al. 2019), and witnessing harm to these individual animals as a result of predation may make the raptors unpopular. These dynamics shape support for provisions or activities that influence habitat quality which will be demonstrated in the next section.

Implications for breeding site quality from human-raptor entanglements: an urban peregrine case study.

Situated close to a large cemetery, wetlands and the River Thames which provide plenty of foraging opportunities,
London’s Charing Cross hospital could be considered an ecologically stable, high quality habitat for breeding peregrines with 16 young having successfully fledged from its roof since the arrival of its first pair in 2007. However, closer scrutiny into the history and workings of the site reveals the many socio-ecological mechanisms involved in its making. Initial attempts at nesting by the peregrines on the hospital’s roof ledge failed, as although the ledge appeared structurally suitable, it was vulnerable to heavy rainfall. This prompted FaB Peregrines to facilitate the installation of a bespoke nestbox in 2010. The peregrines’ acceptance of this human provision, intended to improve the poor breeding conditions that would have otherwise turned this site into an ecological trap, led to the resident pair’s consistent breeding success in subsequent years. However, this process was not straightforward – accepting (and encouraging) peregrines breeding on their roof meant the hospital ceded their rights to part of their property under conservation legislation (Wildlife and Countryside Act 1981) for the duration of the peregrines’ persistence, which can be antagonizing – and FaB Peregrines needed to mediate on behalf of the resident falcons as their de facto representatives given their ecological expertise.

Conditions constantly evolve and common across groups caring for wildlife is the ability to detect potential risks emerging in the landscape apparent only to the animals (Hunold 2017; Darke 2017). Using their intimate familiarity with the falcons’ routines, FaB Peregrines “thinks like a peregrine” when interpreting behavioral cues unusual to the falcons’ daily patterns, in order to identify potential threats (Wolch 1998). For example, in 2019 the group observed how a new female falcon which had arrived late in the breeding season was poorly habituated to human activity within the building and was frequently provoked by the sight of hospital staff seen through windows close to its nest. FaB Peregrines conveyed the falcon’s alarm to the hospital, which eventually led to the offending windows being modified to obstruct its view (Fig. 4), and the distress stopped – a compromise allowing the needs of both peregrines and humans to be met without detriment to each other had been found. The group’s deep knowledge of the peregrines’ ecology stems from their routine monitoring of the resident falcons throughout the year, using CCTV’s installed around the nest and also from the ground with binoculars and telescopes. This vigilance combined with help elicited from the public through posters and social media allows inexperienced juveniles that become grounded or trapped in obstacles during fledging season to be rapidly located and returned to the nest before they are taken by potential predators.

Acts of passive animal watching by individuals growing into extensive networks of enthusiasts actively entangled in their natural processes have been similarly documented elsewhere (Hunold 2017; Darke 2017; Khoo and Lee 2020). Such everyday engagements with the peregrines, from casual bird watching to intervening in potentially life-threatening events for the falcons, emotionally bond the human attendants to peregrines and keep the community cohesive (Crowley et al. 2019). Even for passive observers, the common sight (and sound) of peregrines from within the hospital, together with FaB Peregrines’ presence standing in as their proxy, elevate the peregrines’ profile amongst hospital staff, for many of whom the raptors have become a desired element of the work environment and embedded in their identities. We were approached by staff on their way to and from work to check in on the peregrines or share personal sightings, during which we were made aware of peregrine-themed social events at work. Their popularity may have contributed to the willingness of the building managers to accept accommodations benefitting the peregrines but yield no tangible returns for the hospital. More importantly, affection for the resident peregrines may provide them additional protection (Crowley et al. 2019), as hospital staff have previously helped stop suspected illegal persecution attempts.

However, as we have discussed throughout the paper, some elements of the peregrines’ activities may not be universally welcomed. For building managers, the legislation protecting raptors from disturbance during the breeding season – which FaB Peregrines monitors compliance of – introduces obstacles for access to, and use of, the roof for substantial periods, imposing potential operational and financial challenges on the hospital. As recounted in the blogpost titled History – Oct 2007 to Sep 2011 (FaB Peregrines 2012), these restrictions initially dampened the hospital’s willingness to cooperate with FaB Peregrines (and therefore accommodate the raptors’ needs). Additionally, the hospital may become a contested site when facing pressure from external actors negatively impacted by the presence of peregrines, with negative exposure challenging their readiness to host peregrines thus undermining the stability of the habitat (Peregrine Network, personal communication). Pigeon racing groups, or pigeon fanciers, are one such group that views raptors as a threat due to their perceived risk of depredation, despite actual losses from peregrines being relatively minor (Rutz et al. 2006a; UK Raptor Working Group 2019), and are opposed to urban raptor conservation to protect their interests (Raptor Alliance 2012; UK Raptor Working Group 2019). We observed this hostility towards peregrine conservation when pigeon fanciers disparaged the FaB Peregrines community on Facebook (which led to censoring en masse) and in person as we were conducting our fieldwork. Pigeon fanciers’ activities share many similarities with that of other animal interest groups (e.g. Gullo et al. 1998; Hunold 2017; Crowley et al. 2019), namely engaging the public through advocacy work favorable to their cause but detrimental to urban raptor populations in general. This includes lobbying and support for culling of antagonistic raptors (e.g. Pigeon Racing UK and Ireland 2019; Royal Pigeon Racing Association 2019), as well as efforts to erode the popularity of peregrines which have led to the removal of nestboxes at other host sites (Peregrine Network, personal communication). While
not yet apparent, potential conflicts may emerge in the future from the peregrines’ ongoing predation of other sensitive or charismatic species, such as house sparrows which are facing population declines (Bell et al. 2010) or parakeets (the preferred prey of the current breeding peregrine pair at Charing Cross hospital – FaB Peregrines community leader, pers. comm.) which also have dedicated interest groups of their own internationally (Crowley et al. 2019). The responses of these actors will dynamically shape the life chances of predator and prey, legally or otherwise, and require careful management. In these ways, the quality of the peregrines’ habitat, as indicated by their ability to persist and raise successive broods here, is the product of ecological viability consequential of urbanization and a human dimension which includes the efforts of social networks motivated by collective experiences and perceptions of the peregrines alongside the normative laws governing human activity (Gullo et al. 1998; Bélaire et al. 2016; Hunold 2017; Crowley et al. 2019; Khoo and Lee 2020).

**Conclusion**

In this paper, we have identified the habitat components and resources commonly found in urban environments across European cities utilized by raptor populations to breed and/or feed. We have found that these features tend to be primarily intended for human use but are also capable of being exploited by opportunistic raptors. Suitable nest sites can be found in buildings and trees (themselves located in both built-up areas and green spaces), within which the presence of pre-built nests are especially useful to the secondary nesting owl and falcon species (Newton 2010). In addition to the nesting opportunities, the anthropogenic objects or structures found therein provide novel hunting opportunities which the predatory birds use to their advantage when seeking out (the usually abundant urban dwelling) prey. However, many of their activities may be responses to human actions, or vice versa, potentially creating feedback loops (e.g. use of nestboxes and food provided by humans; people respond to predation by persecution) (Clayton and Myers 2015; Bélaire et al. 2016). As urban environments are socio-ecological systems it is inadequate to analyze ecological and social aspects of the raptors’ habitat decoupled from each other, particularly given the proximity at which humans and raptors live that result in their entanglements (Francis and Chadwick 2013; Soulsbury and White 2015). As we have demonstrated in our case study, Charing Cross hospital exemplifies the extent to which the quality of the raptors’ breeding habitat is one that is continually shaped by the diverse interests of human citizens and resident peregrines (through their attendants), intentionally or otherwise, and that human-raptor interactions arising from shared use of urban spaces motivate specific decisions influencing the quality of the habitat. While this is rarely reflected in the literature we have reviewed, the socio-ecological processes that make Charing Cross hospital an ideal habitat for breeding raptors is not unique. Compassionate human groups are known to actively engage in activities that improve the survival of urban wildlife, even if their presence and activities are polarizing (Gullo et al. 1998; Hunold 2017; Crowley et al. 2019; Khoo and Lee 2020). These examples highlight the potential for human-animal interaction to positively contribute to the success of raptors in urban environments through their resource use/availability but are difficult to quantify, as reflected in the bias towards human-animal conflicts in research (Soulsbury and White 2015). As conservation efforts shift towards the adoption of reconciliation ecology in cities (Rosenzweig 2003; Francis and Lorimer 2011), resulting in human and animal biomes becoming intertwined, we stress the importance of assessing these habitats ecologically and socially in tandem. Others have already illustrated how the efforts of individual citizens, whether disparately or collectively, incite broader impacts at the population scale, and their contribution whether as resource managers or spokespeople/informal conservationists should be recognized (Bélaire et al. 2016; Hunold 2017; Crowley et al. 2019). Communities like FaB Peregrines are important not only for their tangible contributions to improving breeding sites and arresting raptor mortality, but also for their public-facing role as accessible intermediaries between the wild raptors and bewildered citizens. Their in-depth vernacular knowledge of the biology and movements of local populations can complement i) expert research activities limited by challenges in collecting field data and, ii) the suite of existing technocratic urban wildlife conservation initiatives (Sielicki and Sielicki 2009; Soulsbury and White 2015).

**Acknowledgements** The authors would like to acknowledge four anonymous reviewers for their helpful comments that greatly improved early versions of the paper. We would also like to thank the volunteers of FaB Peregrines for the work they do and Nathalie Mahieu for being so welcoming, for without whom this research would not have been possible.

**Availability of data and materials** Systematic mapping and semi-structured interview data are available on request: contact corresponding author.

**Authors’ contributions** BM, RF and MC conceived the research; BM collected and analysed the data; and BM, RF and MC wrote the paper.

**Funding** No funding was received in support of this research.

**Declarations**

**Ethics approval and consent to participate** Data was collected under ethical approval from King’s College London (project reference: MRS-18/19–13,499) which conforms to standards of the UK ESRC.

**Consent for publication** All authors give their consent for publication.

**Competing interests** The authors have no conflicts of interest to declare.
### Table 1 European raptors. Bolded species have urban populations

| Family               | Species                      | Family               | Species                      |
|----------------------|------------------------------|----------------------|------------------------------|
| Accipitridae         | Egyptian Vulture Neophron percnopterus | Accipitridae         | Sparrowhawk Accipiter nisus  |
| Accipitridae         | Griffon Vulture Gyps fulvus   | Accipitridae         | Levant Sparrowhawk Accipiter badius |
| Accipitridae         | Black Vulture Aegypius monachus | Falconidae           | Gyr Falcon F. rusticolus      |
| Accipitridae         | Bearded Vulture Gypaëtus barbatus | Falconidae           | Saker Falcon F. cherrug       |
| Accipitridae         | Golden Eagle Aquila chrysaëtos | Falconidae           | Lanner Falcon F. biarmicus    |
| Accipitridae         | Tawny Eagle Aquila rapax      | Falconidae           | Peregrine Falcon F. peregrinus |
| Accipitridae         | Imperial Eagle Aquila heliaca  | Falconidae           | Eleonora’s Falcon F. eleonora  |
| Accipitridae         | Spotted Eagle Aquila clanga    | Falconidae           | Hobby F. subbuteo             |
| Accipitridae         | Lesser Spotted Eagle Aquila pomarina | Falconidae           | Merlin F. columbarius         |
| Accipitridae         | Bonelli’s Eagle Hieraaëtus fasciatus | Falconidae           | Red-footed falcon F. vespertinus |
| Accipitridae         | Booted Eagle Hieraaëtus pennatus | Falconidae           | Kestrel F. tinnunculus        |
| Accipitridae         | Short-toed Eagle Circaëtus gallicus | Falconidae           | Lesser Kestrel F. naumann     |
| Accipitridae         | Rough-legged Buzzard Buteo lagopus | Tytonidae           | Barn Owl Tyto alba             |
| Accipitridae         | Buzzard Buteo buteo          | Strigidae            | Eagle Owl Bubo babo           |
| Accipitridae         | Long-legged Buzzard Buteo rufinus | Strigidae           | Snowy Owl Nyctea scandiaca    |
| Accipitridae         | Red Kite Milvus milvus        | Strigidae            | Great Grey Owl Strix nebulosa  |
| Accipitridae         | Black Kite Milvus migrans    | Strigidae            | Ural Owl Strix uralensis      |
| Accipitridae         | Black-winged Kite Elanus caeruleus | Strigidae           | Tawny Owl Strix aluco         |
| Accipitridae         | White-tailed Eagle Haliaeëtus albicilla | Strigidae           | Scops Owl Otus scops          |
| Accipitridae         | Palla’s Sea Eagle Haliaeëtus leucoryphus | Strigidae           | Long-eared Owl Asio otus      |
| Accipitridae         | Honey Buzzard Pernis apivorus | Strigidae            | Short-eared Owl Asio flammeus  |
| Accipitridae         | Marsh Harrier Circus aeruginosus | Strigidae           | Tengmalm’s Owl Aegolius funereus |
| Accipitridae         | Hen Harrier Circus cyaneus   | Strigidae            | Hawk Owl Surnia ulula         |
| Accipitridae         | Pallid Harrier Circus macrourus | Strigidae           | Pygmy Owl Glaucidium passerinum |
| Accipitridae         | Montagu’s Harrier Circus pygargus | Strigidae           | Little Owl Athene noctua      |
| Accipitridae         | Goshawk Accipiter gentillis  |                      |                              |
## Appendix 2

### Table 2  Topics discussed in literature reviewed

| Species               | Location                  | Population | Reproduction | Habitat | Feeding/hunting | Others | Reference                                      |
|-----------------------|---------------------------|------------|--------------|---------|-----------------|--------|------------------------------------------------|
| Bonelli’s Eagle       | Aragon (Spain)            | ✓          |              |         |                 |        | Martínez-Miranzo et al. (2016)                |
| Booted Eagle          | Madrid (Spain)            | ✓          |              |         |                 |        | Palomino and Carrascal (2007)                |
| Buzzard               | Wroclaw (Poland)          | ✓          |              |         |                 |        | Kopij (2018)                                  |
|                       | Various (Spain)           | ✓          |              |         |                 |        | Patón et al. (2012)                          |
| Red Kite              | Saxony-Anhalt (Germany)   | ✓          | ✓            |         |                 |        | Nicolai et al. (2017)                        |
|                       | Reading (UK)              | ✓          |              | ✓       |                 |        | Orros and Fellowes (2015)                    |
| Black Kite            | Various (Spain)           | ✓          |              |         |                 |        | Patón et al. (2012)                          |
| White-tailed Eagle    | North Podlasie Region (Poland) | ✓       |              |         |                 |        | Jankowiak et al. (2015)                      |
| Goshawk               | Wroclaw (Poland)          | ✓          |              |         |                 |        | Kopij (2018)                                  |
|                       | North Podlasie Region (Poland) | ✓       |              |         |                 |        | Rutz et al. (2006b)                          |
|                       | Cologne (Germany)         | ✓          |              | ✓       |                 |        | Rutz et al. (2005)                           |
|                       | Berlin (Germany)          | ✓          |              | ✓       |                 |        | Rutz et al. (2006)                           |
|                       | Hamburg (Germany)         | ✓          |              | ✓       |                 |        | Rutz (2003a)                                  |
|                       |                           | ✓          |              | ✓       |                 |        | Rutz (2003b)                                  |
|                       |                           | ✓          |              | ✓       |                 |        | Rutz et al. (2004)                           |
|                       |                           | ✓          |              | ✓       |                 |        | Rutz (2005)                                   |
|                       |                           | ✓          |              | ✓       |                 |        | Rutz (2006)                                   |
|                       |                           | ✓          |              | ✓       |                 |        | Rutz (2012)                                   |
|                       |                           | ✓          |              | ✓       |                 |        | Rutz et al. (2004)                           |
|                       |                           | ✓          |              | ✓       |                 |        | Rutz et al. (2006a)                          |
|                       |                           | ✓          |              | ✓       |                 |        | Solonen (2008)                                |
|                       |                           | ✓          |              | ✓       |                 |        | EK et al. (2004a)                             |
|                       |                           | ✓          |              | ✓       |                 |        | EK et al. (2004b)                             |
|                       |                           | ✓          |              | ✓       |                 |        | Frimer (1989a)                                |
|                       |                           | ✓          |              | ✓       |                 |        | Frimer (1989b)                                |
|                       |                           | ✓          |              | ✓       |                 |        | Kunca et al. (2015)                           |
|                       |                           | ✓          |              | ✓       |                 |        | Kunca and Yosef (2016)                        |
|                       |                           | ✓          |              | ✓       |                 |        | Kunca et al. (2015)                           |
|                       |                           | ✓          |              | ✓       |                 |        | Papp (2011)                                   |
|                       |                           | ✓          |              | ✓       |                 |        | Mester and Merő TO (2018)                     |
|                       |                           | ✓          |              | ✓       |                 |        | Jankowiak et al. (2015)                      |
|                       |                           | ✓          |              | ✓       |                 |        | Kopij (2018)                                  |
|                       |                           | ✓          |              | ✓       |                 |        | Biaduň (2006)                                 |
|                       |                           | ✓          |              | ✓       |                 |        | Biaduň and Zmihorski (2011)                   |
|                       |                           | ✓          |              | ✓       |                 |        | Schütz and Schulze (2018)                    |
|                       |                           | ✓          |              | ✓       |                 |        | Patón et al. (2012)                          |
|                       |                           | ✓          |              | ✓       |                 |        | Thornton et al. (2017)                       |
|                       |                           | ✓          |              | ✓       |                 |        | Drewitt and Dixon (2008)                     |
|                       |                           | ✓          |              | ✓       |                 |        | Johnson (2014)                                |
|                       |                           | ✓          |              | ✓       |                 |        | Kettel et al. (2016)                          |

© Springer
### Table 2 (continued)

| Species          | Location                        | Population | Reproduction | Habitat | Feeding/hunting | Others | Reference                                      |
|------------------|---------------------------------|------------|--------------|---------|----------------|--------|------------------------------------------------|
| Peregrine        | Various (UK)                    | ✓          | ✓            |         |                |        | Wilson et al. (2018)                           |
|                  | Warsaw (Poland)                 |            |              |         |                |        | Rejt (2001)                                    |
|                  | Wrocław (Poland)                | ✓          |              |         |                |        | Rejt (2003)                                    |
|                  | Warsaw, Kraków (Poland)         | ✓          |              |         |                |        | Sielicki and Sielicki (2009)                   |
|                  | Bryne (Finland)                 | ✓          |              |         |                |        | Time (2016)                                    |
|                  | Göteborg (Sweden)               | ✓          |              |         |                |        | Ek et al. (2004a)                              |
|                  | Florence (Italy)                | ✓          |              |         |                |        | Serra et al. (2001)                            |
|                  | Sicily (Italy)                  | ✓          |              |         |                |        | Leonard and Mannino (2007)                     |
| Hobby            | Berlin (Germany)                |            |              |         |                | ✓      | Fiuczynski and Soemmer (2000)                  |
| Common Kestrel   | Wrocław (Poland)                | ✓          |              |         |                |        | Kopij (2018)                                   |
|                  | Warsaw (Poland)                 | ✓          |              |         |                |        | Rejt (2006)                                    |
|                  |                                 |            |              |         |                | ✓      | Rejt et al. (2000)                             |
|                  |                                 |            |              |         |                | ✓      | Rejt et al. (2004)                             |
|                  |                                 |            |              |         |                | ✓      | Rejt et al. (2005)                             |
|                  |                                 |            |              |         |                | ✓      | Rejt and Raczycska (2003)                      |
|                  |                                 |            |              |         |                | ✓      | Romanowski (1996)                              |
|                  |                                 |            |              |         |                | ✓      | Rutkowski et al. (2006)                        |
|                  |                                 |            |              |         |                | ✓      | Rutkowski et al. (2010)                        |
|                  |                                 |            |              |         |                | ✓      | Kubacka et al. (2010)                          |
|                  |                                 |            |              |         |                | ✓      | Žnihorski and Rejt (2007)                       |
|                  | North Podlasie Region (Poland)  | ✓          |              |         |                |        | Jankowiak et al. (2015)                        |
|                  | Various (Poland)                | ✓          |              |         |                |        | Boratyński and Kasprzyk (2005)                 |
|                  | Bardejov (Slovakia)             | ✓          |              |         |                |        | Mikuła et al. (2013)                           |
| Common Kestrel   | Milan (Italy)                   | ✓          |              |         |                |        | Belcher et al. (2018)                          |
|                  | Rome (Italy)                    | ✓          |              |         |                |        | Fattorini et al. (1999)                        |
|                  |                                 | ✓          |              |         |                |        | Fattorini et al. (2001)                        |
|                  |                                 | ✓          |              |         |                |        | Kečkešová and Noga (2008)                      |
|                  |                                 | ✓          |              |         |                |        | Piatella et al. (1999)                         |
|                  |                                 | ✓          |              |         |                |        | Salvati (2002)                                 |
|                  |                                 | ✓          |              |         |                |        | Salvati et al. (1999)                          |
|                  |                                 | ✓          |              |         |                | ✓      | Kühler et al. (2005)                           |
|                  | Berlin (Germany)                | ✓          |              |         |                | ✓      | Riegert (2007a)                                |
|                  | České Budějovice (Czech Rep.)   | ✓          |              |         |                | ✓      | Riegert et al. (2007b)                         |
|                  |                                 | ✓          |              |         |                | ✓      | Riegert et al. (2009)                          |
|                  |                                 | ✓          |              |         |                | ✓      | Riegert et al. (2010)                          |
|                  |                                 | ✓          |              |         |                | ✓      | Riegert and Fuchs (2004)                       |
|                  |                                 | ✓          |              |         |                | ✓      | Riegert and Fuchs (2011)                       |
|                  | Vienna (Austria)                | ✓          |              |         |                | ✓      | Kreiderits et al. (2016)                       |
|                  |                                 | ✓          |              |         |                | ✓      | Sumasgutner et al. (2014a)                     |
|                  |                                 | ✓          |              |         |                | ✓      | Sumasgutner et al. (2014b)                     |
|                  |                                 | ✓          |              |         |                | ✓      | Sumasgutner et al. (2018)                      |
|                  | Various (Spain)                 | ✓          |              |         |                |        | Patón et al. (2012)                            |
| Species       | Location                      | Population | Reproduction | Habitat | Feeding/hunting | Others | Reference                      |
|--------------|-------------------------------|------------|--------------|---------|-----------------|--------|--------------------------------|
| Lesser Kestrel | Manchester (UK)               | ✓          | ✓            | ✓       |                 | ✓      | Yalden (1980)                  |
| Lesser Kestrel | Bari, Taranto (Italy)         | ✓          | ✓            | ✓       |                 | ✓      | Bux et al. (2008)              |
|               | Andalusia (Spain)             | ✓          |              | ✓       |                 | ✓      | Bustamante (1997)              |
|               | Seville (Spain)               | ✓          |              | ✓       |                 | ✓      | Negro et al. (1991)            |
|               | Castroviejo, Guadiana (Spain) | ✓          |              | ✓       |                 | ✓      | Negro et al. (2000)            |
|               | Andalusia (Spain)             | ✓          |              | ✓       |                 | ✓      | Rodríguez et al. (2013)        |
|               | Seville, Aragon (Spain)       | ✓          |              | ✓       |                 | ✓      | Tella et al. (1996)            |
| Barn Owl      | Rome (Italy)                  | ✓          |              | ✓       |                 | ✓      | Fattorini et al. (1999)        |
|               | Kraków (Poland)               | ✓          |              | ✓       |                 | ✓      | Manganaro et al. (2001)        |
|               | Košice (Slovakia)             | ✓          |              | ✓       |                 | ✓      | Salvati et al. (2002)          |
|               | Kraków (Poland)               | ✓          |              | ✓       |                 | ✓      | Fröhlich and Ciach (2019)      |
| Tawny Owl     | Pavia (Italy)                 | ✓          |              | ✓       |                 | ✓      | Galeotti (1990)                |
|               | Warsaw (Poland)               | ✓          |              | ✓       |                 | ✓      | Galeotti et al. (1991)         |
|               | Kraków (Poland)               | ✓          |              | ✓       |                 | ✓      | Galeotti et al. (1996)         |
|               | Toruń (Poland)                | ✓          |              | ✓       |                 | ✓      | Fattorini et al. (1999)        |
|               | Helsinky (Finland)            | ✓          |              | ✓       |                 | ✓      | Fattorini et al. (2001)        |
|               | Uusimaa (Finland)             | ✓          |              | ✓       |                 | ✓      | Ranazzi et al. (2000a)         |
|               | Pelješac (Croatia)            | ✓          |              | ✓       |                 | ✓      | Ranazzi et al. (2000b)         |
|               | Grosseto (Italy)              | ✓          |              | ✓       |                 | ✓      | Ranazzi et al. (2002)          |
|               | Trento (Italy)                | ✓          |              | ✓       |                 | ✓      | Goszczyński et al. (1993)      |
|               | Long-eared Owl                | ✓          |              | ✓       |                 | ✓      | Gryz and Krauze-Gryz (2018)    |
|               | Kraków (Poland)               | ✓          |              | ✓       |                 | ✓      | Gryz and Krauze-Gryz (2019)    |
|               | Rzeszów (Poland)              | ✓          |              | ✓       |                 | ✓      | Lesiński et al. (2009)         |
|               | Pecs (Hungary)                | ✓          |              | ✓       |                 | ✓      | Fröhlich and Ciach (2018)      |
|               | České Budějovice (Czech Rep.) | ✓          |              | ✓       |                 | ✓      | Fröhlich and Ciach (2019)      |
|               |                               |            |              |         |                 |        | Vrezec (2001)                  |
|               |                               |            |              |         |                 |        | Panzeri et al. (2014)          |
|               |                               |            |              |         |                 |        | Mori et al. (2017)             |
|               |                               |            |              |         |                 |        | Marchesi and Sergio (2005)     |
|               |                               |            |              |         |                 |        | Dziemian et al. (2012)         |
|               |                               |            |              |         |                 |        | Szép et al. (2018)             |
|               |                               |            |              |         |                 |        | Lövy and Riegert (2013)        |
|               |                               |            |              |         |                 |        | Riegert et al. (2009)          |
### Appendix 3 Framework for initial interviews with FaB Peregrines

#### People

**Demography**
- Age
- Occupation/background
- Time given
- How big is the group?
- Who are members of core group?

#### Hardware

- What has been invested (CCTV, nest trays, etc)?
- Who installs/maintains hardware?

#### Organisation

**Structure**
- Hierarchy/ratio of volunteers (How many experts/ringers/amateur citizens)
- Types of roles
- Relationship with other bodies (volunteer groups, BTO, conservation groups, estate managers)

| Species          | Location                           | Population | Reproduction | Habitat | Feeding/hunting | Others | Reference                           |
|------------------|------------------------------------|------------|--------------|---------|----------------|--------|-------------------------------------|
| Milan (Italy)    |                                    | ✓          |              |         |                |        | Pirovano et al. (2000a)             |
| Sofia (Bulgaria) |                                    |            |              |         | ✓              |        | Pirovano et al. (2000b)             |
| Dobrich (Bulgaria)|                                  | ✓          |              |         |                |        | Milchev et al. (2003)               |
| Short-eared Owl  | Various (Spain)                    |            |              |         | ✓              |        | Patón et al. (2012)                |
| Little Owl       | Rome (Italy)                       | ✓          |              |         |                |        | Fattorini et al. (1999)            |
|                  |                                    |            |              |         | ✓              |        | Fattorini et al. (2001)            |
|                  |                                    |            |              |         | ✓              |        | Manganaro et al. (2001)            |
| Kraków (Poland)  |                                    | ✓          |              |         |                |        | Fröhlich and Ciach (2019)          |
| Little Owl       | Łódź, Podlasie, Upper Silesia,    | ✓          |              |         |                |        | Kitowski and Grzywaczewski (2010)  |
|                  | Malopolska, Lublin, Chelm,         |            |              |         |                |        |                                    |
|                  | Sub-Carpathian regions (Poland)    |            |              |         |                |        |                                    |

---

Table 2 (continued)

---

### Data
- What data is collected?
- How/where does data flow
- Who holds what data?

### Intervention/recoveries
- How involved are members in peregrine activities: rescue? Observe-only? What kinds of interventions are there?
- How frequent (many) are interventions?
- Who intervenes, steps of intervention
- How successful?

### Activity
- When is group active – breeding/non-breeding season/all-year?
- What activities occur off-season?
- Are members/group active at other nest sites?

### Peregrines

#### Ringing
- Are they ringed?
- If no, why not?
Who rings them – are ringers part of group (dedicated) or “freelance”?

How many ringers involved (in London)?

Challenges

What difficulties groups face in urban context?

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article’s Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article’s Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.

References

Abramsky Z, Strauss E, Subach A, Riechman A, Kotler BP (1996) The effect of barn owls (Tyto alba) on the activity and microhabitat selection of Gerbillus allenbyi and G. pyramidum. Oecologia 105: 313–319. https://doi.org/10.1007/BF00328733

Arent LR, Willette M, Buhl G (2018) Raptors as victims and ambassadors: raptor rehabilitation, education, and outreach. In: Boal CW, Dykstra CR (eds) Urban Raptors. Island Press/Center for Resource Economics, Washington, DC, pp 229–245

Atkins A, Redpath SM, Little RM, Amar A (2017) Experimentally manipulating the landscape of fear to manage problem animals. J Wildl Manag 81:610–616. https://doi.org/10.1002/jwmg.21227

Bailey RL, Bonter DN (2017) Predator guards on nests boxes improve nesting success of birds. Wildl Soc Bull 41:434–441. https://doi.org/10.1007/s12981-016-0500-z

Belair JA, Westphal LM, Whelan CJ, Minor ES (2015) Urban residents’ perceptions of birds in the neighborhood: biodiversity, cultural ecosystem services, and disservices. Condor 117:192–202. https://doi.org/10.1650/CONDOR-14-128.1

Belair JA, Westphal LM, Minor ES (2016) Different social drivers, including perceptions of urban wildlife, explain the ecological resources in residential landscapes. Landsc Ecol 31:401–413. https://doi.org/10.1007/s10980-015-0256-7

Belcher RN, Fornasari L, Menz S, Schroepfer T (2018) Birds use of vegetated and non-vegetated high-density buildings—a case study of Milan J Urban Ecol 4: https://doi.org/10.1093/jue/juy001

Bell CP, Baker SW, Parkes NG, Brooke ML, Chamberlain DE (2010) The role of the Eurasian Sparrowhawk (Accipiter nisus) in the decline of the house sparrow (Passer domesticus) in Britain. Auk 127: 411–420. https://doi.org/10.1525/auk.2009.09108

Biadu W (2006) Sparrowhawk - a new breeding species in the polish towns? Berkut 15:120–124

Biadu W, Zmihorski M (2011) Factors shaping a breeding bird community along an urbanization gradient: 26-year study in medium size city (Lublin, SE Poland). Pol J Ecol 59:381–389

Bildstein KL, Therrien J-F (2018) Urban birds of prey: a lengthy history of human-raptor cohabitation. In: Boal CW, Dykstra CR (eds) Urban Raptors. Island Press/Center for Resource Economics, Washington, DC, pp 3–17

Bildstein KL, Schelsky W, Zalles J, Ellis S (1998) Conservation status of tropical raptors. J Raptor Res 32:3–18

Bird DM, Varland DE, Negro JH (eds) (1996) Raptors in human landscapes: adaptation to built and cultivated environments. Academic Press Limited, London

Bird DM, Rosenfield RN, Septon G, Gahbauer MA, Barclay JH, Lincer JL (2018) Management and conservation of urban raptors. In: Boal CW, Dykstra CR (eds) Urban Raptors. Island Press/Center for Resource Economics, Washington, DC, pp 258–272

Boal C, Dykstra CR (2018) Urban raptors: ecology and conservation of birds of prey in cities. Island Press/Center for Resource Economics, Washington, DC

Bogliani G, Sergio F, Tavecchia G (1999) Wood pigeons nesting in association with hobby falcons: advantages and choice rules. Anim Behav 57:125–131. https://doi.org/10.1006/anbe.1998.0959

Boratyński Z, Kasprzyk K (2005) Does urban structure explain shifts in the food niche of the Eurasian kestrel (Falco tinnunculus). BUTEO 14:11–17

Brown L (1977) Birds of prey: their biology and ecology. A & W Publishers, London

Bustamante J (1997) Predictive models for lesser kestrel Falco naumanni distribution, abundance and extinction in southern Spain. Conserv Biol 80:153–160. https://doi.org/10.1006/s科比.960136-X

Bux M, Giglio G, Gustin M (2008) Nest box provision for lesser kestrel Falco naumanni populations in the Apulia region of southern Italy. Conser Evid 5:58–61

Campbell B, Lack E (2011) A dictionary of birds. A&C Black, London

Cannon AR, Chamberlain DE, Toms MP et al (2005) Trends in the use of private gardens by wild birds in Great Britain 1995–2002. J Appl Ecol 42:659–671. https://doi.org/10.1111/j.1365-2664.2005.01050.x

Carrillo J, Gonzalez-Davila E (2009) Latitudinal variation in breeding parameters of the common kestrel Falco tinnunculus. Ardeola 56: 215–228

Chace JF, Walsh JJ (2006) Urban effects on native avifauna: a review. Landsc Urban Plan 74:46–69. https://doi.org/10.1016/j.landurbplan.2004.08.007

Chamberlain DE, Cannon AR, Toms MP et al (2009) Avian productivity in urban landscapes: a review and meta-analysis. Ibis 151:1–18. https://doi.org/10.1111/j.1474-919X.2008.00899.x

Charlton M, Ishaki L, Bouskila A, Leisrem Y (2007) Breeding success of the Eurasian kestrel (Falco tinnunculus) nesting on buildings in Israel. J Raptor Res 41:139–143. https://doi.org/10.3356/0892-1016(2007)41[139:BSOTEK]2.0.CO;2

Cianchetti-Benedetti M, Manzia F, Fraticelli F, Cercere JG (2016) Urban effects on native avifauna: a review. Landsc Urban Plan 74:46–69. https://doi.org/10.1016/j.landurbplan.2004.08.007

Clayton S, Myers G (2015) Conservation psychology: understanding and promoting human care for nature. John Wiley & Sons, Chichester

Cooke R, Hogan F, Isaac B, Weaving M, White JG (2018) Urbanization and raptors: trends and research approaches. In: Boal CW, Dykstra CR (eds) Urban raptors: ecology and conservation of birds of prey in cities. Island Press/Center for Resource Economics, Washington, DC, pp 64–75

Cox DTC, Shanahan DF, Hudson HL, Plummer KE, Siriwandana GM, Fuller RA, Anderson K, Hancock S, Gaston KJ (2017) Doses of neighborhood nature: the benefits for mental health of living with nature. BioScience 67:147–155. https://doi.org/10.1093/biosci/biw173

Crowley SL, Hinchliffe S, McDonald RA (2019) The parakeet protectors: understanding opposition to introduced species management. J
null
Hunold C (2017) Why not the city?: urban hawk watching and the end of nature. Nat Cult 12:115–136. https://doi.org/10.3167/nc.2017.120202

James Reynolds S, Ibáñez-Álamo JD, Sumasgutner P, Mainwaring MC (2019) Urbanisation and nest building in birds: a review of threats and opportunities. J Ornithol 160:841–860. https://doi.org/10.1007/s10336-019-01657-8

Jankowiak L, Polakowski M, Kufakowski T, Świętochowski P, Tumiel T, Broniszewska M, Takaćs V (2015) Habitat and weather requirements of diurnal raptors wintering in river valleys. Biologia 70: 1136–1142. https://doi.org/10.1515/biolog-2015-0117

Johnson D (2014) The peregrine falcon and factors affecting its existence in urban London. London Bird Rep 79:189–205

Jokimäki J, Suhonen J, Jokimäki-Kaisanlhti M-L, Carbó-Ramírez P (2016) Effects of urbanization on breeding birds in European towns: impacts of species traits. Urban Ecosyst 19:1565–1577. https://doi.org/10.1007/s11252-014-0423-7

Jones D, Howard P (2006) Wildlife feeding in urban areas: an indecent obsession. Wildlife Australia 38:18–20

Jones DN, Reynolds SJ (2008) Feeding birds in our towns and cities: a global research opportunity. J Avian Biol 39:265–271. https://doi.org/10.1111/j.0908-8857.2008.04271.x

Kečkešová L, Noga M (2008) The diet of the common kestrel in the urban environment of the city of Nitra. Slovak Raptor J 2:81–85. https://doi.org/10.2478/v10262-0012-0021-7

Kekkonen J, Hanski IK, Väisäinen RA, Brommer JE (2012) Levels of heavy metals in house sparrows (Passer domesticus) from urban and rural habitats of southern Finland. Ornis Fenn 89:91–98

Kettel EF, Gentle KL, Yarnell RW (2016) Evidence of an urban peregrine falcon (Falco peregrinus) feeding young at night. J Raptor Res 50:321–323. https://doi.org/10.3356/JRR-16-13.1

Kettel EF, Gentle KL, Quinn JL, Yarnell RW (2018) The breeding performance of raptors in urban landscapes: a review and meta-analysis. J Ornithol 159:1–18. https://doi.org/10.1007/s10336-017-1497-9

Khoo MDY, Lee BPY-H (2020) The urban smooth-coated otters Lutrogale perspicillata of Singapore: a review of the reasons for success. Int Zoo Yb 54:1–12. https://doi.org/10.1111/izy.12262

Kitowski I, Gryzawczezski G (2010) Occurrence of the little owl Athene noctua in towns and cities of Poland. Institute of Landscape Ecology, Slovak Academy of Sciences, Bratislava

Kopij G (2018) Ecological distribution and population densities of raptors in the inner and outer zone of a central European city. Ukr J Ecol 8:772–779. https://doi.org/10.15421/2018.279

Kreiderits A, Gamauf A, Krenn HW, Sumasgutner P (2016) Investigating the influence of local weather conditions and alternative prey composition on the breeding performance of urban Eurasian kestrels Falco tinnunculus. Bird Study 63:369–379. https://doi.org/10.1080/000636657.2016.1213791

Krone O, Altenkamp R, Kenntner N (2005) Prevalence of trichomonas gallinae in northern goshawks from the Berlin area of northeastern Germany. J Wildl Dis 41:304–309. https://doi.org/10.7589/0090-3558-41.2.304

Kross S (2012) The efficacy of reintroducing the New Zealand falcon into the vineyards of Marlborough for pest control and falcon conservation. Thesis, University of Canterbury. https://doi.org/10.26021/8923

Kubacka J, Zmihorski M, Mrkši P, Rejt L (2010) Central-place foraging in an urban landscape: body mass of common voles (Microtus arvalis pall.) caught by breeding kestrels (Falco tinnunculus) is positively correlated with availability of hunting sites. Pol J Ecol 58:387–392

Kübler S, Kupko S, Zeller U (2005) The kestrel (Falco tinnunculus L.) in Berlin: investigation of breeding biology and feeding ecology. J Ornithol 146:271–278. https://doi.org/10.1007/s10336-005-0089-2

Kumar N, Gupta U, Malhotra H, Jhala YV, Qureshi Q, Gosler AG, Sergio F (2019) The population density of an urban raptor is inextricably tied to human cultural practices. Proc R Soc B Biol Sci 286:20182932. https://doi.org/10.1098/rspb.2018.2932

Kunca T, Yosef R (2016) Differential nest-defense to perceived danger in urban and rural areas by female Eurasian sparrowhawk (Accipiter nisus). Peer 4:e2070. https://doi.org/10.7717/peerj.2070

Kunca T, Smejkalova P, Cepicka I (2015) Trichomonosis in Eurasian sparrowhawks in the Czech Republic. Folia Parasitol 62:. https://doi.org/10.14411/fp.2015.035

Larson DW (2004) Urban cliff revolution: new findings on the origins and evolution of human habitats. Fitzhenny & Whiteside, Markham, Ont

Laudrè JW, Hernandez L, Ripple WJ (2010) The landscape of fear: ecological implications of being afraid. Open J Ecol 3:1–7. https://doi.org/10.2174/187421300103030001

Leonardi G, Mannino V (2007) Feeding habits of urban peregrine Falco peregrinus brookii in eastern Sicily. Avocetta 31:73–74

Lesiński G, Gryz J, Kowalski M (2009) Bat predation by tawny owls Strix aluco in differently human-_transformed habitats. Ital J Zool (Modena) 76:415–421. https://doi.org/10.1080/1125000802589353

Liker A, Pap Z, Bókony V, Lendvai ÁZ (2008) Lean birds in the city: body size and condition of house sparrows along the urbanization gradient. J Anim Ecol 77:789–795. https://doi.org/10.1111/j.1365-2656.2008.01402.x

Lohr MT (2018) Anticoagulant rodenticide exposure in an Australian predatory bird increases with proximity to developed habitat. Sci Total Environ 643:134–144. https://doi.org/10.1016/j.scitotenv.2018.06.207

López-JN (2017) Nicho trófico en Falconidae: heterogeneidad de hábitat, nutrición y reproducción. Thesis, Universidad Autonoma de Madrid. Available from: https://repositorio.uam.es/bitstream/handle/10486/682655/navarro_lopez_juan.pdf?sequence=1

Lövy M, Rieger J (2013) Home range and land use of urban long-eared owls. Condor 115:551–557. https://doi.org/10.1525/cond.2013.120017

Mainwaring MC (2015) The use of man-made structures as nesting sites by birds: a review of the costs and benefits. Nat Conserv 25:17–22. https://doi.org/10.1016/j.njnc.2015.02.007

Manguanaro A, Ranazzi L, Salvati L (2001) Diet overlap of barn owl (Tyto alba) and Little owl (Athene noctua) in a Mediterranean urban area. Butoe 12:67–69

Mannan RW, Steidl RJ (2018) Demography of raptor populations in urban environments. In: Boal CW, Dykstra CR (eds) Urban Raptors. Island Press/Center for Resource Economics, Washington, DC, pp 51–63

Marchesi L, Sergio F (2005) Distribution, density, diet and productivity of the Scops Owl Otus scops in the Italian Alps. Ibis 147:176–187. https://doi.org/10.1111/j.1474-919X.2004.00388.x

Markandya A, Taylor T, Longo A, Murty MN, Murty S, Dhavala K (2008) Counting the cost of vulture decline—an appraisal of the human health and other benefits of vultures in India. Ecol Econ 67:194–204. https://doi.org/10.1016/j.ecolecon.2008.04.020

Martínez-Miranzo B, Banda EI, Aguirre JI (2016) Multiscale analysis of the landscape of fear: ecological distribution and population densities of raptors in urban and rural areas by female Eurasian sparrowhawk (Accipiter nisus) in a Mediterranean urban area. Urban Ecosyst (2021) 24:1179–1199

Mestres L, Sergio F (2005) Distribution, density, diet and productivity of the Scops Owl Otus scops in the Italian Alps. Ibis 147:176–187. https://doi.org/10.1111/j.1474-919X.2004.00388.x

Mikula P, Hromada M, Tryjanowski P (2013) Bats and swifts as food of the European kestrel (Falco tinnunculus) in a small town in Slovakia. Ornis Fenn 90:178–185
Milchev B, Ivanov T (2016) Winter diet of long-eared owls Asio otus (L.) in a suburban landscape of North-Eastern Bulgaria. Acta Zool Bulg 68:355–361

Milchev B, Boev Z, Toteva T (2003) Diet composition of the Long-eared Owl (Asio otus) during the autumn-winter period in the northern park of Sofia. Godishnik na Sofiskiya Universitet “Sv Kliment Ohridski” Biologicheski Fakultet Kniga 93:94–95–56. Available from: http://e-ecodb.bas.bg/zb/sci/171_milchev_et_al_2003_asio_otus_diet_sofia.pdf

Miller JR (2005) Biodiversity conservation and the extinction of experience. Trends Ecol Evol 20:430–434. https://doi.org/10.1016/j.tree.2005.05.013

Mori E, Ancilloto L, Menchetti M, Strubbe D (2017) ‘The early bird catches the nest’: possible competition between scops owls and ring-necked parakeets. Anim Conserv 20:463–470. https://doi.org/10.1111/acv.12334

Mueller A-K, Chakarov N, Heseker H, Krüger O (2016) Intraguild predation leads to cascading effects on habitat choice, behaviour and reproductive performance. J Anim Ecol 85:774–784. https://doi.org/10.1111/1365-2666.12493

Negro JJ, De la Riva M, Bustamante J (1991) Patterns of winter distribution and abundance of lesser kestrels (Falco naumanni) in Spain. J Raptor Res 25:30–35

Negro JJ, Bustamante J, Melguizo C et al (2000) Nocturnal activity of lesser kestrels under artificial lighting conditions in Seville, Spain. J Raptor Res 34:327–329

Newton I (1998) Population limitation in birds. Academic press, London

Newton I (2010) Population ecology of raptors. Bloomsbury Publishing, London

Nicolai B, Mammen U, Kolbe M (2017) Long-term changes in population and habitat selection of red kite Milvus milvus in the region with the highest population density. Vogelwelt 137:194–197

ONS (2011) 2011 United Kingdom census. In: Office for National Statistics. https://www.ons.gov.uk/census/2011census. Accessed 1 Jan 2021

Orchan Y, Chiron F, Shwartz A, Kark S (2013) The complex interaction network among multiple invasive bird species in a cavity-nesting community. Biol Invasions 15:429–445. https://doi.org/10.1007/s10530-012-0298-6

Orros ME, Fellowes MDE (2015) Widespread supplementary feeding in domestic gardens explains the return of reintroduced red kites Milvus milvus to an urban area. Ibis 157:230–238. https://doi.org/10.1111/ibi.12237

OtterWatch (2017) Toby Reunion special - one year anniversary. In: OtterWatch Facebook. https://www.facebook.com/OtterWatch/posts/toby-reunion-special-one-year-anniversary19-2016-was-the-day-when-a-6-week-s-1531639680241908/8. Accessed 9 Jan 2020

Pagel JE, Anderson CM, Bell DA, Deal E, Kiff L, McMorris FA, Redig PT, Sallinger R (2018) Peregrine fencers: the neighbors upstairs. In: Boal CW, Dykstra CR (eds) Urban raptors: ecology and conservation of birds of prey in cities. Island Press/Center for Resource Economics, Washington, DC, pp 180–195

Palomino D, Carrascal LM (2007) Habitat associations of a raptor community in a mosaic landscape of Central Spain under urban development. Landsc Urban Plan 83:268–274. https://doi.org/10.1016/j.landurbplan.2007.04.011

Panzeri M, Menchetti M, Mori E (2014) Habitat use and diet of the Eurasian Scops owl Otus scops in the breeding and wintering periods in Central Italy. Ardeola 61:393–399. https://doi.org/10.13157/arra.61.2.2014.393

Papp S (2011) Breeding of Eurasian Sparrowhawks Accipiter nisus in two Hungarian towns. Aquila 11:49–54

Patón D, Romero F, Cuenca J, Escudero JC (2012) Tolerance to noise in 91 bird species from 27 urban gardens of Iberian Peninsula. Landsc Urban Plan 104:1–8. https://doi.org/10.1016/j.landurbplan.2011.09.002

Philó C, Wolch J (1998) Through the geographical looking glass: space, place, and society-animal relations. Soc Anim 6:103–118

Patella E, Salvati L, Manganaro A, Fattorini S (1999) Spatial and temporal variations in the diet of the common kestrels Falco tinnunculus in urban Rome, Italy. J Raptor Res 33:172–175

Pigeon Racing UK & Ireland (2019) Test compensation case. http://www.pigeonracinguk.co.uk/test-compensation-case/. Accessed 10 Oct 2019

Pirovano A, Rubolini D, Brambilla S, Ferrari N (2000a) Winter diet of urban roosting long-eared owls Asio otus in northern Italy: the importance of the Brown rat Rattus norvegicus. Bird Study 47:242–244. https://doi.org/10.1080/00063650009461181

Pirovano A, Rubolini D, Michelis S (2000b) Winter roost occupancy and behaviour at evening departure of urban long-eared owls. Ital J Zool (Modena) 67:63–66. https://doi.org/10.1080/11250000009356296

Poppleton M (2016) Urban raptors: Owl and hawk adaptation to urban centers. Journal for Undergraduate Studies at Trent IV:1–12. Available from: https://ojs.trentu.ca/ojs/index.php/just/article/view/58

Preisser EL, Bolnick DJ, Benard MF (2005) Scared to death? The effects of intimidation and consumption in predator-prey interactions. Ecology 86:501–509. https://doi.org/10.1890/04-0719

QSR International (2018) NVIVO Qualitative Data Analysis Software. Version 12. QSR International. URL https://qsrinternational.com/nvivo/nvivo-products/

Quinn J, Kokorev Y (2002) Trading-off risks from predators and from aggressive hosts. Behav Ecol Sociobiol 51:455–460. https://doi.org/10.1007/s00265-002-0466-2

Ranazzi L, Manganaro A, Ranazzi R, Salveti L (2000a) Woodland cover and tawny owl Strix aluco density in a Mediterranean urban area. Biota 1:27–34

Ranazzi L, Salveti L, Manganaro A (2000b) The breeding success of tawny owls (Strix aluco), in a Mediterranean area: a long-term study in urban Rome. J Raptor Res 34:322–326

Ranazzi L, Manganaro A, Salvati L (2002) Density fluctuations in an urban population of tawny owl Strix aluco: a long-term study in Rome, Italy. Ornis Svecica 12:5

Raptor Alliance (2012) Where have all the songbirds gone? In: The Royal Pigeon Racing Association. https://www.rpra.org/wp-content/uploads/2012/03/Songbirds-Sticker.pdf. Accessed 10 Oct 2019

Rejt Ł (2001) Feeding activity and seasonal changes in prey composition of urban peregrine falcons Falco peregrinus. Acta Ornithol 36:165–169. https://doi.org/10.1361/068.036.0201

Rejt Ł (2003) Why do urban Peregrines lay earlier in Warsaw? Ekologia 22:423–428

Rejt Ł (2006) Does larder-hoarding affect the condition of chicks in urban kestrels? Biologia 61: https://doi.org/10.2478/s11756-006-0033-9

Rejt Ł, Raczyńska M (2003) Variation in egg size of urban kestrels (study in Warsaw, Poland). Bepyrk 12:70–75

Rejt Ł, Turlejski K, Krzysztof B, Topczewski AM (2000) Why do urban peregrine falcons Falco tinnunculus in northern Italy: the importance of the Brown rat Rattus norvegicus. Bird Study 47:242–244. https://doi.org/10.1080/00063650009461181

Rejt Ł, Rutkowski R, Gryczańska-Siemiatkowska A (2004) Genetic variability of urban kestrels in Warsaw—preliminary data. Zool Pol 49:199–209

Rejt Ł, Gryczańska-Siemiatkowska A, Rutkowski R, Malewska A (2005) Does egg sex ratio in urban kestrels Falco tinnunculus differ from parity? Pol J Ecol 53:545–552

Riegert J, Fuchs R (2004) Inseets in the diet of urban kestrels from Central Europe: an alternative prey or constant component of the diet. Ornis Fenn 81:23–32
Riegert J, Fuchs R (2011) Fidelity to roost sites and diet composition of wintering male urban common kestrels *Falco tinnunculus*. Acta Ornithol 46:183–189. https://doi.org/10.3161/001064511X625955

Riegert J, Dušek A, Fainová D, Mikes V, Fuchs R (2007a) Increased hunting effort buffers against vole scarcity in an urban kestrel *Falco tinnunculus* population. Bird Study 54:353–361. https://doi.org/10.1080/00063650709461495

Riegert J, Fainová D, Mikes V, Fuchs R (2007b) How urban kestrels *Falco tinnunculus* divide their hunting grounds: partitioning or co-habitation? Acta Ornithol 42:69–76. https://doi.org/10.3161/068.042.0101

Riegert J, Lövy M, Fainová D (2009) Diet composition of common kestrels *Falco tinnunculus* and long-eared owls *Asio otus* coexisting in an urban environment. Omis Fenn 86:123–130

Riegert J, Fainová D, Bystiká D (2010) Genetic variability, body characteristics and reproductive parameters of neighbouring rural and urban common kestrel (*Falco tinnunculus*) populations. Popul Ecol 52:73–79. https://doi.org/10.1007/s10144-009-0168-y

Rodríguez A, Negro JJ, Bustamante J, Antolín J (2013) Establishing a lesser kestrel colony in an urban environment for research purposes. J Raptor Res 47:214–218. https://doi.org/10.3356/JRR-12-56.1

Romanowski J (1996) On the diet of urban kestrels (*Falco tinnunculus* in Warsaw). Buteo 8:123–130

Rosenzweig ML (2003) Win-win ecology: how the earth’s species can survive in the midst of human enterprise. Oxford University Press, New York

Royal Pigeon Racing Association (2019) Royal pigeon racing association raptor petition. https://www.rpra.org/wp-content/uploads/2012/03/Hawk-Petition-Form.pdf. Accessed 11 Oct 2019

Rutz C (2012) Brood sex ratio varies with diet composition in a non-breeding raptor. Biol J Linn Soc Lond 105:937–951. https://doi.org/10.1111/j.1095-8312.2011.01818.x

Rutz C, Zinke A, Bartels T, Wohlesin P (2004) Congenital neuropathy and dilution of feather melanin in nestlings of urban-breeding northern kestrels (*Accipiter gentilis*). J Zoo Wildl Med 35:97–103. https://doi.org/10.1618/zjm.2006.031.1

Rutz C, Bijsma RG, Marquiss M, Kenward RE (2006a) Population limitation in the northern kestrel in Europe: a review with case studies. Stud Avian Biol 31:158–197

Rutz C, Whittingham MJ, Newton I (2006b) Age-dependent diet choice in an avian top predator. Proc R Soc B 273:579–586. https://doi.org/10.1098/rspb.2005.3353

Salvati L (2002) Spring weather and breeding success of the Eurasian kestrel (*Falco tinnunculus*) in urban Rome, Italy. J Raptor Res 36:81–84

Salvati L, Manganaro A, Fattorini S, Piattella E (1999) Population features of kestrels *Falco tinnunculus* in urban, suburban and rural areas in Central Italy. Acta Ornithol 34:53–58

Salvati L, Ranazzi L, Manganaro A (2002) Habitat preferences, breeding success, and diet of the barn owl (*Tyto alba*) in Rome: urban versus rural territories. J Raptor Res 36:224–228

Schütz C, Schulze CH (2018) Park size and prey density limit occurrence of Eurasian Sparrowhawks in urban parks during winter. Avian Res 9:30. https://doi.org/10.1007/s10336-018-0122-9

Serra G, Lucentini M, Romano S (2001) Diet and prey selection of non-breeding peregrine falcons in an urban habitat of Italy. J Raptor Res 35:61–64

Sielicki S, Sielicki J (2009) Restoration of Peregrine falcon in Poland 1989-2007. In: Sielicki J, Mizera T (eds) Peregrine falcon populations-status and perspectives in the 21st century. Turul–Poznań University of Life Sciences Press, Poznan, pp 699–722

Soga M, Gaston KJ (2016) Extinction of experience: the loss of human–nature interactions. Front Ecol Environ 14:94–101. https://doi.org/10.1002/fee.1225

Solonen T (2008) Larger broods in the northern goshawk *Accipiter gentilis* near urban areas in southern Finland. Omis Fenn 85:118–125

Solonen T (2014) Timing of breeding in rural and urban tawny owls *Strix aluco* in southern Finland: effects of vole abundance and winter weather. J Ornithol 155:27–36. https://doi.org/10.1007/s10336-013-0983-y

Solonen T, Ursin K (2008) Breeding of tawny owls *Strix aluco* in rural and urban habitats in southern Finland. Bird Study 55:216–221. https://doi.org/10.3356/000164511X625955

Sorensen T, Tella J, Hiraldo F, Donazar-Sancho J, Negro JJ (1996) Costs and benefits of avoidable dispersal. Ibis 148:175–189. https://doi.org/10.1111/0006-3550.001420.x

Stoltenberg AR (1993) The distribution of its avian prey. J Raptor Res 27:59–76. https://doi.org/10.3161/000164511X625955

Sorensen T, Tella J, Hiraldo F, Donazar-Sancho J, Negro JJ (1996) Costs and benefits of avoidable dispersal. Ibis 148:175–189. https://doi.org/10.1111/0006-3550.001420.x

Taylor I (2003) Barn owls; predator-prey relationships and conservation. Cambridge University Press, Cambridge

Tella J, Hiraldo F, Donazar-Sancho J, Negro JJ (1996) Costs and benefits of urban nesting in the lesser kestrel. In: Bird DM, Varland DE, Negro JJ (eds) Raptors in human landscapes: adaptation to built and cultivated environments. Academic press, London, pp 53–60

Thiollay J-M (2006) The decline of raptors in West Africa: long-term assessment and the role of protected areas. Ibis 148:240–254

Thornton M, Todd I, Roos S (2017) Breeding success and productivity of urban and rural Eurasian sparrowhawks *Accipiter nisus* in Scotland. Écoscience 24:115–126. https://doi.org/10.1080/11958660.2017.1374322
Time BE (2016) Hunting activity by urban Peregrine falcons (*Falco peregrinus*) during autumn and winter in south-West Norway. Ornis Norv 39:39–44. https://doi.org/10.15845/on.v39i0.1048
Ueta M (2007) Effect of Japanese lesser sparrowhawks *Accipiter gularis* on the nest site selection of azure-winged magpies *Cyanopica cyanus* through their nest defending behavior. J Avian Biol 38:427–431. https://doi.org/10.1111/j.0908-8857.2007.04172.x
UK Raptor Working Group (2019) Racing pigeons and birds of prey. In: RSPB. https://www.rspb.org.uk/our-work/our-positions-and-casework/our-positions/species/birds-of-prey-in-the-uk/racing-pigeons-and-birds-of-prey/. Accessed 1 Oct 2019
Vincze E, Seress G, Lagisz M, Nakagawa S, Dingemanse NJ, Sprau P (2017) Does urbanization affect predation of bird nests? A meta-analysis Front Ecol Evol 5:. https://doi.org/10.3389/fevo.2017.00029
Voous KH, Thomson SAL (1960) Atlas of European birds. Nelson, London
Vrezec A (2001) The breeding density of Eurasian Scops owl *Otus scops* in urban areas of Peljeac peninsula in southern Dalmatia. Acrocephalus 22:149–154
Whelan CJ, Şekercioğlu ÇH, Wenny DG (2015) Why birds matter: from economic ornithology to ecosystem services. J Ornithol 156:227–238. https://doi.org/10.1007/s10336-015-1229-y
Wiklund CG (1982) Fieldfare (*Turdus pilaris*) breeding success in relation to colony size, nest position and association with Merlins (*Falco columbarius*). Behav Ecol Sociobiol 11:165–172. https://doi.org/10.1007/BF00300059
Wildlife and Countryside Act 1981 (UK) Retrieved from https://www.legislation.gov.uk/ukpga/1981/69/contents
Wilson MW, Balmer DE, Jones K, King VA, Raw D, Rollie CJ, Rooney E, Ruddock M, Smith GD, Stevenson A, Stirling-Aird PK, Wernham CV, Weston JM, Noble DG (2018) The breeding population of Peregrine falcon *Falco peregrinus* in the United Kingdom, Isle of Man and Channel Islands in 2014. Bird Study 65:1–19. https://doi.org/10.1080/00063657.2017.1421610
Wolch J (1998) Zoöpolis. In: Animal geographies: place, politics, and identity in the nature-culture borderlands. Verso, London, pp 119–138
Yalden DW (1980) Notes on the diet of urban kestrels. Bird Study 27: 235–238. https://doi.org/10.1080/00063658009476683
Zalewski A (1994) Diet of urban and suburban tawny owls (*Strix aluco*) in the breeding season. J Raptor Res 28:246–252
Zmihorski M, Rejt Ł (2007) Weather-dependent variation in the cold-season diet of urban kestrels *Falco tinnunculus*. Acta Ornithol 42: 107–113. https://doi.org/10.3161/068.042.0105