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MOVEMENT AND HOME RANGE OF

GPS TAGGED ROOKS *Corvus frugilegus* IN HUNGARY

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1. INTRODUCTION.

The Rooks (*Corvus frugilegus*) are sociable birds that nest in colonies, roost communally, forage in flocks usually on the ground, and consume a variety of animals and vegetable sources (Patterson et al., 1971; Mason & Macdonald, 2004). Rooks are common birds, especially in Central Europe, and breed amid agricultural landscapes (Kasprzykowski, 2003; Orłowski & CZapulak, 2007; Kitowski et al., 2017). The breeding range of the species can be found between South Scandinavia and North Spain, then through Eurasia to the River Yenisei (Madge, 2020).

In birds, colonial breeding is prevalent (Power, 1983). Rooks are one of the more robustly colonial social birds, establishing rookeries amid stands of towering, old trees that might range in size from a few couples to thousands of pairs (Madge, 2020). Breeding in colonies offers both advantages and disadvantages for nesting individuals (Power, 1983). One of its largest benefits is a decrease in predation as a result of quicker predator detection, group defense, and a lower chance of attack per individual (Brown & Brown 2001; Kasprzykowski, 2008). Another benefit is group feeding leads to an increase in foraging effectiveness (Kasprzykowski, 2008). Breeding in colonies can have adverse effects such as an increase in parasitism and disease transmission, kleptoparasitism of nestlings, brood parasitism, and over-exploitation of food supplies nearby (Brown& Brown 2001). A large number of nests in species that breed communally can draw predators, but this effect can be mitigated by cooperative defense (Kasprzykowski, 2008).

Rooks form colonies of different sizes and factors that affect variance in colony size are not thoroughly understood and remain enigma (Kasprzykowski, 2007; Kasprzykowski, 2008). Although Mason & Macdonald (2004) suggested that both the distribution of foraging habitat and inter-colony competition may have an impact on the spatial distribution and number of rook breeding colonies. Further studies on colonial bird species are required because the causes of formation and the functioning governing breeding colonies remain a contentious issue (Brown & Brown 2001).

Despite the Rooks to be known for their variability in movements between seasons as their movements being confined within 1 km during the breeding season (Kasprzykowski 2003) and they can expand up to 40 km during the winter season (Jadczyk & Jakubiec, 2005) in Poland, still the gape exist on the information of spatial and temporal ecology of Rooks in Hungary. Understanding these aspects of Rooks' ecology is beneficial for both of its conservation and land management practices as it will provides valuable information on the habitat requirements of this species.

Thus the aim of this study is to portray the home range sizes and habitat use of GPS tagged Rooks during breeding season in Hungary. In this study I expect to have an answers on 1) what is the home range size of Rooks in Hungary during breeding season, and how individual varies in home range sizes?; 2) which diurnal habitats are used by Rooks in Hungary, is there individual variation in the use of habitat?; 3) which nocturnal habitats are used by Rooks, is there individual variation in the use of habitat?

Results of this study will help to identify important areas for conservation and management of the species and develop strategies to mitigate necessary conflicts that may arise with humans.

2. LITERATURE REVIEW

2.1. Description of the Rooks (*Corvus frugilegus*)

The rooks are medium-sized black birds with shiny black plumage (Glenlivet Wildlife, 2023), exhibiting a blue or bluish-purple sheen in direct sunlight, and they have greyish feathers around their necks (ENvironmental InFOrmation, 2023; Glenlivet Wildlife, 2023). They range in length from 44 to 46 cm (Madge, 2020) and weight ranging from 337 to 551 g (Carlson & Townsend, 2014). They have a wingspan ranging from 81 to 99 cm (Madge, 2020). Rooks' bills are relatively broad and thick for their size, ranging from 53 to 51 mm long, the tip of it is acute, and curved downwards, making them well-adapted also for scavenging (Carlson & Townsend, 2014; Glenlivet Wildlife, 2023). The eyes are dark brown, and the legs are relatively short and strong (Glenlivet Wildlife, 2023). The legs and feet are normally black and the bill grey-black (Madge, 2020). Rooks show weak sexual dimorphism (Madge, 2020), the males are slightly larger than the females (Carlson & Townsend, 2014).

Rooks can be distinguished from similar members of the crow family by virtue of their size; rooks are larger than jackdaws (*Corvus monedula*) but smaller than ravens (*Corvus corax*) or crows (*Corvus corone*) (Glenlivet Wildlife, 2023). The most prominent feature of rooks is bare grey-white skin around the base of the adult's bill in front of the eyes (Madge, 2020; ENvironmental InFOrmation, 2023; Glenlivet Wildlife, 2023), however the juvenile is superficially more like to the Crow because it lacks the bare patch at the base of the bill, but it loses the facial feathers after about 10–15 months of age (Madge, 2020). Rooks have distinctive calls that sound like ‘kaaark’ or ‘caw’, which helps to distinguish them from other birds in their habitat (Carlson & Townsend, 2014; Glenlivet Wildlife, 2023). A single loud ‘caw’ is used by the rook during foraging and migration in order to stay in contact with other Rooks, Although it is believed that Rooks mainly vocalize with their mate rather than other social interaction (Carlson & Townsend, 2014).

2.2. Distribution

The Rooks are broadly distributed in the Palearctic region, two subspecies are found in a region; western subspecies (*C. f. frugilegus*) and eastern subspecies (*C. f. pastinator*) (Han et al., 2015; Salinas et al., 2021). The western subspecies is distributed throughout temperate and boreal zones of Europe, western Siberia, Central Asia and Middle East (Han et al., 2015; Madge, 2020; Salinas et al., 2021). The eastern subspecies are found Northeast Asia including far east Russia, Mongolia, Korean peninsula, China and Japan (Han et al., 2015; Larionov, 2017; Madge, 2020; Hattori et al., 2022).

A populations of *C. f. frugilegus* was also introduced in New Zealand by Acclimatisation Societies between 1862 and 1874 where they flourish (Carlson & Townsend, 2014; Porter, 2017).

Figure 1: Global distribution map of rooks (BirdLife International, 2023)

2.3. Habitat

Rook is a bird species closely linked to agricultural areas of temperate zones, particularly in Central and Eastern Europe (Orłowski et al., 2010; Kitowski et al., 2017). They likely prefer mixed-farmland areas in relatively open areas, flat terrain, usually in lowland riverine plains, with stands of large trees or patches of woods for nesting and roosting (Madge, 2020). Rooks require arable farmland or a vast grassland and steppe habitats for foraging, where the soil is typically soft and fertile (Carlson & Townsend, 2014; Madge, 2020).

Rooks are less prevalent in specialized agricultural regimes and prefer areas of mixed farming (Brenchley, 1984), in some parts of the distribution also Rooks tend to avoid places where winter cereal grains like rye and wheat are cultivated, favoring instead regions where spring cereals like barley, which are softer and easier to obtain (Carlson & Townsend, 2014). According to Brenchley (1984), a habitat with 45% tillage (cereals, roots, and vegetables) and 55% grass (temporary and permanent excluding overgrazing) was ideal for rooks. Rooks can also be found in large metropolitan parks, churchyards, tall trees at the outskirts of towns and villages (Madge, 2020).

Rooks breed in colonies of nests that are scattered spatially in tree canopies (Kasprzykowski, 2008) and rookeries are formed in areas with a minimum amount of man-made disturbances (Orłowski & CZapulak, 2007; Czarnecka & Kitowski 2010).

Rooks can find resources in a wide range of elevations, from sea level to around 4,000 m, which explains why they are widely inhabited throughout most of Europe and Asia (Feare, 1974; Carlson & Townsend, 2014).

2.4. Space use of the species in their distribution range.

The rook is a common bird that is extensively dispersed over the Palearctic region and an intriguing organism in terms of migration ecology (Hattori et al., 2022). In the past, large flocks of rooks from populations in north-eastern Europe used to regularly spend the winter in the Mediterranean region, mostly in the Iberian and Italian Peninsulas, but in recent decades, the number of wintering individuals has been declining, and at this time, only anecdotal records have been documented (Salinas et al., 2021).

Current studies consider rooks to be primarily resident in the western and southern regions of their distribution range, however they demonstrate migratory behaviors in the northern and eastern Palearctic region (Madge, 2020; Hattori et al., 2022). East Asian populations of Rook migrate from breeding grounds in the Eurasian continent around the Amur river basin to wintering grounds in central and south China, the Korean peninsula, and Japan (Hattori et al., 2022).

Although rooks are considered as native to much of the western range, during the winter they frequently relocate to more urban areas searching for more food options, such as farmland or trash dumps and they return to their customary breeding locations in forest or meadow settings during the summer (Glenlivet Wildlife, 2023).

The breeding rook population of Hungary is resident with smaller scale southern displacements in the Carpathian Basin. The large number of wintering rooks originate from northern and North Eastern populations(Solt, 2009).

2.5. Feeding behaviour of Rooks

Rooks are omnivorous corvid species (Horváth et al., 2015; Kitowski et al., 2017; Bird Life International, 2023), who is likely to be evolved as a grassland feeder (Lockie, 1955) and grassland invertebrates are important diet, particularly in the spring and summer (Mason & Macdonald, 2004). Due to their omnivorous nature and propensity for opportunistic feeding, their diet fluctuates considerably depending on what is available at a particular time (Glenlivet Wildlife, 2023). Habitat type is the main determinant of diet composition; for instance, in Poland, rooks with breeding colonies in cities consumed fleshy fruits while rooks with rookeries in agricultural landscapes consumed cereal grains (Kitowski, 2017).

Rooks' foraging behavior is closely related to topsoil because they gather food from the soil's surface or probe it with their powerful bills (Kitowski et al., 2017). Rooks are also specialized in obtaining invertebrates from the moist soils below the soil's surface, especially in meadows (Olea, 2009). Generally the diet of the Rook includes cereal grains from farmed crop fields and grasslands as well as soil invertebrates like earthworms and ground-dwelling coleopterans (Orłowski et al., 2010; Czarnecka & Kitowski, 2013; Kitowski, 2017; Kitowski et al., 2017). Gromadzka (1980) estimated that an adult Rook consumes roughly 13 kg of grain and 16 kg of animals each year.

Most rooks feed between 0.5 and 1 km from the breeding colony (Kasprzykowski, 2003); for wintering birds, the distance is greater; they forage up to 40 kilometres from the winter roost area (Czarnecka & Kitowski, 2010). The changing length of daylight affects when birds arrive at the roost in the evening and leave in the morning for foraging (Jadczyk & Jakubiec, 2005). The rooks leave their foraging areas in the evening and stay on nearby electrical wires, trees, and buildings until dusk where they move into their roosts for the night (Hattori et al., 2022).

Many species of birds and mammals hoard food (Andersson & Krebs, 1978). Of all the *Corvus* species, rooks are the most skilled food hoarders (Källander, 2007). In autumn stores food items for the winter, placing acorns, walnuts and pine cones in hole and covering it over with grasses; reported also as storing earthworms, but this possibly only for short period

(Purchas, 1975; Madge, 2020). Rooks know the exact location of their caches and probably possess the long-term memory capacity necessary to relocate caches made several months earlier (Källander, 2007).

The caching behavior of Rooks is described by Källander (2007) as follows;

“A bird arriving with acorns deposits them on the ground, picks up one of them and keeps it under the tongue (or in the bill in the case of some large acorns), searches for a suitable cache site, pecks a hole and hammers the acorn into it (large acorns and walnuts are placed on the ground while the cache site is being prepared and then picked up and put in place). The acorn is then covered with soil and debris, after which the site is inspected. The bird then returns to the deposited acorns, where a new one is picked up, carried a short distance (often not more than 0.5–2 m) and the procedure is repeated. Several sites may be tried (sometimes as many as 10–15) before an acorn is finally cached.”

2.6. Nest building

Rooks often construct their nests in mature tall deciduous trees; one extremely large tree can have up to 60 nests in its top (Carlson & Townsend, 2014; Madge, 2020); In areas of open steppe, rookeries can be found as low as 4 meters from the ground in bushy thickets, moreover there have been instances of nests being built on power lines and even in reed beds, such as in Azerbaijan, where a rookery of 250 nests constructed on bent reed stems and dried leaves (Madge, 2020).

Mature Rooks always establish strong pair bond and roost communally in a rookeries (Carlson & Townsend, 2014). The nest is constructed by both sexes and is a substantial cup like made of dried grasses, roots, and dead leaves (BirdLife International 2023). Male always bringing in material and female undertaking most of construction work which might take from one up to four weeks depending on how much of the material is stolen from nearby nests (Madge, 2020).

Nest building in this species is very costly as it can take up to a month, thus rooks should time the construction of their nests to coincide with favorable weather conditions (Madge, 2020). For instance, a sudden deterioration in weather, like strong winds, which sometimes happens in the early spring, can cause nests to collapse especially during the first stage of construction, thus In order to avoid higher energy expenditure in these unfavorable weather conditions, rooks extend the time of building nests, in order to coincide with favorable weather conditions (Zbyryt et al., 2022). A nest may be repaired and re-used for many years (Madge, 2020; BirdLife International 2023). Also rooks reported to willfully take additional supplementary nest-building materials that are placed nearby and incorporate them into their nests (Horváth et al., 2015).

2.7. Breeding behavior

Rooks are strong colonial birds that form rookeries of a few pairs up to thousands of pairs, for example in Central Europe bond pairs can reach 2000 pairs and can be maximum up to 50,000 pairs in Kazakhstan (Madge, 2020). Although Rooks are very gregarious, they create pair relationships that can last several years or for a lifetime (Carlson & Townsend, 2014).

Rooks mate when they reach maturity, which typically occurs in their third calendar year but can occasionally happen in the second calendar year (one year after hatching and fledging) (Madge, 2020). During the breeding season, pair bonds build their nests together in rookeries and although the large number of birds living in a single rookery, rooks manage to retain their pair bonds by extensive communication (Carlson & Townsend, 2014). Despite the fact that rooks and other corvid species like common ravens and Carrion crows are believed to be monogamous, there have been a documented cases of social promiscuity (Green, 2008; Madge, 2020).

Egg-laying period often starts in Britain at the end of February, but in Central Europe and Russia, where the cold weather lasts for a longer time, it may start from April or May (Carlson & Townsend, 2014). Introduced Rooks in New Zealand, breed throughout the austral spring, and egg laying start from late August until mid-November (Madge, 2020).

Rooks lay two to seven (average four) blue-green eggs that are covered with brown and grey mottling (Slagsvold et al., 1986; Carlson & Townsend, 2014; BirdLife International 2023). Rooks' eggs which are typically 40 mm long, resemble to raven eggs in appearance but are slightly smaller (Carlson & Townsend, 2014). Females incubates the eggs, but males occasionally covers the eggs while the female is shortly away from the nest (Madge, 2020).

Incubation period is 16 to 18 days, after that chicks are hatched in blind and helpless condition (Kasprzykowski, 2007). Both sexes care for and feed the chicks throughout the nestling phase which lasts for 30 to 36 days (Madge, 2020). Young fly strongly at 42 to 45 days and continue to stay with their parents and are fed by them for more six weeks from fledging before joining non-breeding roving flocks, which some-times composed entirely of juveniles (Madge, 2020).

In autumn, the young birds of the summer collect into large flocks together with unpaired birds of previous seasons, often in company with jackdaws (ENvironmental InFOrmation, 2023).

Outside of the breeding season, rooks from various rookeries share a single roost, with rooks from a single rookery frequently using different roost in the autumn and winter (Coombs, 1961). These winter roosts are frequently thought of as a collection of smaller social groups known as rook parishes (Patterson et al., 1971).

2.8. Social and cognitive behavior

Rooks are known to its gregarious behaviors like living in large colonies (Glenlivet Wildlife, 2023), forming pair mate that last for several years (Carlson & Townsend, 2014), bonds nesting together and they cooperate in nesting construction (Madge, 2020; BirdLife International 2023). During incubation period male rook help female to cover the eggs once a female depart a nest for a short period and both parents involving in rearing of chicks especially before the chicks are fledged (Madge, 2020).

In addition to the cooperative behavior, Rooks are known for their intelligence; Rooks have been observed in Rome carrying mussels from the beach to the optimum distance into the air and letting them fall amid stones to break the shells in order to access the contents (Allen, 1883). They have even been seen covering food with leaves or twigs to prevent other birds from stealing it (Källander, 2007). Also studies of Rooks in captivity showed that they are capable of finding the solution to a problem without being trained (Seed et al., 2008) such as, removing objects from difficult-to-reach spots or opening boxes with several latches using instruments like twigs or stones (Glenlivet Wildlife, 2023). Rooks also can solve complex problems such as trap tube problem. The trap-tube problem is used to determine whether an individual has the capacity for anticipating the results of its actions (Tebbich et al., 2007). In this, animal must use a tool to push a piece of food out of a tube, which has a trap along its length. Tebbich et al., (2007) attested that rooks are able to complete this challenge, however they are not able to use the acquired knowledge to solve a novel problem.

2.9. Ecological importance of the rook

Rooks are strongly colonial social birds, forming rookeries of a few pairs up to thousands of pairs in stands of tall mature trees (Madge, 2020). Their congregation behavior especially during breeding and roosting period result to have some ecological significance in ecosystem.

2.9.1. Alter the soil's chemical properties and influence plant community diversity

The presence of Rook colonies caused the soil's wetness and acidity to increase, and its amount of biogenic elements to rise (Borkowska et al., 2015). Bird nesting colonies have a huge impact on the soil and flora because their droppings can change the characteristics of the soil by adding more nutrients like organic matter, nitrogen, and phosphorus (Mun, 1997). On the one hand, a high concentration of nutrients in the soil brought on by bird excrement deposition can disrupt the equilibrium of the soil or plants and affect how terrestrial ecosystems function (Borkowska et al., 2015). The effect on plants depends on the quantity of chemical substances and excrements added to the soil (Ishida, 1997; Mun, 1997). For example Rook nesting reduced the total number of plant species in impoverished habitat like pine forests while increasing the number of species in fertile areas like parks (Borkowska et al., 2015). Birds, on the other hand, carry diaspores and then deposit them in their habitats, influencing the development of a particular phytocoenoses representation (Orłowski & Czarnecka, 2009; Khoreva & Mochalova, 2009; Borkowska et al., 2015). Due to this, plant diversity may be reduced, the taxonomic representation decreases, or some species may even completely vanish (Ishida, 1997; Mun, 1997; Khoreva & Mochalova, 2009).

2.9.2. Seed dispersal and influencing seed germination

The Rooks, are one of the key seeds distribution vectors, can internally carry some amounts of seeds (Czarnecka & Kitowski 2013; Kitowski, 2017). They are able to crack, open, and eat cereal grains like barley, hence facilitate seeds dispersal (Carlson & Townsend, 2014). In Poland, Rooks are regarded as an important dispersal vector for fleshy-fruited species like the sour cherry (*Prunus cerasus*), strawberries (*Fragaria x ananassa*), and common mulberry (*Morus alba*), and at the same time, it is a non-standard vector for less frequently distributed dry-fruited species other than cereals, which were probably inadvertently swallowed during foraging for (Czarnecka & Kitowski, 2013). Rook breeding colonies (rookeries), develop in areas with a moderate amount of man-made disruptions (Orłowski & CZapulak, 2007; Czarnecka & Kitowski 2010) and thus with small vegetation gaps enable the germination of transported seeds (Czarnecka & Kitowski 2010). Additionally, the presence of the Rook colonies change soil parameters, hence contributing to the rise in soil humidity and content of biogenic elements, which are crucial during seed germination and seedling establishment (Borkowska et al., 2015).

2.9.3. Provide nest sites to other bird species

Rookeries provide ideal nest-sites for many other birds in regions where trees sparse; disused nests often taken over by falcons, particularly Red-footed (*Falco vespertinus*), Amur Falcons (*Falco amurensis*), Common Kestrel (*Falco tinunculus*), and Lesser Kestrel (*Falco naumanni*) which may form small colonies scattered within rookery (Horváth et al., 2015).

2.9.4. Rooks serve as the host and vectors of parasites

Rooks host a variety of protozoan species, including trypanosomes and leucocytozoans (Carlson & Townsend, 2014). Parasites just use Rooks as vectors hence does not directly cause it any harm, in this way, Rooks support these organisms' life cycles (Baker, 1974).

Orobatic mites also use Rooks as hosts. Oribatid mites are soil mites that consume decaying plants and fungus. It is thought that these mites devour fungi while living in the Rooks' feathers. Although the effects of such a relationship are not immediately apparent, they are actually beneficial for rooks. (Krivolutsky & Lebedeva, 2004).

2.10. Economic constraints of rooks.

Rooks have both negative and positive economic impacts on humans. Rooks are frequently referred to be agricultural pests, which means they damage and consume crops (Carlson & Townsend, 2014). Rooks frequently forage in field crops, using the opportunity of cereals and grains availability, which may lead to loss of income for farmers (Carlson & Townsend, 2014; Therkildsen et al.,2021). Although Feare (1978) suggested that Rooks are only known to harm crops when their favorite foods are not available.

While many farmers assert that rooks causing more harm than good, a number of studies indicates that 60 to 90% of insects devoured by Rooks are agricultural pests (Kalotás, 1985; Carlson & Townsend, 2014). Thus, large numbers of Rooks may help to regulate and control population of pest insect (Feare, 1974). Rooks are known to dig in the ground to find insects, which may have a modest aeration impact that is crucial in agricultural fields (Carlson & Townsend, 2014).

2.11. World population and conservation status of Rooks

Current it is estimated that the global population size of Rooks range between 54,000,000–94,999,999 individuals (BirdLife International, 2023). Rooks have been classified into Least Concern in IUCN category of red list due to the fact that; it has enormously range, Consequently, the species does not get close to the range size thresholds for vulnerability (Extent of Occurrence < 20,000 km^2), Regardless of the population trend that seems to be declining, it is assumed that the reduction is not occurring quickly enough to reach the criteria for vulnerability as determined by the population trend criterion (> 30% decline over ten years or three generations) and because of the population's size, it is very large and does not approach the population size criterion's thresholds for vulnerability (< 10,000 mature individuals with a continuing decline estimated to be > 10% in ten years or three generations, or with a specified population structure) (Carlson & Townsend, 2014; ENvironmental InFOrmation, 2023; BirdLife International, 2023).

2.12. Threats to the species

However Rooks has been classified into Least Concern in IUCN category of red list due to large range of its distribution and large population size which shows a slow decline trends, Rooks face threats that may cause further population decline.

2.12.1. Secondary poisoning

Rooks are principally susceptible to ingesting excessive levels of heavy metals from agrochemicals (fertilizers, pesticides) because of their close ties to agricultural areas (Malmberg, 1973). After consuming excessive heavy metal-contaminated prey or cereal grains, the metals can permeate and contaminate the entire tissue of birds (Schafer et al., 1983). According to studies done on birds, exposure to metals and metalloids has a negative impact on the ability of birds to reproduce (Kitowski et al., 2017). Metals and metalloids like Arsenic may interfere calcium metabolism, which could affect the formation of eggshells and their physical characteristics (Scheuhammer, 1987), and also heavy metals can have direct impact on development of eggs and embryos (Kitowski et al., 2017). The effects on embryos and chicks include death or decreased hatchability, failure of the chicks to flourish, and teratological effects producing skeletal abnormalities (Eeva & Lehikoinen, 1996). Previous studies on Rooks revealed acute levels of Cadmiun (Cd) in nestling tissues and extremely high amounts of arsenic (As) in eggshells come from from fertilizers and pesticides (Orłowski et al., 2016).

2.12.2. Persecution by human.

The Rook is extensively distributed in the Palearctic region and is generally regarded as a pest species of agriculture and at airfields, in addition, rooks are reported causing a nuisance in urban areas due to raiding in refuse collection sites and or creating fecal pollution (Browne et al., 2007; Therkildsen et al.,2021; Hattori et al., 2022). As agricultural pests and nuisance causing in urban areas, the Rooks were heavily persecuted in the last century, especially in Central Europe (Kalotás & Nikodémusz, 1981; Orłowski & CZapulak, 2007) and recently in Scandinavian countries (Therkildsen et al.,2021) and northern and eastern part of its distribution (Hattori et al., 2022).

2.12.3. Changing agricultural land use

Rook population has been fluctuated especially in XXth Century main causes of fluctuations were due to extensive agriculture associated with expansion of agricultural fields that lead to the loss of extensive pasture for Rooks foraging, also application of pesticides and seed dressings (mercury) reducing food availability to the birds (BirdLife International, 2023).

Extensive agriculture in central Europe lead to the insufficiency of mature forest covers in distinctive habitats of rooks (Horváth et al., 2015). This means to shortage of twigs and sticks that are potential material to build up the body of a nest. Horváth et al., (2015) consider the scarcity of nesting material as a threat to rooks with regards to the facts that in the same location, hundreds of nests are constructed, and the weight of a branch may be sizeable considering an individual’s body mass, thus Rooks have been observed to willingly steal nest material from conspecifics in a rookery and willing to utilize supplementary nesting material provided nearby (Goodwin 1955; Horváth et al., 2015).

3. MATERIAL AND METHODS

3.1. Study area

The research was carried out on breeding populations of Rooks at Érsekvadkert village in Nógrád county, Balassagyarmati district Northern Hungary (approximately 47.992194, 19.192357). Érsekvadkert village is situated at the base of the Börzsöny Mountains, in the Nógrádi Basin, in the western portion of Nógrád County. The majority of people who live in the village today are employed, most of them in the construction sector, mills and wood processing industries. The village is one of the county's biggest agricultural producer cooperatives.

Figure 2: Map of Hungary showing Nógrád county (Nógrád, 2023).

Figure 3: Map of Érsekvadkert village (Google Maps, 2023)

3.2. Data collection

Four individual Rooks were captured at the beginning of different two breeding seasons named Bibor and Ersek who were captured in April, 2017 and Vadkert and Toro who were captured in March, 2018. The birds were captured with mist nets while foraging in gardens. Rooks were fitted with 10 gram GPS-UHF tags (Milsar Inc.). The manufacturer provided the tags for testing purposes to Mr. Peter Palatitz (MME BirdLife Hungary). Bird handling time was 15–30 minutes, after ringing the transmitters were deployed as backpack harness using teflon ribbon. This method is the most commonly used in case of raptors and storks, and ideally allows the solar panel to recharge the battery of the GPS devices.

GPS was designated to systematically record the coordinates at an average interval of 15 minutes for each birds, when the battery level of the devices was higher than 3.5 V. Therefore GPS fixes were only recorded when reception conditions (more or less clear visibility of the sky) and power level of the transmitters allowed. The full dataset associated with the position of the tag was date, time, latitude, longitude, and altitude. The GPS device also stored the data for later download. The base station of the tags downloaded the recorded data when established radio (UHF) connection with the GPS transmitter.

Data was collected between early April 2017 and late September 2017 for Bibor and Ersek and from early March 2018 to September 2018 for Vadkert and Toro. A total of 21,044 points were recorded during the study period. A maximum number of points were recorded from Toro (7,301) and minimum points were recorded from Ersek (2,611). Localization points were fitted in Q GIS 3.16 Hannover then exported to Microsoft excel 2010 for analysis.

Table 1: Information of captured Rooks and GPS tracking period

Name of bird	Year	Number of tag	Age in calendar-year (Year)	Observation period (Months)	Number of points recorded
Vadkert	2018	314	2+	March–June (6)	5,906
Toro	2018	313	2+	March–August (4)	7,301
Bibor	2017	310	2y	April–September (6)	5,226
Ersek	2017	311	2+	April–June (3)	2,611

3.3. Data analysis

For home range sizes, I have data from March to September but none of the birds has data for all seven months. Bibor has data for six months (from April to September), Ersek has data for three months (from April to June), Vadkert has data for four months (from March to June) and Toro has data for six months (March to August). In my analysis, I considered three months (April, May and June) where data for all four birds in all three months were available. A minimum convex polygon in QGIS 3.16 Hannover software was used to calculate monthly home range size (km^2) covered by all four birds then exported to Microsoft office Excel 2010. PAST version 4.11 software was used to perform descriptive statistics and plotting graph and table were maximum, minimum, median, mean and standard deviation of home range sizes for all tagged birds were described. QGIS 3.16 Hannover software was also used to draw a maps showing home ranges for all four birds, where visualization of individual birds' monthly home ranges was displayed to show the variation between birds.

For habitat use analyses, I had data from March to September but in analysis, only data for April, May and June was used. I did not involve data collected in March, July, August, and September due extremely outliers in number of points recorded (Table 2).

Table 2: Total number of location recorded in each month

	Months						
	March	**April**	**May**	**June**	**July**	**August**	**September**
Number of location recorded	1,700	9,005	7,886	1,445	487	486	35

Monthly habitat use was displayed, Corine Land Cover legend was used to describe habitat characteristics. Habitat was described as;

i. Discontinuous urban fabric area.
ii. Industrial or commercial areas which comprised of; Industrial or commercial units, and Sports and leisure facilities.
iii. Agricultural areas which involved; Non-irrigated arable land, Land principally occupied by agriculture with significant areas of natural vegetation, Complex cultivation patterns, Annual crops associated with permanent crops, and Pastures.
iv. Forest and semi-natural areas which involved; Broad-leaved forest, mixed forest, Natural grasslands and Transitional woodland-shrub.

Diurnal habitat use was presented in percentage in all three months. Percentage of habitat use was obtaining by first by finding the frequencies of occurrences of each bird in each habitat per month, then I summed up the frequencies of all birds occurred in the same habitat where then I calculated the percentage use of each habitat in each month.

Diurnal individual variation of the habitat use was also portrayed. Individual diurnal variation was presented in form of percentage of the proportional use of habitat of all birds in each month. Percentage of proportional of diurnal habitat use for each bird was obtained by first finding the frequencies of occurrence of each bird in each habitat per month, then I summed up the frequencies of occurrence of the same bird in different habitat, then I calculated the percentage of the proportional habitat use.

Nocturnal habitat use was only displayed in April due fewer number of night locations recorded in May and June. In April data of only two birds (Bibor and Ersek) was used since other two birds (Vadkert and Toro) had fewer night locations (Table 3). Night habitat use was presented in percentage similar to diurnal habitat use but displayed in Bar graph and individual variations in the use of habitat at night was presented and displayed the same to diurnal individual variation in habitat use.

Based on the study of locations and aggregation of recorded points in QGIS 3.16 Hannover software for all four birds, a general rule to differentiate between daytime and nighttime was to mark a point between 04:00 HRS and 18:00 HRS (Zone: GMT+1), thus in the analysis, I considered daytime starting from 04:00 HRS and end at 17:59 HRS while nighttime started at 18:00 HRS up to 03:59 HRS. Microsoft Excel 2010 was used to plot graphs displaying the habitat use of birds.

Table 3: Number of locations recorded for each bird from April to June during day time (04:00 - 17:59) and night time (18:00 - 03:59)

Name of bird	Month					
	April		May		June	
	Day	Night	Day	Night	Day	Night
Vadkert	2,083	406	2,344	431	121	208
Toro	2,652	411	2,358	400	512	17
Bibor	293	1,156	1,238	346	395	141
Ersek	1,218	786	596	190	178	61
Total	***6,246***	***2,759***	***6,519***	***1,367***	***1,206***	***239***

4. Results

4.1 Home range size

4.1.1. Monthly home range size

The highest mean home range size in the study area was observed in April 232.8 ± SD 320.2 km^2, followed by June 179.1 ± SD 1,79.6 km^2 and minimum mean home range size was in May 85.8 ± 24.5 km^2 (Fig. 4.). Statistical test was not employed due to small sample size (n=3).

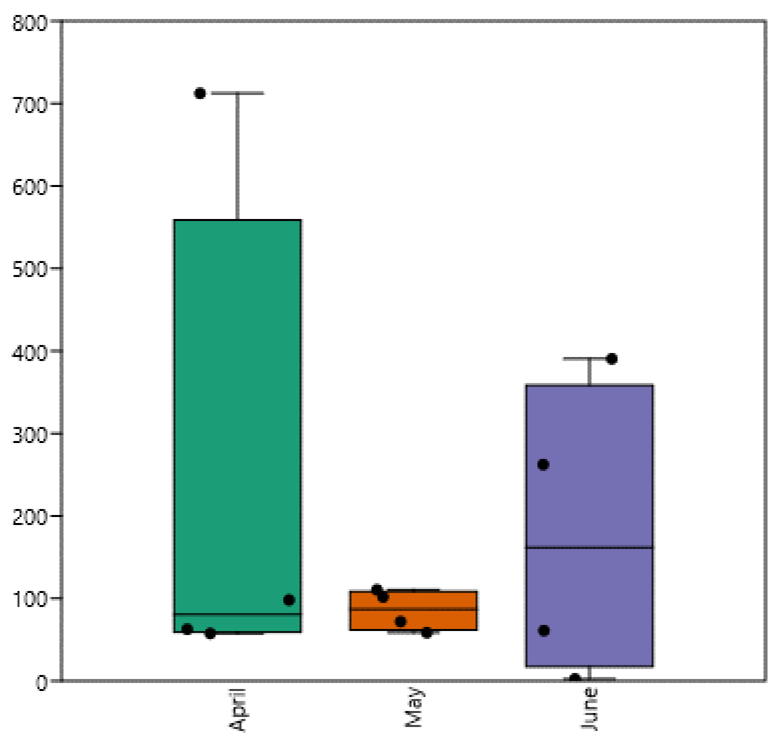

Figure 4: Mean monthly home range size of tagged Rooks

4.1.2. Individual variation in Home range size

Bibor had maximum home range size of 712.3 km^2, minimum home range size of 110.5 km^2 and the mean home range size was 404.4 ± 301.1 km^2. Ersek's maximum home range size was 98.2 km^2, minimum home range size of 61.1 km^2, and Mean home range size was

77.1 ± 19.1 km^2. Vadkert had a maximum home range size of 62.8 Km^2, minimum home range size of 2.5 km^2 and mean home range size was 41.3 ± 33.6 km^2. Toro had maximum home range size of 262.3 km^2, minimum home range size of 57.7 km^2 and mean home range size was 140.6 ± 107.7 km^2 (Table 4).

Table 4: Summary statistics of individual variation in home range size of all four birds

	Bibor	Ersek	Vadkert	Toro
N	3	3	3	3
Min	110.5	61.1	2.5	57.7
Max	712.3	98.2	62.8	262.3
Sum	1,213.3	231.4	123.8	421.9
Mean	404.4	77.1	41.3	140.6
Std. error	173.9	11.0	19.4	62.2
Variance	90,686.4	363.1	1,131.8	11,590.5
Stand. dev	301.1	19.1	33.6	107.7
Median	390.5	72.1	58.5	101.9

4.1.3. Monthly individual home range variation

In April, Bibor had the highest home range size (712 km^2) compared to other three birds Ersek 98.2 km^2, Vadkert 62.8 km^2, and Toro 57.7 km^2 (Figure 5).

In May there were a minor differences in home range sizes among individuals, Bibor had 110.5 km^2, Ersek had 72.5 km^2, Vadkert had 58.5 km^2 and Toro had 101.9 km^2 (Figure 6)

In June there was a variation in home range sizes among individual with Bibor having a largest home range size 390.5 km^2 followed by Toro 262.3 km^2, Ersek 61.1 km^2 and last Vadkert 2.5 km^2 (Figure 7).

Home ranges of Rooks in April

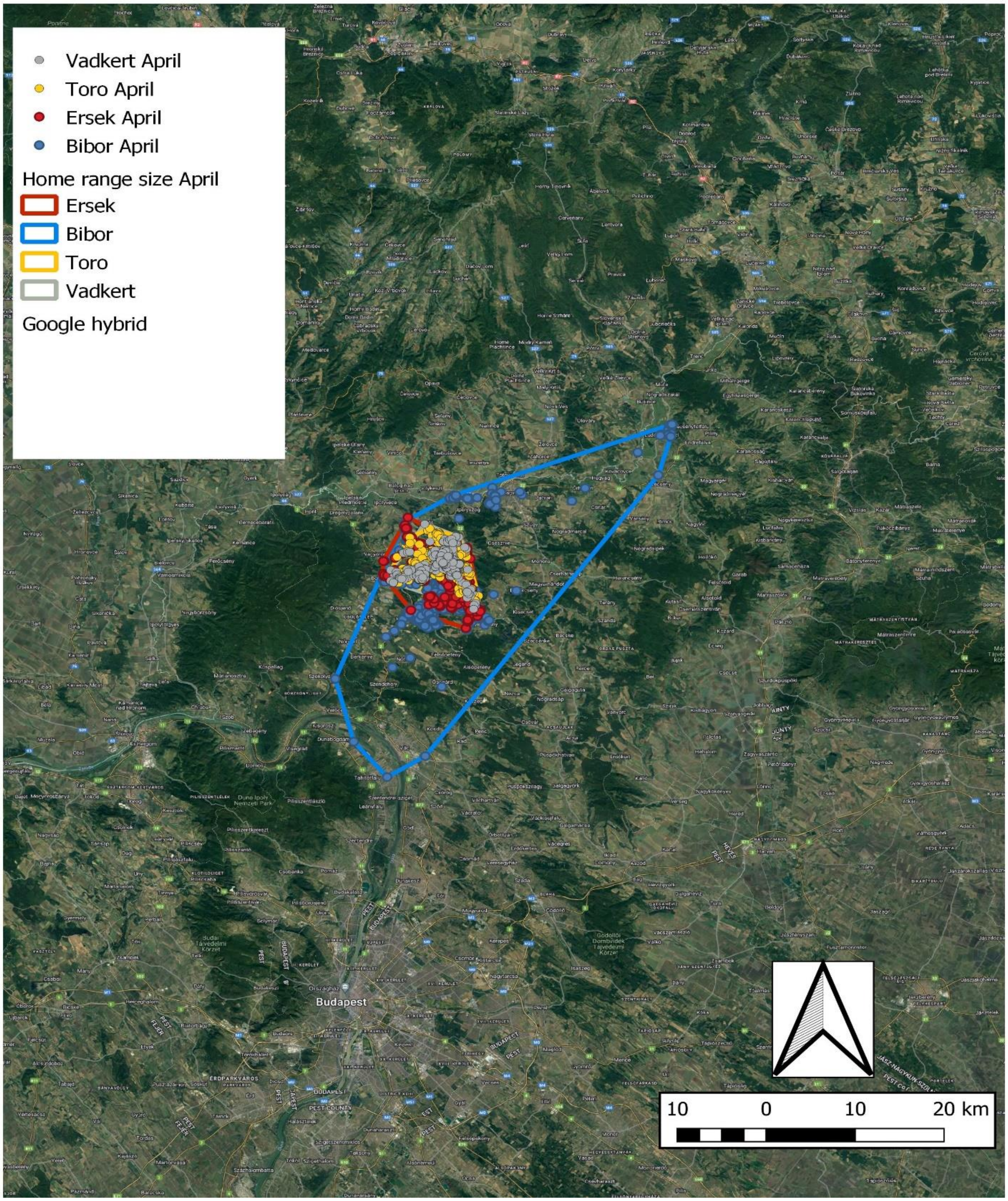

Figure 5: Monthly home ranges of four GPS tagged Rooks in April

Home ranges of Rooks in May

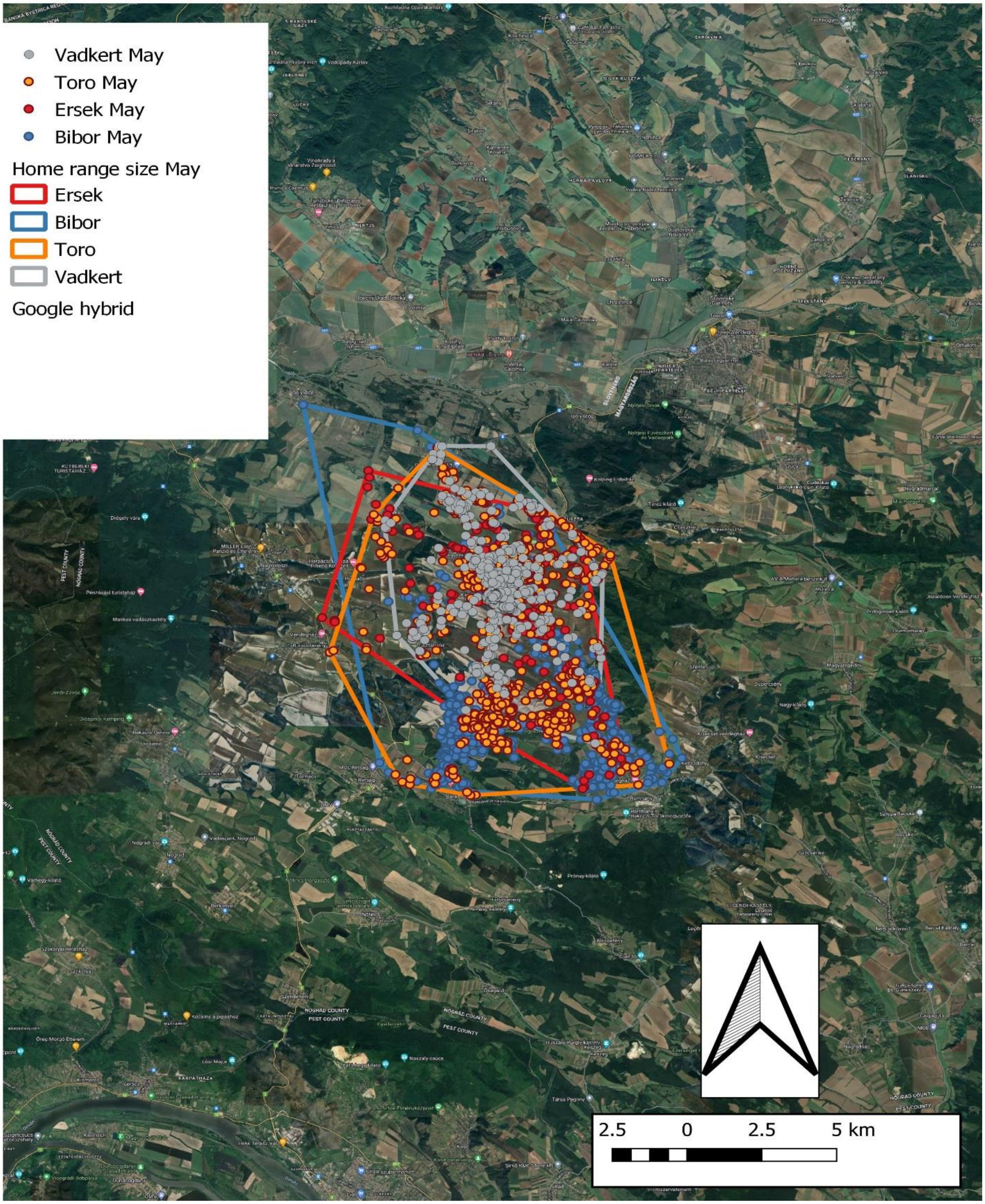

Figure 6: Monthly home ranges of four GPS tagged Rooks in May

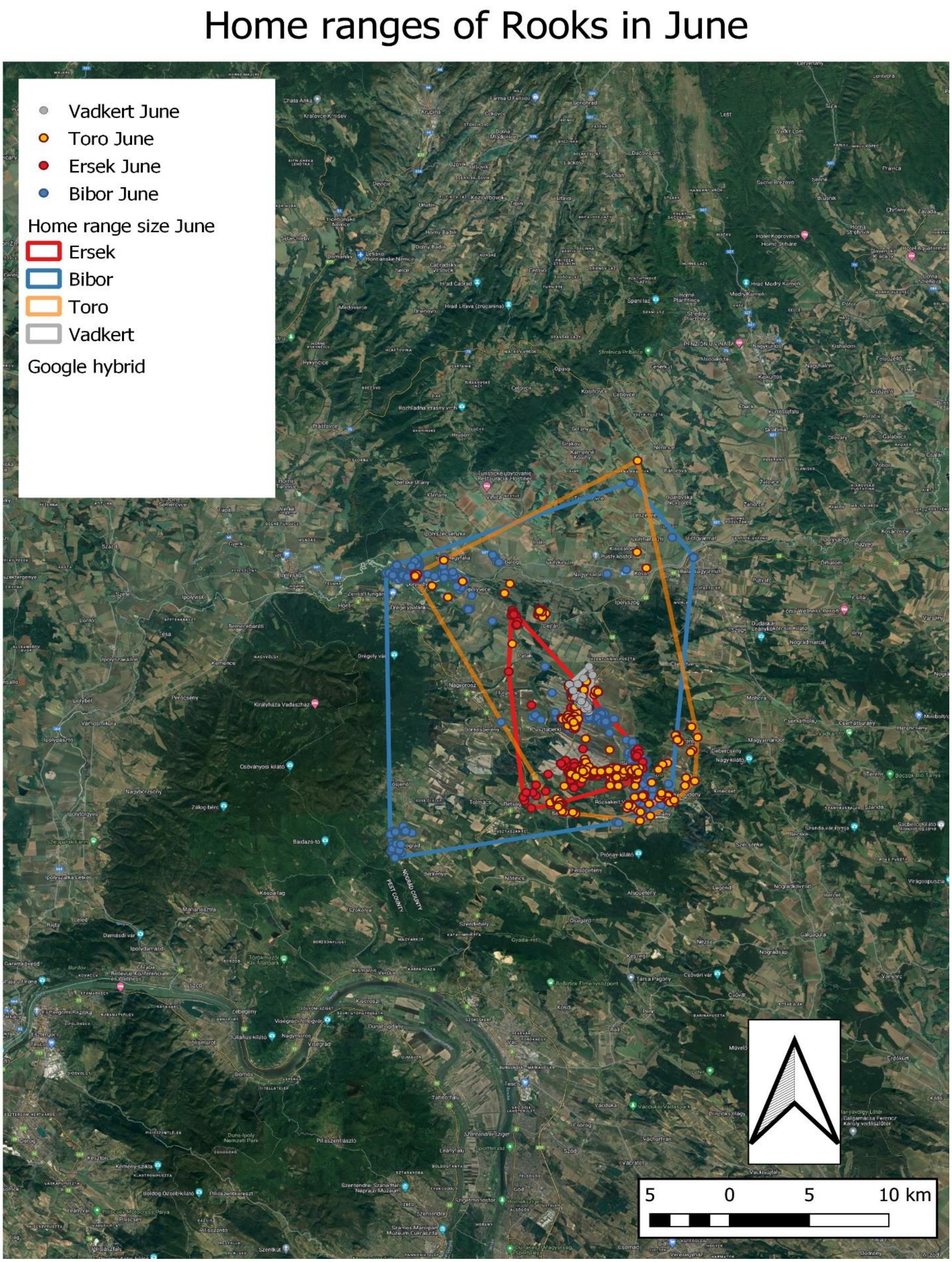

Figure 7: Monthly home ranges of four GPS tagged Rooks in June

4.2. Habitat use of Rooks

4.2.1. Diurnal habitat use in April, May, and June

Agricultural areas had high frequency of Rooks occurance in all three months and the percentage of occurance increased from April to June from 42%, 51.2%, and 69.4% respectively. The second habitat was industrial or commercial areas but the frequency of occurance in this habitat decreased in April to June from 36.6%, 30.7%, and 14.4% respectively. Forest and semi natural areas had minimal frequency of occurance with a percentage of 0.5%, 0.3%, and 1.3% from April, May and June respectively (Figure 8).

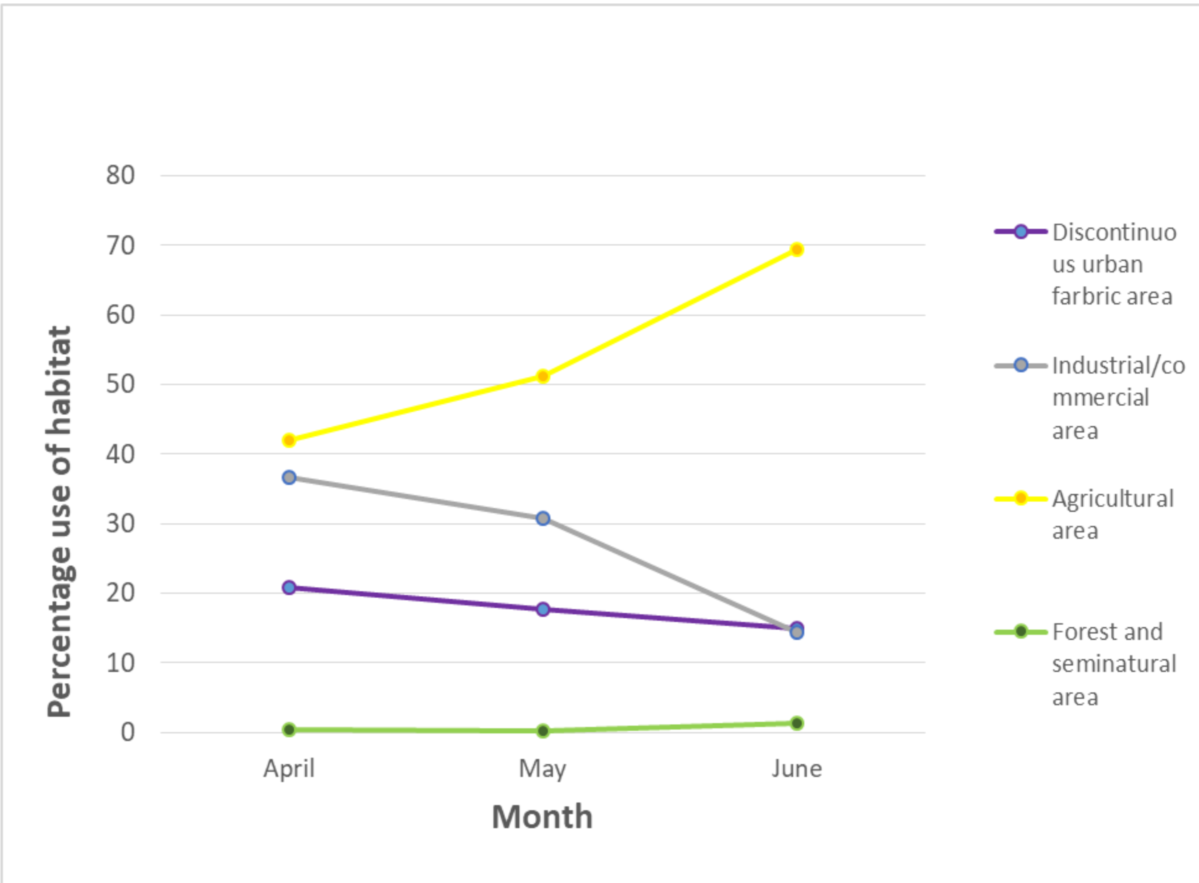

Figure 8: Percentage use of habitat in April, May and June

4.2.2. Individual variation of diurnal habitat use in April

Bibor occurred most in Agricultural areas (74.4%), followed by Toro (45.5%), then Ersek (41.8%) and last Vadkert (16%).

Vadkert was frequently occurred in Industrial or commercial area 56.7% followed by Toro 39.8%, then Ersek 28.3% and finally Bibor 7.3%.

Ersek most occurred in discontinuous urban fabric areas 29%, followed by Vadkert 27.2%, then Bibor 16.7% and finally Toro 14.2%

Forest was less used habitat by all birds with Bibor used it by 1.6%, followed by Ersek 0.4%, then Toro 0.2% and finally Vadkert 0.1% (Figure 9)

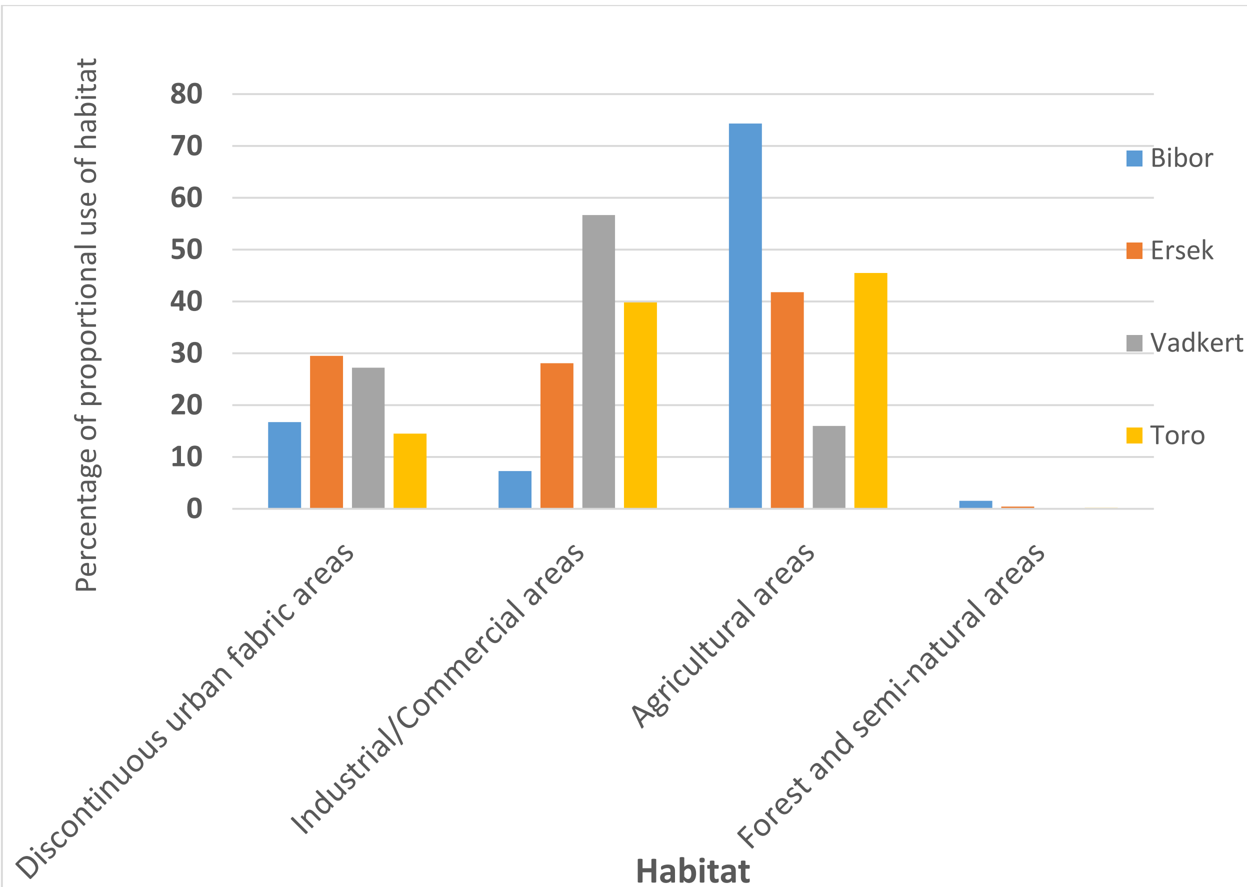

Figure 9: Individual variation of habitat use during the day in April.

4.2.3. Individual variation of diurnal habitat use in May

Agricultural area was mostly used habitat, Bibor use this habitat for 89.4%, followed by Toro 61.8%, then Ersek 46.2% and finally Vadkert 21.5%.

Industrial or commercial area was second used habitat, with Vadkert use the habitat by 50.9% followed by Ersek 27.9%, then Toro 26.1% and last Bibor with 2.7%.

Discontinuous urban fabric area was third habitat used, where Vadkert use the area by 27.5%, followed by Ersek 25.1%, then Toro 11.9% and finally Bibor 7.1%.

Forest and semi natural area was the least used habitat in May with Bibor used the area by 0.73%, followed by Ersek o.7%, then Vadkert 0.2% and last Toro 0.17% (Figure 10).

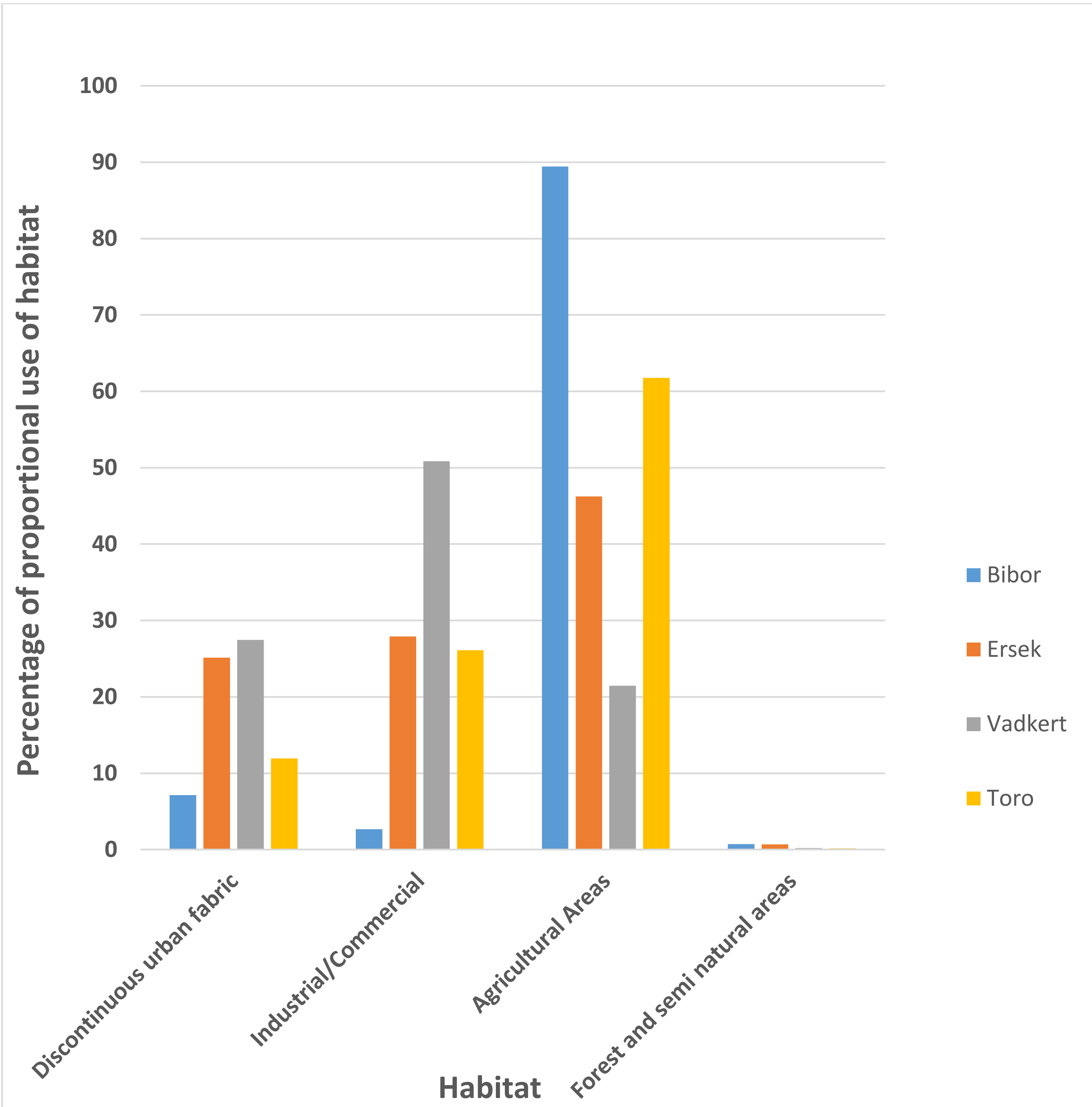

Figure 10: Individual variation of diurnal habitat use of tagged Rooks in May

4.2.4. Individual variation of diurnal habitat use in June

Agricultural area was most used habitat with Bibor used the area by 88.1%, followed by Toro 64.4%, then Ersek 53.8%, finally Vadkert 50.9%.

Discontinuous urban fabric was the second used habitat with Ersek 40.8%, Toro 16.7%, and Vadkert 14.3%, but Bibor show minimal occurrence with 1.3%.

Industrial or commercial areas was third used habitat with Vadkert 34.8%, Toro 17.7%, Bibor 8.8% and last Ersek 4.1%.

Forest and semi natural areas was the least used habitat with Bibor 1.8%, followed by both Toro and Ersek with 1.2%, Vadkert never use this habitat (Figure 11).

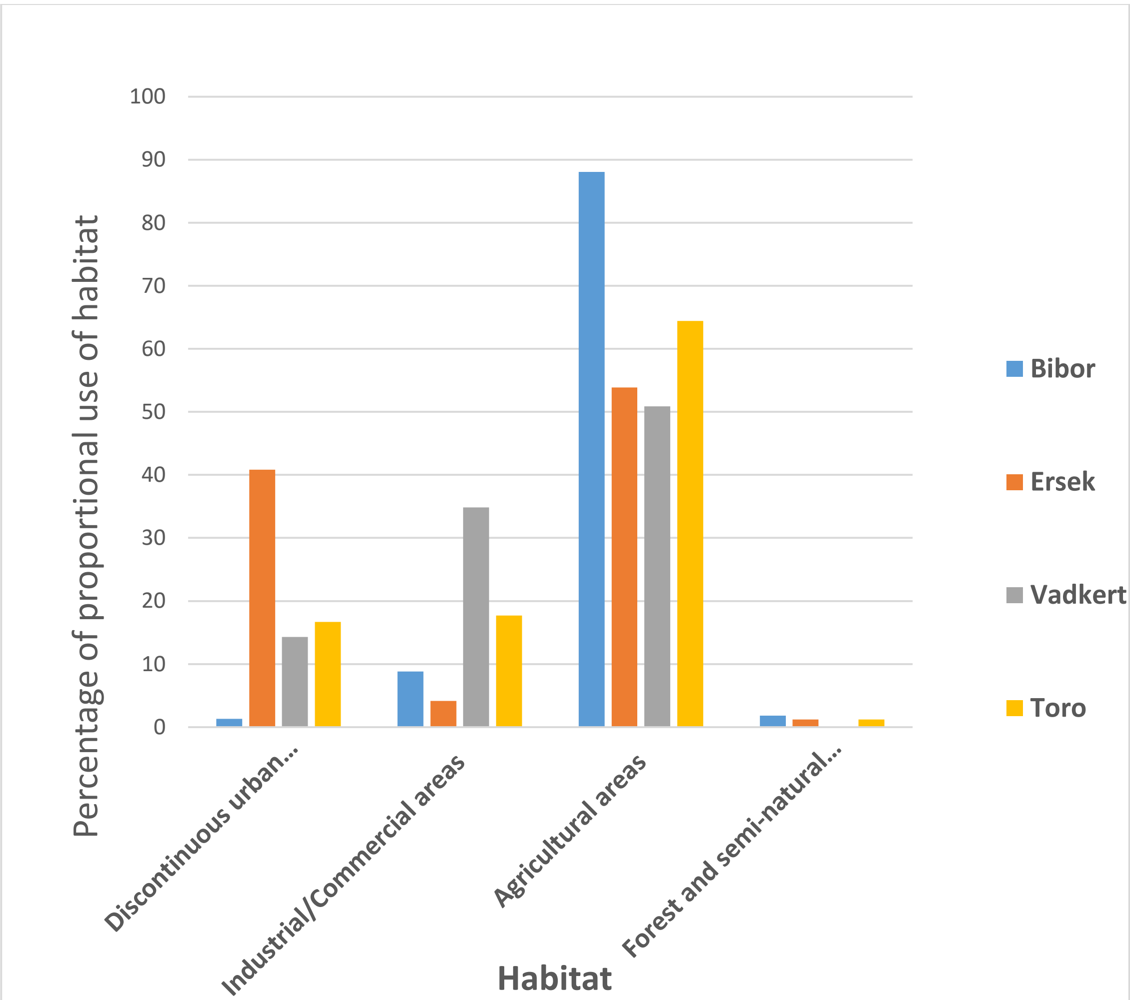

Figure 11: Individual variation of habitat use during the day in June

4.3. Nocturnal habitat use

4.3.1 Nocturnal habitat use in April

Industrial or commercial areas was highly used with 48% of use, the next habitat was discontinuous urban fabric area with 29.4% of use, followed by agricultural area 11.5% and last forest and semi natural area 11.1% (Figure 12).

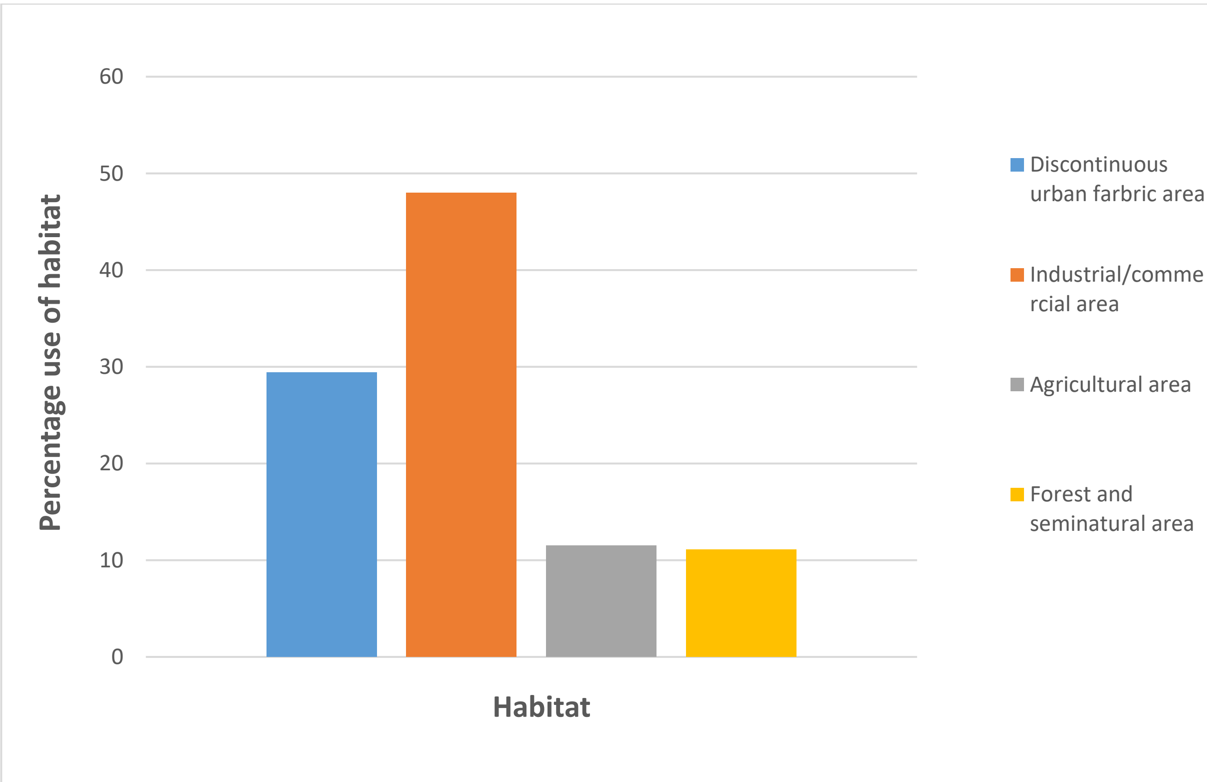

Figure 12: Nocturnal habitat use of tagged Rooks in April

4.3.2. Individual variation of nocturnal habitat use in April

Bibor spend most of the night time in discontinuous urban fabric areas 47%, next habitat was forest and semi-natural areas 23% and less used habitat was both agricultural areas and industrial or commercial area with 15% each.

Ersek spend most of the night time in industrial or commercial areas, followed by discontinuous urban fabric areas then agricultural areas but never utilize forest and semi natural areas (Figure 13).

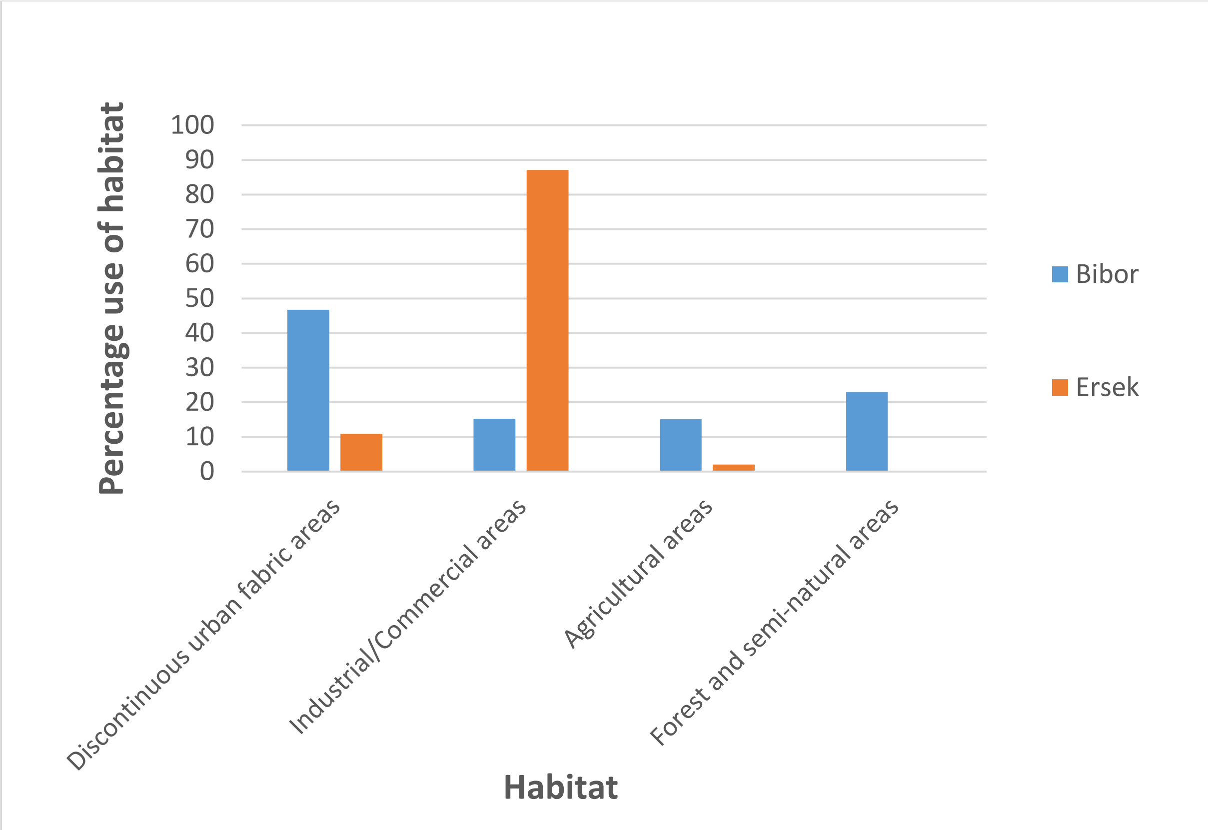

Figure 13: Individual variation of nocturnal habitat use in April

5. Discussion

5.1. Home range size

5.1.1 Monthly Home range size

Home range is an area where an animal normally traverse through when foraging, mating, and caring for its young (Burt, 1943). It gives wild animals a range of essential natural resources and conditions (Gareshelis 2000). The home range size varied temporally, where the mean home range size was the largest in April 232.8 ± SD 320.2 km^2, followed by June 179.1 ± SD 1 79.6 km^2, and the mean home range size was the smallest in May 85.8 ± SD 24.5 km^2.

Overall for a breeding Rook, nest building, and mating occurs in March and egg laying start at late March or early April (Carlson & Townsend, 2014). From mid to late April hatching occurred which is 16 to 18 days from end of egg laying period (Kasprzykowski, 2007) and the parents' starts to feed the chicks, Chick fledges in mid to late May and In June adults do not stay necessarily at the same colony where by this time Juvenile may join non breeding flocks (Madge, 2020). Time of occurrences of these breeding activities (from mating to hatching) depends on when nest building has started and this is controlled by weather condition during early spring. Rooks can adjust the time of starting nest construction if weather condition is unfavorable in early spring especially due to strong winds that may occur and cause nest collapsing during the early stage of construction (Madge, 2020). Thus in study area, the high mean home range size in April might be it was the period were Rooks constructed their nests hence resulted to have large movements in searching for building materials. The minimum home range size that occurred in May might be due to the fact that it was incubation period followed by chick rearing, since both male and female Rooks are involved in taking care of nestling then there movements might be were limited by such reason. Relative high mean home range size in June compared to April might be was due to fledging time of chicks, thus little care from parents are needed and adult Rooks start to increase their movements for searching better habitat for foraging.

5.1.2. Individual variation in home range size

The home range sizes in the study area had a considerable inter-individual variation, the largest mean home range was observed from Bibor 404 ± SD 301 km^2 followed by Toro 140.6 ± SD 107.7 km^2, then Ersek 77.1 ±19.1 Km^2 and last Vadkert 41.3 ± 33.6 SD km^2. Thus Bibor has 4.7-fold mean home range size than the average of mean home range sizes of Toro, Ersek and

Vadkert. The extent to which individual and environmental factors may have an impact on how much area wild animals use has been the subject and several hypotheses have been developed (Reinecke et al., 2014; Christiansen et al., 2017). Previous studies has demonstrated that ecological factors like food availability, topography, and shelter conditions as well as internal factors like sex and age can all have an impact on how animals' home ranges are (Guarino, 2002; Teng et al., 2021). In this case relative higher mean home range size of Bibor might be due to the fact that Bibor was in the second calendar year at the time of capture while other three birds were estimated to have more than two years old, So at that age Bibor likely was not yet to establish a breeding pair bond while other three Rooks are older enough to have a pair bond. By considering April to June it is a breeding season, pair bonds always do not move far from their nest as both pairs involved in chick rearing. For this reason I can suggest that minimum mean home range sizes of Vadkert, Toro, and Ersek were attributed by involved in breeding activities while large mean home range size of Bibor was due to not being involved in breeding activities.

5.2. Habitat use

5.2.1. Diurnal habitat use

Rooks are bird species that are attached to agricultural regions in temperate zones, especially in Central and Eastern Europe (Orłowski et al., 2010; Kitowski et al., 2017). They most favor mixed-farmland environments (Madge, 2020) and showing less prevalent in specialized agricultural regimes (Brenchley, 1984). For foraging, Rooks need large grasslands and steppe ecosystems with arable land, where the soil is often soft and fertile (Carlson & Townsend, 2014; Madge, 2020). In this study, I found the same that Rooks were strongly associated with farmland areas, especially during the day furthermore, the intensity of use of farmland areas increased from April, May to June by 42%, 51.2%, and 69.4% respectively. April is a period of planting most spring cereal grains in Hungary including the study area, at this time the soil is soft after plowing during farm preparation. The high frequency of Rooks toward these areas might be due to easy probing of invertebrates and planted cereal grain seeds from plowed soils. Rooks are omnivorous in nature and their diet fluctuates considerably depending on what is available at a particular time (Glenlivet Wildlife, 2023). Thus increasing the percentage of occurrences in agricultural areas, especially in June might be strongly associated with the period when cereals like spring barley, oat, pea, and bean start to ripen, so at this time cereal grains become more abundant and Rooks show strong affection to the area due to high availability of food.

5.2.2. Individual variation in diurnal habitat use

Habitat use and selection is described as the intensity of usage of a habitat relative to its availability (Johnson, 1980; Mauritzen et al., 2003), which may reflect the habitat's worth or configuration and may persist through time (Augé et al., 2014) or may be functionally responsive to a variety of internal and external circumstances, including age, sex, competition, or climate (Mauritzen et al., 2003; Godvik et al., 2009). Individuals in a population of animals are likely to choose different foraging habitats, which shows how they respond to environmental cues (Mitchell et al., 2020), which also might vary with sex, age, and breeding stage. Individuals within populations may exhibit both generalist and specialized habitat use tendencies (Patrick & Weimerskirch, 2017). Generalists have a wider niche and use extensive variety of resources than specialists, whose diet or habitat choice is thinner and frequently more inflexible (Wilson & Yoshimura, 1994). A high grade of habitat specialization should encourage higher effectiveness in the foraging individual (Garnick et al., 2016). Nevertheless, this may also imply that these individuals are less able to adapt to alternative resources, making them more susceptible to change (Wilson & Yoshimura, 1994; Polito et al., 2015). The benefit of specialization can be seen when resources are plenty and individuals have ability to isolate their resource use from conspecifics (Maldonado et al., 2017). In this study I can propose that Bibor, Toro and Vadkert are habitat specialist with Bibor and Toro specialized in Agricultural areas with 84% and 57.2% of the average use of the agricultural areas in three months respectively while Vadkert specialized in Industrial or commercial areas with 47.5% of average use of this habitat in three months. The relative high frequency of occurrence of Bibor and Toro in Agricultural areas and Vadkert in industrial or commercial areas support assumption of their specialization toward these habitats. Ersek were seemed to be generalist in habitat use (Agricultural areas 47.4%, Industrial or commercial areas 20.4% and discontinuous urban habitat 32.2%) with exception to forest and semi-natural areas. All individuals seemed to have less use in forest and semi-natural areas in all three months with an average use of Bibor (1.4%), Ersek (0.8%), Toro (0.5%) and Vadkert (0.1%) which may suggest that forest and semi-natural areas are not preffered habitat by Rooks foraging.

5.3. Nocturnal habitat use

Rooks are highly social colonial birds, creating rookeries in stands of tall, mature trees that might range in size from a few couples to thousands of pairs (Madge, 2020). Rookeries can also be found in large metropolitan parks, churchyards, tall trees at the outskirts of towns and villages (Madge, 2020). The rooks leave their foraging areas in the evening and stay on nearby electrical wires, trees, and buildings until dusk when they move into their roosts for the night (Hattori et al., 2022). In the study area Rooks frequently occurred in Industrial or commercial areas with 48%, the next habitat was discontinuous urban fabric areas with 29.4%, followed by agricultural areas with 11.5% and last forest and semi-natural area 11.1%. The highest frequency of occurrence in Industrial or commercial areas can be supported by the presence of abandoned buildings like warehouses or factories that are surrounded by relative tall trees where nests can be constructed. Since breeding colonies of the rooks (rookeries) can be formed in places with a medium level of man-made disturbances (Orłowski & CZapulak, 2007; Czarnecka & Kitowski 2010) similarly Rooks can be found in discontinuous urban fabric areas provided that there are relative tall stand trees and minimal human disturbance. Occurrence of Rooks in Agricultural areas was not expected but this happened may be due to variation in length of day light and night as in this study I considered daytime starting from 04:00 HRS and end at 17:59 HRS and nighttime started at 18:00 HRS up to 03:59 HRS, so it might happened that in a couple of days during study the study dusk started later than 18:00 HRS and birds continue foraging in Agriculture areas. Also without ignoring the effects of GPS malfunctions and unexpected abnormal behavior of birds may all contribute to this situation. The minimal frequencies of occurrence in forest habitat was also unexpected, but happened may be due to the inadequate of relative tall tree in forest or the forest has closed canopy, since Rooks always establish rookeries in tall trees that are in relative open areas (Carlson & Townsend, 2014; Madge, 2020).

5.3.1 Individual variation in nocturnal habitat use

Two birds use different roosting habitat at varying frequencies at night. Ersek predominately occurred in industrial or commercial areas (87.2%) while Bibor frequently occurred in discontinuous urban fabric habitat (46.8%). This indicate that all birds were searching for a habitat that offered the same essential conditions for night roosting. Ersek discovered that industrial or commercial areas were the best habitat for night roosting, whereas Bibor pointed discontinuous urban fabric areas. Results was contrary to my expectation in forest and semi–natural areas habitat where I expected to have relative high frequency of occurrence of all birds but instead, Bibor used it by 23% while Ersek never used (0%) this means that forest and semi-natural areas at the study site were unfavorable habitat for night roosting either due to presence of inadequate relative tall trees or a significant portion of the forest has a closed canopy as it has been documented by Carlson & Townsend (2014) and Madge, 2020 that Rooks establish rookeries in areas with relative tall tree and avoid closed canopy forest. Also competition for limited resources in habitat has been mentioned by Mauritzen et al., (2003) and Godvik et al., (2009) as one of the factors that may influence individual variation in habitat use. From this study I can agree that, Ersek did not use forest and semi-natural areas for roosting at night may be to lessen the competition with its conspecifics in roosting sites or even may be the way to avoid predators.

6. Conclusion

Despite the small number of individuals (n=4) tracked in this study, it represented the first attempt to conduct a descriptive analysis on the size of the home range and habitat use of the Rooks during breeding season in Hungary using GPS tags, which helps us better understand the spatial behavior for this bird species. Three things can be highlighted from this study. First, movement of Rooks in Hungary during breeding season is larger compared to another part in Central Europe for-instance in Poland where movement of Rooks are confined within 1km from their nest during breeding season (Kasprzykowski 2003). Second, during breeding season of Rooks in Hungary, Rooks frequently occur in Agricultural areas during the day and their frequencies of occurrences increased from April to June. The increase of the percentage use of Agricultural areas in breeding season can be presumed that is associated with the availability of grain cereals during the planting period and immediately after the grain crops start to ripen. This may rise tension to the farmers and public on the impact of these birds' species to the crops since in many parts of Central Europe Rooks are considered as agricultural pest (Kalotás & Nikodémusz, 1981; Orłowski & CZapulak, 2007). Third to the large extent rookeries were established in artificial areas. As seen in nocturnal habitat use where Rooks used most of the time in industrial or commercial and discontinuous urban habitat, this may result to increase in human-Rooks-interaction and become a potential source of conflict through nuisance (Therkildsen et al.,2021; Hattori et al., 2022).

Based on this, I suggest that habitat improvements for Rooks in forest and semi-natural areas are essential in the study site. This will create a favorable environment for Rooks to establish rookeries in forest and semi-natural areas which may result in a reduction in human-Rook conflict that may arise in areas predominantly used by humans. I also recommend that further studies of this bird species be conducted, especially the habitat requirements of the Rooks which will assist to explain why there is such a big movement of Rooks in Hungary during the breeding season, and studies on diet composition of Rooks will help to comprehend and explain why Rooks are strongly associated with agricultural areas in Hungary.

7. SUMMARY

The breeding Rook population of Hungary is resident with smaller-scale southern displacements in the Carpathian Basin. In spite of the relatively low number of individuals (n=4) tracked in this study, it marked the first attempt to make a descriptive analysis on the home range size and habitat use of the Rooks during breeding season in Hungary with GPS tags, which contributes to providing us a better understanding about the spatial behavior for this bird species. The result show home range size varied temporally between months and between individuals, where the mean home range size was the largest in April 232.8 ± SD 320.2 km^2, followed by June 179.1 ± SD 179.6 km^2, and the mean home range size was the smallest in May 85.8 ± SD 24.5 km^2. Age which direct relate to the breeding activities was the main factor accounted for the large inter-individual variation in home range sizes. One young bird (not breeding) has large mean home range size (404.4 ± SD 301.1 Km^2) compared to other three breeding birds 140.6 ± SD 107 .7 km^2, 77.1 ± SD 19.1 km^2, and 41.3 ± SD 33.6 km^2. Agricultural areas were the most used habitat during the day and the intensity of use increased from April (42%), May (51.2%) and June (69.4%). Diurnal specialization of habitat use were observed where two birds specialized in agricultural areas (84% and 57.2%), one bird specialized in industrial or commercial areas (57.2%) and last bird seemed to be generalist in three habitats agricultural areas (47.4%), Discontinuous urban fabric areas (32.2%) and industrial or commercial areas (20.4%). Forest and semi-natural areas were not I deal diurnal habitat for all four Rooks (1.4%, 0.8%, 0.5%, and 0.1%). Industrial or commercial areas and discontinuous urban fabric were the most nocturnal habitat use by the Rooks (48% and 29.44%). Forest and semi-natural areas was the least used habitat (11.1%) which was contrary to the expectation. Individual specialization in nocturnal habitat use were also observed. One bird specialize in industrial or commercial areas 87.2% and another in discontinuous urban fabric areas 46.8%. From this study it indicates that to a large extent, Rookeries are established in artificial areas which may facilitate human-Rooks interaction and also agricultural areas are optimal habitat for Rooks foraging. Thus habitat management is important in natural and semi-natural areas around the study area in order to create suitable conditions for rookeries establishment in natural areas rather than artificial areas. Further studies are recommended especially in diet composition of Rooks in Hungary which will

help to understand and explain the strong association between foraging Rooks and agricultural areas.

8. ACKNOWLEDGMENT

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9. REFERENCES

Allen, J. A. (1883). Intelligence of the Crow. *Science*, *1*(18), 513–513.

Andersson, M., & Krebs, J. (1978). On the evolution of hoarding behaviour. *Animal Behaviour*, *26*, 707–711. https://doi.org/10.1016/0003-3472(78)90137-9

Augé, A. A., Chilvers, B. L., Moore, A. B., & Davis, L. S. (2014). Importance of studying foraging site fidelity for spatial conservation measures in a mobile predator. *Animal Conservation*, *17*(1), 61–71. https://doi.org/10.1111/acv.12056

Baker, J. R. (1974). Protozoan parasites of the blood of British wild birds and mammals. *Journal of Zoology, Lond.*, *172*, 169–190.

BirdLife International (2023) Species factsheet: *Corvus frugilegus*. Retrieved February 13, 2023, from http://www.birdlife.org.

Borkowska, L., Królak, E., Kasprzykowski, Z., & Kaczorowski, P. (2015). The influence of Corvus frugilegus nesting on soil parameters and plant composition in poor and fertile habitats. *Landscape and Ecological Engineering*, *11*(1), 161–167. https://doi.org/10.1007/s11355-014-0256-9

Brenchley A. (1984): The use of birds as indicators of change in agriculture. In: Jenkins D. (ed.), Agriculture and the 123–128environment. *Natural Environment Research Council, Cambridge:*

Brown, C.R. & Brown, M.B. 2001. Avian coloniality, progress and problems. *Curr. Ornithol*. 16: 1–82

Browne, R. G., Kelly, T. C., Culloty, S., Davenport, J., & Deeny, T. (2007). The schematic eye of the rook, Corvus frugilegus. *Folia Zoologica*, *56*(4), 399–404.

Burt, W. H. (1943). Territoriality and Home Range Concepts as Applied to Mammals. *Journal of Mammalogy*, *24*(3), 346–352. https://doi.org/10.2307/1374834

Carlson, L., & Townsend, K. (2014). *Corvus frugilegus (rook)*. Animal Diversity Web. Retrieved February 19, 2023, from https://animaldiversity.org/accounts/Corvus_frugilegus/

Coombs, C. J. F. (1961). Rookeries and Roosts of the Rook and Jackdaw in South-West Cornwall. Part II. Roosting. *Bird Study*, *8*(2), 55–70. https://doi.org/10.1080/00063656109475989

Czarnecka, J., & Kitowski, I. (2010). Seed Dispersal by the Rook Corvus Frugilegus L. in Agricultural Landscape—Mechanisms and Ecological Importance. *Polish Journal of Ecology*, *58*(3), 511–523.

Czarnecka, J., & Kitowski, I. (2013). Rook Spring Seed Dispersal in the Agricultural Landscape – Frugivory, Granivory or Accidental Transport? *Folia Geobotanica*, *48*(1), 55–73. https://doi.org/10.1007/s12224-012-9134-0

Eeva, T., & Lehikoinen, E. (1996). Growth and mortality of nestling great tits (Parus major) and pied flycatchers (Ficedula hypoleuca) in a heavy metal pollution gradient. *Oecologia*, *108*(4), 631–639. Scopus. https://doi.org/10.1007/BF00329036

ENvironmental inFOrmation (2023). *Rook (Corvus frugilegus)* | Retrieved February 19, 2023, from https://enfo.hu/index.php/en/node/10788

Feare, C. J. (1974). Ecological Studies of the Rook (Corvus frugilegus L.) in North-East Scotland. Damage and Its Control. *Journal of Applied Ecology*, *11*(3), 897–914. https://doi.org/10.2307/2401752

Feare, C. 1978. The ecology of damage by rooks (*Corvus frugilegus*). *Annals of Applied Biology*, 88/2: 329-334.

Gareshelis, D.L. (2000) *Delusions in Habitat Evaluation: Measuring Use, Selection, and Importance*. ResearchGate. Retrieved April 6, 2023, from https://www.researchgate.net/publication/236981849_Delusions_in_Habitat_Evaluation_Measuring_Use_Selection_and_Importance

Garnick, S., Di Stefano, J., Elgar, M. A., & Coulson, G. (2016). Ecological specialisation in habitat selection within a macropodid herbivore guild. *Oecologia*, *180*(3), 823–832. https://doi.org/10.1007/s00442-015-3510-4

Glenlivet Wildlife (2023) Rooks (Corvus frugilegus). Retrieved February 15, 2023, from https://glenlivet-wildlife.co.uk/birds/rook/

Goodwin, D. 1955. Some observations on the reproductive behaviour of Rooks. *British Birds*48:97–107.

Godvik, I. M. R., Loe, L. E., Vik, J. O., Veiberg, V., Langvatn, R., & Mysterud, A. (2009). Temporal scales, trade-offs, and functional responses in red deer habitat selection. *Ecology*, *90*(3), 699–710. https://doi.org/10.1890/08-0576.1

Google Maps (2023). *Érsekvadkert—Google Maps*. Retrieved April 27, 2023, from https://www.google.com/maps/place/%C3%89rsekvadkert.

Green, P. T. (2008). Bigamy in the rook Corvus frugilegus. *Ibis*, *124*(2), 193–196.

Gromadzka, J. 1980. Food composition and food consumption of the Rook *Corvus frugilegus* in agrocenoses in Poland. *Acta Ornithol*. 17: 227256.

Guarino, F. (2002). Spatial ecology of a large carnivorous lizard, Varanus varius (Squamata: Varanidae).*Journal of Zoology*: *258*. https://doi.org/10.1017/S0952836902001607

Han, S.-H., Kim, T.-W., Kim, Y.-K., Park, J.-H., Kim, D.-M., Adhikari, P., Park, S.-G., Park, S.-M., Kim, G.-R., Lee, J.-W., & Oh, H.-S. (2015). Molecular identification and Phylogenetic relationship of the rook (Corvus frugilegus) population in Jeju-do Province, South Korea. *Korean Journal of Environment and Ecology*, *29*(5), 693–702. https://doi.org/10.13047/KJEE.2015.29.5.693

Hattori, M., Sobagaki, T., Matsuda, H., Nakamura, S., & Tokuda, M. (2022). The wintering ecology of the Rook Corvus frugilegus in Northern Kyushu, Japan. *Urban Ecosystems*, *25*(6), 1901–1911. https://doi.org/10.1007/s11252-022-01273-0

Horváth, É., Solt, S., Kotymán, L., Palatitz, P., Piross, I. S., & Fehérvári, P. (2015). Provisioning nest material for Rooks; a potential tool for conservation management. *Ornis Hungarica*, *23*(1), 22–31. https://doi.org/10.1515/orhu-2015-0002

Ishida, A. (1997). Seed germination and seedling survival in a colony of the common cormorant,Phalacrocorax carbo. *Ecological Research*, *12*(3), 249–256. https://doi.org/10.1007/BF02529454

Jadczyk, P., & Jakubiec, Z. (2005). Wintering of rooks Corvus frugilegus in Poland. *Ptaki Krukowate Polski (Corvids of Poland)*, 541–556.

Johnson, D. H. (1980). The comparison of usage and availability measurements for evaluating resource preference. Ecology, 61(1), 8. https:// doi.org/10.2307/1937156

Källander, H. (2007). Food hoarding and use of stored food by Rooks *Corvus frugilegus*. *Bird Study*, *54*(2), 192–198. https://doi.org/10.1080/00063650709461475

Kasprzykowski, Z. (2007). Reproduction of the rook, *Corvus frugilegus* in relation to the colony size and foraging habitats. *Folia Zool. – 56(2):* 186–193

Kasprzykowski, Z. (2003). Habitat Preferences of Foraging Rooks Corvus frugilegus During the Breeding Period in the Agricultural Landscape of Eastern Poland. *Acta Ornithologica*, *38*, 27–31. https://doi.org/10.3161/068.038.0107

Kasprzykowski, Z. (2008). Nest location within the tree and breeding parameters of Rooks Corvus frugilegus. *Bird Study*, *55*(1), 59–65. https://doi.org/10.1080/00063650809461505

Kitowski, I. (2017). Diet of Rooks *Corvus frugilegus* and potential seed dispersal in urban and agricultural habitats of Romania and Poland. *North-western journal of zoology 13 (1)*: 94-100

Kitowski, I., Jakubas, D., Wiącek, D., & Sujak, A. (2017). Inter-colony differences in hepatic element concentrations of European flagship farmland bird, the Rook Corvus frugilegus, breeding in rural habitats in East Poland. *Agriculture, Ecosystems & Environment*, *250*, 123–132. https://doi.org/10.1016/j.agee.2017.08.027

Krivolutsky, D., & Lebedeva, N. (2004). Oribatid Mites (Oribatei) in Bird Feathers: Passeriformes. *Acta Zoologica Lituanica*, *14*, 19–38. https://doi.org/10.1080/13921657.2004.10512577

Lockie, J. D. (1955). The Breeding and Feeding of Jackdaws and Rooks with Notes on Carrion Crows and Other Corvidae. *Ibis*, *97*(2), 341–369. https://doi.org/10.1111/j.1474-919X.1955.tb01919.x

Madge, S. (2020). Rook (Corvus frugilegus), version 1.0. *Birds of the World*. https://doi.org/10.2173/bow.rook1.01

Maldonado, K., Bozinovic, F., Newsome, S. D., & Sabat, P. (2017). Testing the niche variation hypothesis in a community of passerine birds. *Ecology*, *98*(4), 903–908. https://doi.org/10.1002/ecy.1769

Malmberg, T. (1973). Pesticides and the Rook Corvus frugilegus in Scania, Sweden between 1955 and 1970. *Oikos*, *24*(3), 377–387. https://doi.org/10.2307/3543814

Mason, C. F., & Macdonald, S. M. (n.d.). *Distribution of foraging rooks, Corvus frugilegus, and rookeries in a landscape in eastern England dominated by winter cereals*.

Mauritzen, M., Belikov, S. E., Boltunov, A. N., Derocher, A. E., Hansen, E., Ims, R. A., ... Yoccoz, N. (2003). Functional responses in polar bear habitat selection. Oikos, 100(1), 112–124. https://doi. org/10.1034/j.1600-0706.2003.12056.x

Mitchell, L. J., Kohler, T., White, P. C. L., & Arnold, K. E. (2020). High interindividual variability in habitat selection and functional habitat relationships in European nightjars over a period of habitat change. *Ecology and Evolution*, *10*(12), 5932–5945. https://doi.org/10.1002/ece3.6331

Mun, H. T. (1997). Effects of colony nesting of Adrea cinerea and Egretta alba modesta on soil properties and herb layer composition in a Pinus densiflora forest. *Plant and Soil*, *197*(1), 55–59. https://doi.org/10.1023/A:1004292103610

Nógrád (2023). Retrieved April27, 2023, from https://www.automataontozorendszeres.hu/nograd

Olea, P. P. (2009). Analysing spatial and temporal variation in colony size: An approach using autoregressive mixed models and information theory. *Population Ecology*, *51*(1), 161–174. https://doi.org/10.1007/s10144-008-0106-4

Orłowski, G., & CZapulak, A. (2007). Different Extinction Risks of the Breeding Colonies of Rooks Corvus frugilegus in Rural and Urban Areas of SW Poland. *Acta Ornithologica*, *42*(2), 145–155. https://doi.org/10.3161/068.042.0209

Orłowski, G., & Czarnecka, J. (2009). Granivory of birds and seed dispersal: Viable seeds of Amaranthus retroflexus L. Recovered from the droppings of the Grey Partridge Perdix Perdix L. *Polish Journal of Ecology*, *57*, 191–196.

Orłowski, G., Kasprzykowski, Z., Dobicki, W., Pokorny, P., & Polechoński, R. (2010). Geographical and habitat differences in concentrations of copper, zinc and arsenic in eggshells of the Rook Corvus frugilegus in Poland. *Journal of Ornithology*, *151*(2), 279–286. https://doi.org/10.1007/s10336-009-0453-8

Orłowski, G., Siebielec, G., Kasprzykowski, Z., Dobicki, W., Pokorny, P., Wuczyński, A., Polechoński, R., & Mazgajski, T. D. (2016). Effect of spatial resolution of soil data on predictions of eggshell trace element levels in the Rook Corvus frugilegus. *Environmental Pollution*, *219*, 288–295. https://doi.org/10.1016/j.envpol.2016.10.048

Patrick, S. C., & Weimerskirch, H. (2017). Reproductive success is driven by local site fidelity despite stronger specialisation by individuals for large-scale habitat preference. *Journal of Animal Ecology*, *86*(3), 674–682. https://doi.org/10.1111/1365-2656.12636

Patterson, I. J., Dunnet, G. M., & Fordham, R. A. (1971). Ecological Studies of the Rook, Corvus frugilegus L., in North-East Scotland. Dispersion. *Journal of Applied Ecology*, *8*(3), 815–833. https://doi.org/10.2307/2402685

Polito, M., Trivelpiece, W., Patterson, W., Karnovsky, N., Reiss, C., & Emslie, S. (2015). Contrasting specialist and generalist patterns facilitate foraging niche partitioning in sympatric populations of Pygoscelis penguins. *Marine Ecology Progress Series*, *519*, 221–237. https://doi.org/10.3354/meps11095

Porter, R.E.R. 2013 [updated 2017]. Rook. *In* Miskelly, C.M. (ed.) *New Zealand Birds Online*. Retrieved March 12, 2023, from www.nzbirdsonline.org.nz.

Power, D. M. (1983). *Current Ornithology*. Springer Science & Business Media.

Purchas, T. P. G. (1975). Rooks (Corvus frugilegus frugilegus L.) Hiding Nuts in Hawke's Bay. *Proceedings (New Zealand Ecological Society)*, *22*, 111–112.

Reinecke, H., Leinen, L., Thißen, I., Meißner, M., Herzog, S., Schütz, S., & Kiffner, C. (2014). Home range size estimates of red deer in Germany: Environmental, individual and methodological correlates. *European Journal of Wildlife Research*, *60*(2), 237–247. https://doi.org/10.1007/s10344-013-0772-1

Salinas, P., Morinha, F., Literak, I., García, J., Milá, B., & Blanco, G. (2021). Genetic diversity, differentiation and historical origin of the isolated population of rooks Corvus frugilegus in Iberia. *Journal of Avian Biology*, *52*(3). https://doi.org/10.1111/jav.02689

Schafer, E. W., Bowles, W. A., & Hurlbut, J. (1983). The acute oral toxicity, repellency, and hazard potential of 998 chemicals to one or more species of wild and domestic birds. *Archives of Environmental Contamination and Toxicology*, *12*(3), 355–382. https://doi.org/10.1007/BF01059413

Scheuhammer, A. M. (1987). The chronic toxicity of aluminium, cadmium, mercury, and lead in birds: A review. *Environmental Pollution*, *46*(4), 263–295. https://doi.org/10.1016/0269-7491(87)90173-4

Seed, A. M., Clayton, N. S., & Emery, N. J. (2008). Cooperative problem solving in rooks (Corvus frugilegus). *Proceedings of the Royal Society B: Biological Sciences*, *275*(1641), 1421–1429. https://doi.org/10.1098/rspb.2008.0111

Slagsvold, T., Røskaft, E., & Engen, S. (1986). Sex Ratio, Differential Cost of Rearing Young, and Differential Mortality between the Sexes during the Period of Parental Care: Fisher's Theory Applied to Birds. *Ornis Scandinavica (Scandinavian Journal of Ornithology)*, *17*(2), 117–125. https://doi.org/10.2307/3676860

Solt, S. (2009). Vetési varjú konfliktuskezelési javaslatok (p. 32). *MME*.

Tebbich, S., Seed, A. M., Emery, N. J., & Clayton, N. S. (2007). Non-tool-using rooks, Corvus frugilegus, solve the trap-tube problem. *Animal Cognition*, *10*(2), 225–231. https://doi.org/10.1007/s10071-006-0061-4

Teng, yang, TANG, S., meng, lai, Wu, L., HAN, Z., Han, Y., & Bao, W. (2021). *A Pilot Study on Home Range and Habitat Use of Chinese Goral (Naemorhedus Griseus): Exploring GPS Tracking Data in Cliff Landscape by Three Estimation Methods*. https://doi.org/10.21203/rs.3.rs-597882/v1

Therkildsen, O.R., Fox, A. D., Heldbjerg, H., Dalby, L., Bregnballe, T. and Vikstrøm, T. (2021). Seeking explanations for rooks shifting rookeries to urban areas and depredating sensitive crops in Denmark. *Abstracts of the 35 IUGB Congress. Budapest, 20-24 September 2021 (Vadbiológia 21)—35th Congress of the International Union of Game Biologists*, 72-73

Wilson, D. S., & Yoshimura, J. (1994). On the coexistence of specialists and generalists. The American Naturalist, 144(4), 692–707. https://doi. org/10.1086/285702

Zbyryt, A., Zub, K., & Mitrus, C. (2022). The development of the Rook's (Corvus frugilegus) colony in the face of shifting spring phenology. *Avian Research*, *13*, 100029. https://doi.org/10.1016/j.avrs.2022.100029

10. APPENDICIES

i. Pictures of captured Rooks (Photos: Katalin Odett Lukács)

(a)Bibor

(b) Ersek

(c)Toro

(d) Vadkert

ii. Corine Land Cover legend

CLC CODE	LABEL 1	LABEL 2	LABEL 3
111	Artificial surfaces	Urban fabric	Continuous urban fabric
112	Artificial surfaces	Urban fabric	Discontinuous urban fabric
121	Artificial surfaces	Industrial, commercial and transport units	Industrial or commercial units
122	Artificial surfaces	Industrial, commercial and transport units	Road and rail networks and associated land
123	Artificial surfaces	Industrial, commercial and transport units	Port areas
124	Artificial surfaces	Industrial, commercial and transport units	Airports
131	Artificial surfaces	Mine, dump and construction sites	Mineral extraction sites
132	Artificial surfaces	Mine, dump and construction sites	Dump sites
133	Artificial surfaces	Mine, dump and construction sites	Construction sites
141	Artificial surfaces	Artificial, non-agricultural vegetated areas	Green urban areas
142	Artificial surfaces	Artificial, non-agricultural vegetated areas	Sport and leisure facilities
211	Agricultural areas	Arable land	Non-irrigated arable land
212	Agricultural areas	Arable land	Permanently irrigated land
213	Agricultural areas	Arable land	Rice fields
221	Agricultural areas	Permanent crops	Vineyards
222	Agricultural areas	Permanent crops	Fruit trees and berry plantations
223	Agricultural areas	Permanent crops	Olive groves
231	Agricultural areas	Pastures	Pastures
241	Agricultural areas	Heterogeneous agricultural areas	Annual crops associated with permanent crops
242	Agricultural areas	Heterogeneous agricultural areas	Complex cultivation patterns
243	Agricultural areas	Heterogeneous agricultural areas	Land principally occupied by agriculture, with significant areas of natural vegetation
244	Agricultural areas	Heterogeneous agricultural areas	Agro-forestry areas
311	Forest and semi natural areas	Forests	Broad-leaved forest
312	Forest and semi natural areas	Forests	Coniferous forest
313	Forest and semi natural areas	Forests	Mixed forest
321	Forest and semi natural areas	Scrub and/or herbaceous vegetation associations	Natural grasslands
322	Forest and semi natural areas	Scrub and/or herbaceous vegetation associations	Moors and heathland
323	Forest and semi natural areas	Scrub and/or herbaceous vegetation associations	Sclerophyllous vegetation
324	Forest and semi natural areas	Scrub and/or herbaceous vegetation associations	Transitional woodland-shrub
331	Forest and semi natural areas	Open spaces with little or no vegetation	Beaches, dunes, sands
332	Forest and semi natural areas	Open spaces with little or no vegetation	Bare rocks
333	Forest and semi natural areas	Open spaces with little or no vegetation	Sparsely vegetated areas
334	Forest and semi natural areas	Open spaces with little or no vegetation	Burnt areas
335	Forest and semi natural areas	Open spaces with little or no vegetation	Glaciers and perpetual snow
411	Wetlands	Inland wetlands	Inland marshes
412	Wetlands	Inland wetlands	Peat bogs
421	Wetlands	Maritime wetlands	Salt marshes

422	Wetlands	Maritime wetlands	Salines
423	Wetlands	Maritime wetlands	Intertidal flats
511	Water bodies	Inland waters	Water courses
512	Water bodies	Inland waters	Water bodies
521	Water bodies	Marine waters	Coastal lagoons
522	Water bodies	Marine waters	Estuaries
523	Water bodies	Marine waters	Sea and ocean
999	NODATA	NODATA	NODATA
990	UNCLASSIFIED	UNCLASSIFIED LAND SURFACE	UNCLASSIFIED LAND SURFACE
995	UNCLASSIFIED	UNCLASSIFIED WATER BODIES	UNCLASSIFIED WATER BODIES

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