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INVESTIGATIONS REGARDING THE PERSECUTION OF RAPTORS IN AUSTRIA

Master thesis

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submitted by

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Index

1 Introduction

Raptors and ecosystems

Ecosystems are dependent on top predators and scavengers, such as raptors, because they regulate prey populations and consume carcasses and organic waste. Raptors vary considerably in size, activity (diurnal/nocturnal), and behaviour. Depending on the species they are either resident or migratory, but certain weather conditions might also result in long-distance movements of resident raptors. Consequently the number of birds in a region is subjected to variation (Richardson 1990, Forsman 2006). Besides that, their occurrence is vital for ecosystems and their disappearance can have far reaching consequences, such as loss of plant species diversity, altered disease dynamics and carbon sequestration. Because of their ecological value, predators and scavengers are considered flagship and keystone species. Nevertheless many of them have a poor public reputation, they are perceived negatively, because they depredate livestock, kill pets, or harbour disease (O'Bryan et al. 2018). Especially raptors indicate biodiversity and environmental health (Donázar et al. 2016), but their high trophic level and slow life history makes them vulnerable to anthropocentric threats (Owens & Bennett 2000, Sergio et al. 2008). Besides loss of habitat, human persecution is one of their main risks (Owens & Bennett 2000, McClure et al. 2018).

Threats and legal protection

Due to severe population declines in the last decades, several programmes have been invented to evaluate the population status of raptors. On international level, the IUCN Red List of Threatened Species differentiates seven hazard categories (Dvorak et al. 2017), on a European level Species of European Conservation Concern (SPEC) classifies three categories (Dvorak et al. 2017) and on Austrian level Birds of Conservation Concern also classifies three categories (BirdLife International 2017).

Based on the evaluation programmes, agreements and laws have been passed in order to protect birds. The Birds Directive of the European Union is the main legal regulation on European level and it controls the protection of wild birds (European Union 2010). It has to be implemented in the respective national laws of the member states, which are in Austria the Federal Nature Conservation Laws.

Each of the nine federal states of Austria has its own Nature Conservation Law (Naturschutzgesetz). Despite minor differences between the states, the main aim of these laws is, that free-living animals, including all developmental stages, must not be disturbed, persecuted, caught, hurt, killed, trapped or taken away. The habitat of free-living animals should be unaffected by human disturbance as much as possible (e.g. NÖ NSchG 2000). Free-living animals that are not huntable according to the Lower Austrian Hunting Law 1979 (Niederösterreichisches Jagdgesetz 1979) can be completely protected under certain conditions, which does not only apply to the whole animal but also its parts and products. Furthermore it is prohibited to trade and transport live or dead animals (NÖ JG 1974).

The Animal Protection Act (Tierschutzgesetz) is of particular importance for raptors, because it regulates interactions with animals in general in order to guarantee their welfare (TschG 2004). It prohibits cruelty to animals such as unjustified pain, suffering, or injury to an animal or the exposition to extreme anxiety and prohibits to kill animals without proper reason. Violating these laws is punished by fines from 7,500€, in case of a repeated offence up to 15,000€ (TschG 2004).

Each of the nine federal states in Austria has its own hunting law (Jagdgesetz), which defines huntable animals and their hunting seasons. In seven of the nine federal states all regionally occurring raptors are listed as huntable (e.g. NÖ JG 1974). In Salzburg, twelve raptor species and in Upper Austria four species are listed as generally huntable (S JG 1993, Appendix I, p. 34), but have closed season throughout the whole year (e.g. S JG 1993).

Human persecution

McClure *et al.* (2018) identified agriculture and aquaculture as the most common threats for raptors (except Old World vultures) followed by logging and wood harvesting. However, both legal and illegal hunting and trapping have been identified as the overall third highest threat; for Old World vultures, it is even the highest. Stress factors, such as species mortality – that is, direct killing or capturing – ecosystem conversion and ecosystem degradation have been found to be the three most important stressors (McClure et al. 2018).

A study from Cianchetti-Benedetti *et al*. (2016) examined 2367 injured raptors from a wildlife rehabilitation centre in Rome and found out that the most frequent cause of injury was trauma (61%), followed by gunshot (20%) (Cianchetti-Benedetti et al. 2016). Although raptors have

been protected in Italy since 1977 the high occurrence of shot-wounded raptors shows that illegal killing is still widespread and thus a serious threat. The results of this study also revealed that persecution is not confined to rural areas but it is also occurring in suburban areas (Cianchetti-Benedetti et al. 2016).

The definition of illegal killing by BirdLife International is "any form of deliberate action that results in the death or removal from the wild of an individual bird (regardless of whether it was the target of this action or not), that is prohibited under national or regional legislation" (BirdLife International 2015), such as poisoning with chemicals, shooting or trapping. Among those three categories poisoning is currently the most severe problem, it can be divided into direct and secondary poisoning. While secondary poisoning is characterised by the misuse of permitted, non-selected rodenticides and other poisoning chemicals, direct poisoning consists of the use of non-permitted, illegal poisons (*e.g.* carbofuran), which are usually distributed to kill carnivores and birds (Pannoneagle LIFE project n.d.). Carbofuran is an extremely toxic carbamate pesticide, which elicits toxic manifestations of the central and peripheral nervous system. In general this poison leads to death in animals and birds through respiratory failure, but it is also highly toxic to humans when being inhaled or swallowed (Gupta 2009).

According to Brochet *et al*. (2017) 7,500-40,500 raptors per year are estimated to be killed or taken illegally in Central Europe. Moreover raptors were the group with the highest number of species affected by illegal killing (Brochet et al. 2017).

A recent study from Hirschfeld *et al*. (2017) investigated raptor persecution in Germany. They found, that between 2005 and 2015 998 cases of illegal persecution have been documented. In total 1,445 raptors (20 species) and 44 owls (five species) were reportedly killed or injured, 49 % of which coming surprisingly from one federal state (North-Rhine – Westphalia). The methods of persecution are ranging from poisoning, trapping, shooting to nest destruction or nest disturbance. The success rate regarding prosecution in Germany is very low with 7.2 % (Hirschfeld et al. 2017), consequently making a reduction and prevention of persecution even more difficult. Despite that, it is known that predominantly hunters and poultry keepers are the perpetrators due to still existing beliefs of raptors as pests or competitors (of ground game) (Hirschfeld et al. 2017).

Indicators of persecution

Although official numbers of raptor persecution are available from several countries (Belka & Horal 2009, Coeurdassier & Scheifler 2010, RSPB Scotland 2015, Cianchetti-Benedetti et al. 2016, Molenaar et al. 2017, Hirschfeld et al. 2017), unreported case numbers are estimated to be much higher, since little is known about trustworthy indicators and evidences of illegal persecution (BirdLife International 2017). Asymmetrical gaps in the plumage of wings and/or tails (Fig. 1) are conspicuous and differ from regular, symmetrical moulting (Forsman 2006), thus can be suspected to be predominantly a result of gunshots. Depending on the damage of the plumage the feathers of these shot marks either regrow or not. Furthermore, this assumption can be supported by the fact that most raptors stop moulting in winter (Forsman 2006).

Figure 1: Examples of shot marks shown on a *Buteo buteo* and a *Haliaeetus albicilla.* Copyright: Benjamin Watzl

Aim of this study

In Austria persecution of raptors seems to be still a widespread problem. Especially in Lower Austria, not only many shot marks have been reported, but also several cases which generated great medial interest were located in Lower Austria (Windtner 2015, ORF 2013). Especially one case in the district Mistelbach achieved attention, because 37 shot *Circus aeruginosus* were found by ornithologists in one soybean field (Windtner 2015).

Therefore, this study aims to investigate the magnitude of persecution of diurnal raptors in Lower Austria. Raptor monitoring in earlier detected hotspots was performed and combined with information from existing data bases.

Thus, we tested the hypotheses that (i) the number of proven cases of persecution is correlated with the occurrence of raptors with shot marks, (ii) the number of proven cases of persecution is correlated with the density of ground game and (iii) the number of proven cases of persecution is correlated with the relative abundance of raptors.

2 Material and Methods

Raptor monitoring

From November 2017 until March 2018, data on relative abundances and signs of shot marks were collected using the line transect method without distance measurement (Bibby et al. 1995), which has already been shown to be a suitable method in previous raptor surveys in Austria (Bieringer & Laber 1999, Dvorak & Wendelin 2008). Following the transect line, observations were performed by one person. Stops were made occassionally, *e.g.* at vantage points with a clear sight in order to investigate the area closer. Species, number of individuals and shot marks were written down, additionally, wherever possible, age and sex were documented. Double counts were noted and excluded from the data.

Study area

The study area is located in the North-Eastern part of Austria in the federal states Upper (UA) and Lower Austria (LA). All regions are characterised by comparatively flat and slightly hilly countrysides which are mainly used for intensive agriculture. These areas are in general clearly visible apart from shelter belts or small forests. For data collection preferably small streets or agricultural roads were chosen whereas heavily travelled roads or cities were avoided. As far as possible the routes remained the same throughout all observations although minor changes occurred due to the weather conditions. The study area is the ideal habitat for numerous raptor species, which rely on open areas like agricultural fields or meadows (*e.g. Buteo buteo, Falco tinnunculus*), but also rarer species like *Aquila heliaca* or winter guests like *Buteo lagopus* are found in this region (Forsman 2006).

Routes

In total ten different routes were surveyed between two and five times (see Tab.2) by five observers (Tab. 1). Areas with the highest number of known cases of persecution were chosen. Detailed route descriptions are given in Appendix II (p. 34).

Table 1: Number, districts and observers of all ten routes. LA= Lower Austria, UA= Upper Austria

Name	District (Federal state)	Observer
R1	Mistelbach, Gänserndorf, Korneuburg (LA)	Sabine Riener
R2	Gänserndorf (LA)	Sabine Riener, Helmut Jaklitsch
R3	Hollabrunn, Korneuburg, Tulln (LA)	Sabine Riener
R4	Gänserndorf (LA)	Matthias Schmidt
R5	Linz-Land, Steyr-Land (UA)	Sabine Riener
R6	Horn, Hollabrunn (LA)	Johannes Hohenegger
R7	Horn (LA)	Johannes Hohenegger
R8	Horn, Hollabrunn (LA)	Johannes Hohenegger
R9	Waidhofen an der Thaya, Horn (LA)	Benjamin Watzl
R10	Waidhofen an der Thaya, Zwettl (LA)	Benjamin Watzl

Technical devices

Route tracking has been performed on mobile phones using applications, such as Bergfex Touren (Bergfex GmbH, version 231, 2018, Austria). NaturaList Application (Biolovision Sàrl, version 0.92, 2017, Switzerland) was used to immediately record all observations which have been imported to the www.ornitho.at data base (https://www.ornitho.at/) hereinafter simply referred to as ornitho.at. Observations were performed using binoculars and spotting scops. Evidence pictures were taken.

Control status

Individuals have been assigned to two groups regarding the visibility of potential shotmarks: Controlled (c) defined by wing and tail feathers visible; not controlled (nc) – not visible (due to distance, behaviour or visibility).

Data base evaluation

Raptor persecution

Persecution data of raptors were collected from BirdLife Austria and WWF Austria as part of the LIFE project "Conservation of the eastern imperial eagle by decreasing human-caused mortality in the Pannonian Region"and ranged from 1999 to 2019. Despite the amount of data this data base is not complete – mainly because cases of persecution are not reported in general to these organizations.

In addition all documented cases from the raptor sanctuary „Eulen- und Greifvogelstation Haringsee" in Lower Austria between 2002 and 2018 were provided as well as respective entries from ornitho.at from 1999 to 2018.

Information about shot marks was obtained from ornitho.at after two appeals in September 2015 (independently from this work) and in January 2018 and filtered for mortality plus the keywords: "illegale Verfolgung", "Schrot", "Schuss", "verletzt", and "Falle". The timespan of the entries ranged from the beginning of this data base in 2013 to 2019.

Every case contains information at least about the number and species of the victims, the type of persecution, date and location (district). Further evidences (X-ray and/or toxicologic test) and regarding shot marks a detailed description of the observations were required in order to categorize a case as proven. One case can contain more than one victim.

Within this study four different types of persecution are distinguished: Shooting, direct poisoning, decoy and trap. Shooting is defined by at least one shot raptor regardless of whether it was injured or killed. Poisoning must include an intoxicated raptor, while decoy are only poisoned baits. All illegal traps, which have the purpose to catch raptors, regardless of the presence of a trapped raptor, are defined as such. Redundant cases were excluded.

Ground game

The statistics of shot ground game were received from the federal hunting associations from Upper and Lower Austria (Landesjagdverband Oberösterreich & Niederösterreich), while we received data from all 15 districts in Upper Austria for 2017/2018, we only got data from six out of twenty districts in Lower Austria for 2017.

Statistical analysis

Data management was done in Microsoft Office Excel 2010. Graphs were depicted using IBM SPSS Statistics VS 24.0.0 and Microsoft Office Excel 2010. Descriptive statistics was calculated with Microsoft Office Excel 2010, correlations were analysed with IBM SPSS Statistics VS 24.0.0.

To analyse the data gained from monitoring, individuals per 10 km were calculated i) per route and ii) per district in order to get relative abundances. Further means and standard deviations were computed from the relative abundances of all routes. Species occurrence was analysed among all observations, minima and maxima were assessed for the three most common species selected per district.

All reported shot marks were selected per district and species, furthermore a separation between the reports on ornitho.at and the reports during monitoring was performed due to different survey methods. For the calculation of correlations the shot marks assessed during monitoring were excluded due to different evaluation methods.

Persecution cases were distinguished and analysed per state and district. Besides that, the percentage of proven cases and types of persecution were calculated.

Regarding the density of ground game numbers of shot hare (*Lepus europaeus*) and pheasant (*Phasianus colchicus*) were used.

To investigate a possible correlation of proven cases of persecution and the occurrence of raptors with shot marks a Spearman's rank correlation test was performed using all 43 districts with both variables available. Additionally Spearman's rank correlation was calculated between shot marks and persecution cases of the type shooting, where all 21 districts with both variables available were used.

The same test was used for calculating the correlation between proven cases of persecution and shot ground game using all 15 districts with both variables available. For the analysis of the relation between proven cases of persecution and the relative abundances Spearman's rank correlation was performed using all six districts with both variables available.

3 Results

Raptor census

During all 35 counts on ten different routes, 1259 raptors in total were spotted (Tab. 2), out of which 425 individuals (33.76 %) could be controlled for shot marks. Between five and 93 raptors could be observed per count, the relative abundance ranged between 0.86 individuals/10 km and 9.89 individuals/10 km. The lowest values were found in Waidhofen an der Thaya and Zwettl (R10) in December and January, whereas the highest value was near Horn and Hollabrunn (R8) in November. The mean of all routes was 4.32 individuals/10 km with a standard deviation of 2.19. The assessment of raptors per district ranged from 3.03 individuals/10km in Korneuburg to 6.21 individuals/10km in Horn (Tab. 3).

Out of the controlled raptors 16 birds with shot marks (3.76 %) could be identified. Most shot marks were observed in *Buteo buteo* (10), besides *Buteo lagopus* (3), *Haliaeetus albicilla* (1), *Milvus milvus* (1), and *Falco tinnunculus* (1) showed shot marks.

Species occurrence

In the investigated period, *Buteo buteo* was the most abundant species with 58.78 %, followed by *Falco tinnunculus* with 25.02 %. The remaining eleven species were ranged from 6 % in *Buteo lagopus* to 0.08 % in *Milvus migrans* and *Circus aeruginosus*. Three observed raptors could not be identified properly due to big distance or bad visibility (Tab. 4).

B*uteo buteo* was most abundant in Horn and rarest in Korneuburg. The highest abundance of *Falco tinnunculus* was in Gänserndorf, the lowest in Linz-Land. B*uteo lagopus* could only be registered in three of the six districts: Horn, Hollabrunn, and Gänserndorf (Tab. 3).

Table 2: Total number of individuals of all species observed and the relative abundance of raptors given as individuals/10 km for each route.

Name of routes	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
Number of counts	**3**	**3**	**3**	**3**	**3**	**5**	**5**	**5**	**3**	**2**
Buteo buteo	66	56	49	109	90	213	82	75	0	0
Falco tinnunculus	33	40	31	42	23	73	23	50	0	0
Buteo lagopus	0	2	1	4	0	22	2	7	25	10
Circus cyaneus	0	1	4	8	3	13	2	2	0	0
Haliaeetus albicilla	2	3	3	7	0	4	0	5	0	0
Accipiter nisus	1	4	3	0	1	3	6	5	0	0
Milvus milvus	1	9	0	3	0	0	0	0	0	0
Aquila heliaca	0	1	1	3	0	0	0	7	0	0
Falco colombarius	0	0	0	2	0	1	1	4	0	0
Falco cherrug	0	2	0	2	0	0	0	4	0	0
Accipiter gentilis	0	1	0	0	0	1	1	2	0	0
Unidentified	1	0	2	0	0	0	0	0	0	0
Milvus migrans	0	0	0	1	0	0	0	0	0	0
Circus aeruginosus	0	0	0	1	0	0	0	0	0	0
Individuals/10 km	3.51	4.88	3.42	6.30	4.18	7.02	4.03	4.74	1.16	0.86

Table 3: Mean abundances (individuals/10 km) of the three most common raptor species selected per district. GF=Gänserndorf, HL=Hollabrunn, HO=Horn, KO= Korneuburg, MI=Mistelbach, LL=Linz-Land

Abundance/ district	GF	HL	HO	KO	MI	LL
∅ km	89	45	66	51	43	89
Buteo buteo	3.10	2.67	4.06	1.45	2.58	3.21
Falco tinnunculus	1.54	1.51	1.33	1.05	1.25	0.86
Buteo lagopus	0.11	0.22	0.35	0	0	0
Total density	5.65	5.42	6.21	3.03	4.00	4.22

Table 4: Species occurrence throughout the whole monitoring given in percent.

Species	**Percentage (%)**
Buteo buteo	58.78
Falco tinnunculus	25.02
Buteo lagopus	5.80
Circus cyaneus	2.62
Haliaeetus albicilla	1.91
Accipiter nisus	1.83
Milvus milvus	1.03
Aquila heliaca	0.95
Falco columbarius	0.64
Falco cherrug	0.64
Accipiter genitilis	0.40
Unidentified	0.24
Milvus migrans	0.08
Circus aeruginosus	0.08

Data base evaluation of potential shot marks

After filtering for relevant cases, 196 entries in ornitho.at fulfilled the search criteria. Lower Austria (146) showed highest numbers of potential shot marks, followed by Styria (19) and Burgenland (15), Upper Austria and Carinthia (6), Salzburg (3) and Vienna (1). No reports were listed for Tyrol and Vorarlberg. Most shot marks were reported for *Buteo buteo* (120) followed by *Circus aeruginosus* (13) and *Haliaeetus albicilla* (12). For the remaining species eight or less birds with shot marks have been reported (Tab. 5).

Table 5: Species distribution of shot marks based on entries of ornitho.at

Species	**Number of shot marks**
Buteo buteo	120
Circus aeruginosus	13
Haliaeetus albicilla	12
Milvus milvus	8
Buteo lagopus	7
Circus cyaneus	6
Falco tinnunculus	6
Pernis apivorus	6
Milvus migrans	5
Aquila heliaca	4
Circus pygargus	4
Accipiter gentilis	1
Accipiter nisus	1
Aquila chrysaetos	1
Falco perigrinus	1
Pandion haliaetus	1

The evaluation of the reported shot marks per district listed Horn (47) with the highest number of reports, followed by Mistelbach (27), Gänserndorf (22), Hollabrunn (16) and Waidhofen an der Thaya (13). Neusiedl in Burgenland (13) was the only district outside of Lower Austria exceeding more than ten reports (Fig. 2).

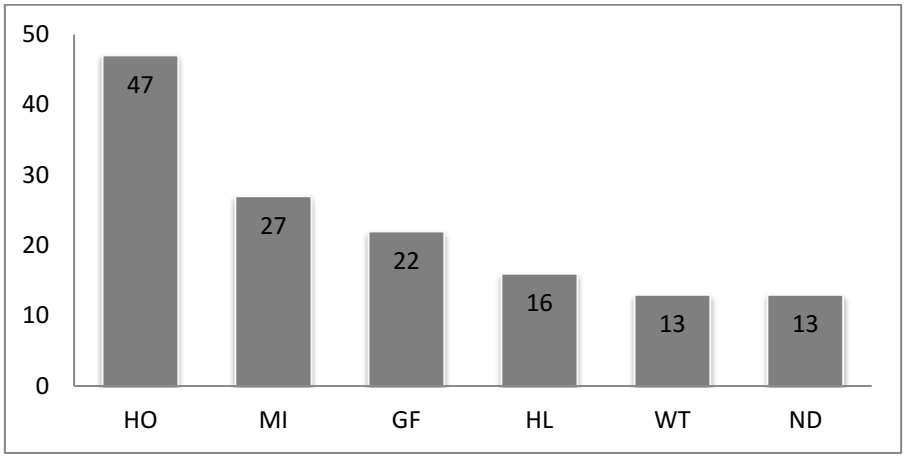

Figure 2: Total number of reported birds with potential shot marks selected per district escending 10 from 2013 to 2019; WT= Waidhofen an der Thaya, ND=Neusiedl

Data base evaluation of cases of persecution

Within the last twenty years 237 cases of persecution of raptors with 293 victims were reported in Austria, 190 of which were evidently proven. The proportion of the persecution types shooting (89), poisoning (85), decoy (43) and trap (25) are shown in Fig. 3. Most persecution cases were reported in Lower Austria (155), followed by Burgenland (46), Upper Austria (22), Styria (8), Carinthia and Vienna (3) (Fig. 4). Persecution cases and victims selected per district above a level of 10 are shown in Fig. 5.

In total 29 cases were excluded from the data due to lack of reliability or information. Eighteen cases from "Eulen- und Greifvogelstation Haringsee" were missing crucial information about the location, although they were assured cases of shooting.

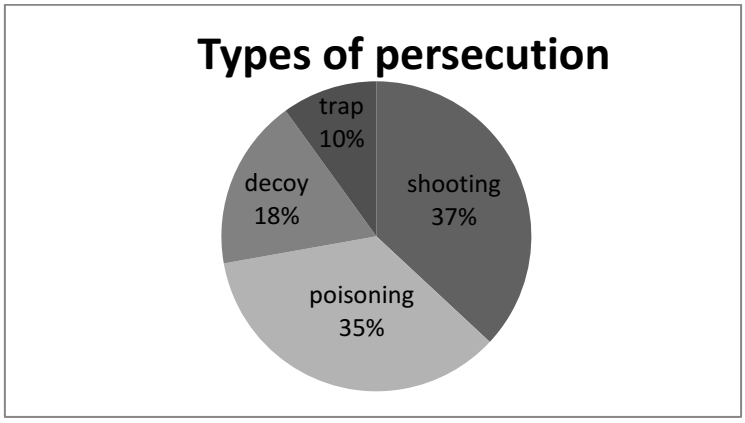

Figure 3: Distribution of types of persecution in percent (1999-2019).

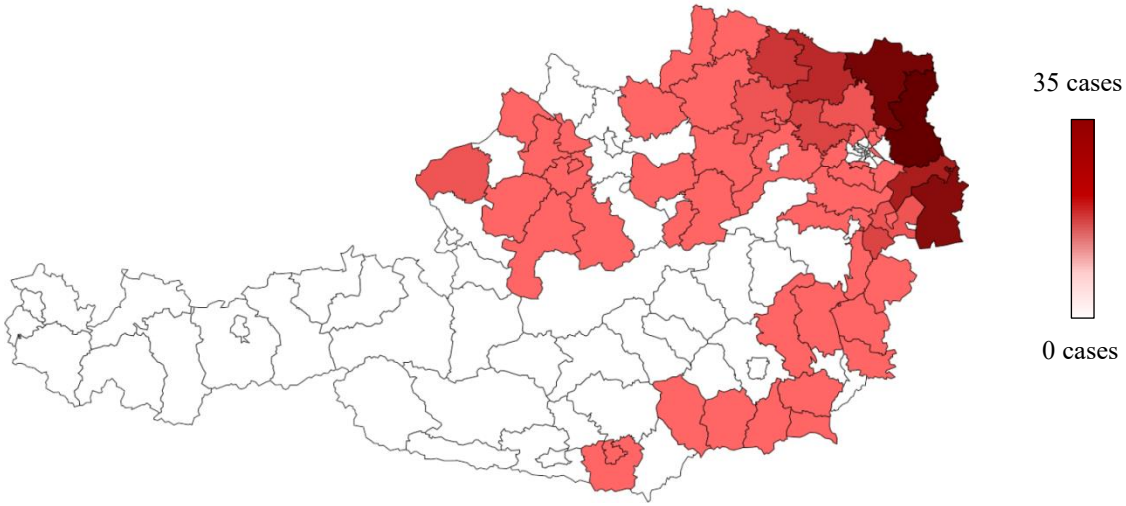

Figure 4: Persecution cases selected per districts of Austria (1999-2019). Color scale represents the gradient from the lowest to the highest.

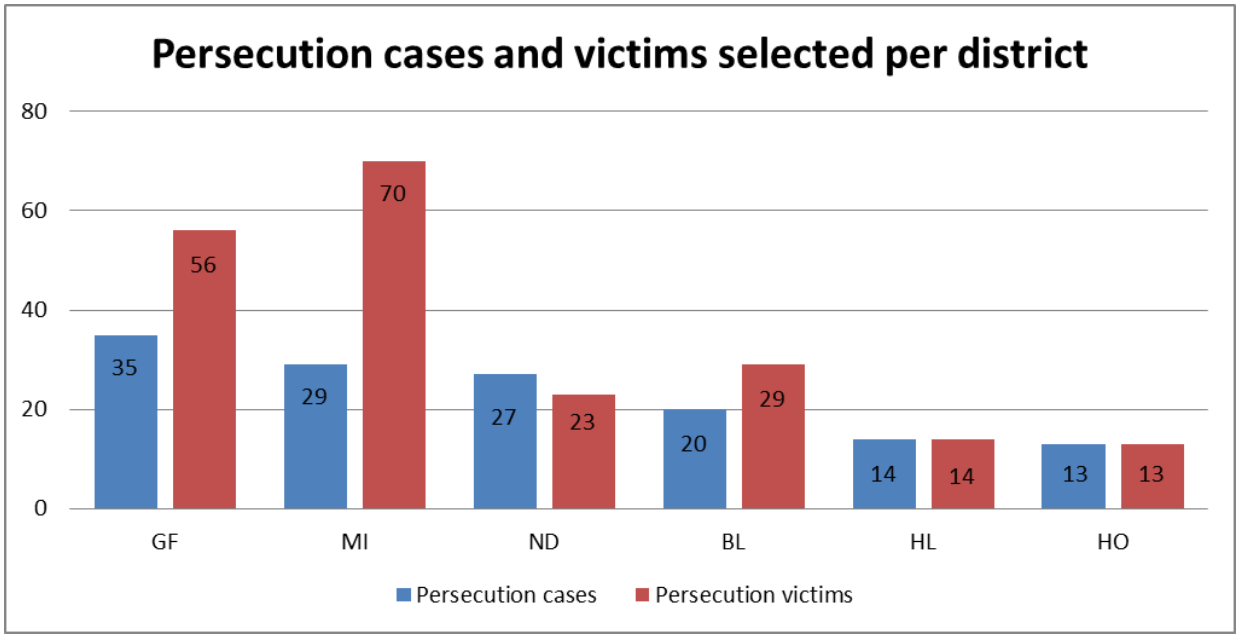

Figure 5: Reported cases of persecution and total number of victims. Only values exceeding a threshold of either ten cases or ten victims during a time period from 1999 to 2019 are shown. BL= Bruck an der Leitha.

Comparison between raptors with potential shot marks and proven cases of persecution

The total number of raptors with potential shot marks reported in ornitho.at is positively correlated with the total number of proven cases of persecution from the BirdLife data base (r_s=0.552, p<0.001, N=43) (Fig. 6). The total number of raptors with shot marks reported in ornitho.at is as well positively correlated with the total number of persecution cases involving shooting (r_s=0.670, p=0.001, N=21) (Fig. 7).

Comparison between relative abundances and proven cases of persecution

The mean relative abundance of raptors registered during monitoring is not positively correlated with the total number of proven cases of persecution from the data base (r_s=0.486, p= 0.329, N= 6).

Comparison between shot ground game and proven cases of persecution

The total numbers of shot European hares and pheasants are positively correlated with the total number of proven cases of persecution reported in the BirdLife data base (hare: r_s=0.600, p=0.018, N=15)(pheasant: r_s=0.629, p=0.012, N=15).

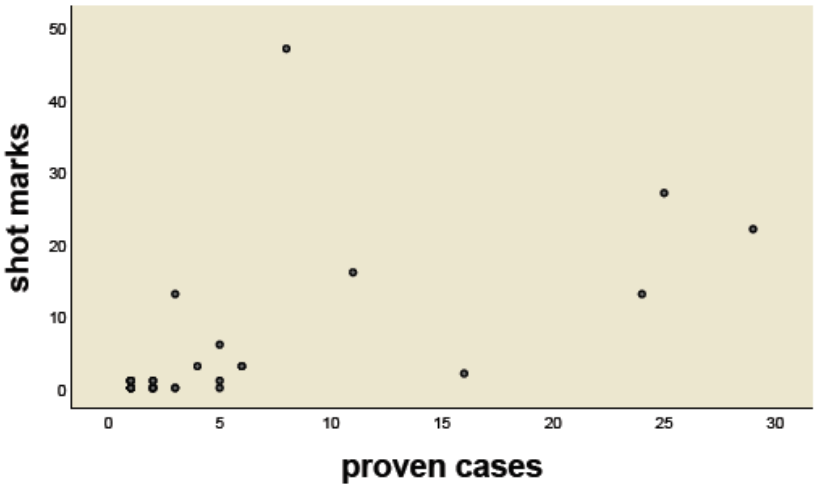

Figure 6: Number of birds with potential shot marks and total number of proven cases of persecution per district. N= 43, r_s=0.552, p<0.001.

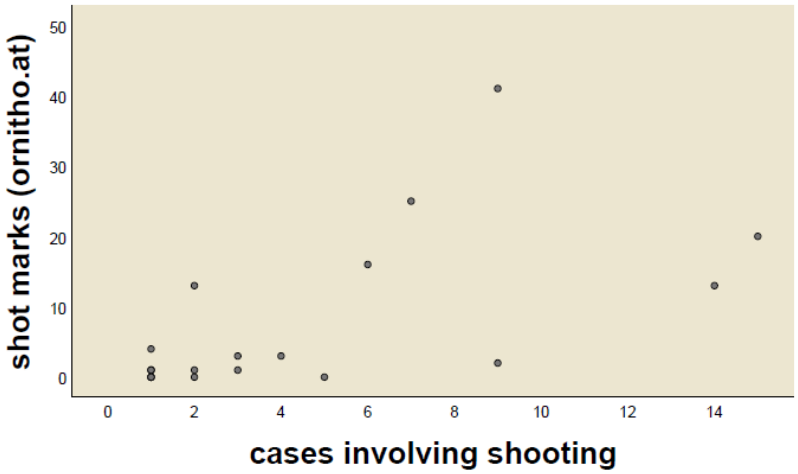

Figure 7: Shot marks and persecution cases involving shooting per district. N= 21, r_s=0.670, p=0.001.

4 Discussion

Field studies in general, and raptor monitoring in particular, are influenced by a variety of factors. First, the number of observed birds in the fields is dependent on the weather. In general the winter of 2017/2018 was dull and with high precipitation, in December and January it was mild while in February it was cold (ZAMG 2018). Weather conditions during the raptor monitorings were variable due to long time span and changing season. The temperatures ranged from -10 °C to +12 °C and the snow cover on the ground varied from no snow to fully covered. Apart from the weather the frequency of raptors is fluctuating with the population of small mammals (Uttendörfer 1939, Newton 1976), especially the frequency of *Microtus arvalis,* the main food resource of several raptor species, influences their population densities (Korpimäki 1984).

Persecution

Within the last twenty years 237 cases of raptor persecution were reported in Austria, a similar study from Hirschfeld *et al*. (2017) revealed 998 cases of raptor persecution within ten years in Germany. When comparing Austria and Germany regarding their persecution cases and their inhabitants the proportion of 1:10 is consistent (Statistik Austria 2019, Statistisches Bundesamt 2019).

The methods of persecution can be roughly divided into poisoning (poisoning and decoy) and shooting (nonlethal and lethal) besides trapping. Shooting was the most abundant type of persecution with 37 % of all cases. These findings are in agreement with the fact that in Rome 40 % of all injured raptors brought to wildlife rehabilitation centres were victims of gunshots (Cianchetti-Benedetti et al. 2016). Contrary to that in Germany only around 20 % of all cases were categorised as shot (Hirschfeld et al. 2017). Furthermore findings from England, the Czech Republic and Austria conclude that the main threat for reintroduced raptor species, *e.g. Milvus milvus* or *Haliaeetus albicilla,* is poisoning (Molenaar et al. 2017, Belka & Horal 2009, BirdLife Österreich n.d.). In this study poisoning was ranked second after shooting with 35 % of all cases, which is coherent with findings from Germany, where poisoning was ranked first, indeed, but also occurred in 35 % of all cases (Hirschfeld et al. 2017). However,

the presented data seem to show the lower limit of persecution cases regarding poison and support the assumption of high dark figures.

Buteo buteo was the most abundant species regarding poisoning in this study as well as in Germany (Hirschfeld et al. 2017). This species is the most numerous raptor in Europe and as opportunistic predator also feeding on carrion, which makes it especially susceptible for poisoned baits (Bieringer & Laber 1999, Dvorak & Wendelin 2008, Forsman 2006). In both of the aforementioned countries carbofuran (furadan), which is an illegal poison, is most commonly used (Hirschfeld et al. 2017). In most of the cases which involve poisoned baits apart from raptors and crows also foxes, martens, dogs and cats are intoxicated and killed. 19 % of all cases consisted of decoy, where only the poisoned baits were found, although this does not guarantee that no animal was harmed. Sometimes the animals are able to leave the crime scene due to delayed neurotoxic symptoms and die somewhere else (Gupta 2009).

In this study around 9 % of all cases involved traps, while in Germany more than 30 % of all cases fell in this category (Hirschfeld et al. 2017). Austria is predominantly characterised through alpine regions and therefore a lot of rough terrain. Consequently the number of detected cases could be lower than in flat regions like in Germany, but the dark figures are suggested to be high. The frequency of use of traps might also vary in different regions.

Regional differences

Among all nine states of Austria Lower Austria has by far the highest prevalence with 64 % of all reported cases. Interestingly this concentration to a certain area was similarily found in a study from Hirschfeld *et al.* (2017) in Germany, where they ascertained that around half of all persecution cases were located in one state, North-Rhine-Westphalia, while all other states were far behind. The explanation of the authors is the high effort of detection and investigation of persecution as part of a monitoring project within the last decade (Hirschfeld et al. 2017). This might also be true for the findings of this study. Another possible explanation for Austria might be the presence of an owl and raptor sanctuary “Eulen- und Greifvogelstation Haringsee” in Lower Austria, which is located in the district Gänserndorf. Gänserndorf and the close-by districts Mistelbach, Bruck an der Leitha and Neusiedl in Burgenland might have the highest numbers of persecution cases and victims, because injured raptors are brought to the sanctuary. Consequently persecution cases are better documented compared to other regions, where injured birds are either not found or treated by a local

veterinarian and taken care of in private homes or animal shelters. However, another raptor and owl sanctuary “OAW” is located in Linz, Upper Austria, but the close-by districts Linz-Land, Steyr-Land have no reports of persecution.

In alpine regions like in Tyrol, Vorarlberg, Styria and Salzburg no persecution cases are documented, suggesting that in rough terrain more cases are undetected due to limited presence of people and bigger areas of unspoiled nature.

The given numbers only reflect a fraction of the total number of incidents, therefore dark figures are suggested to be very high. Raptor persecution falls within a kind of crime, that is not easy detectible for authorities without constant monitoring, furthermore perpetrators purposely display baits and traps in isolated places in forests or copses and consequently pick up poisoned or shot cadavers in order to prevent discovery (Hirschfeld et al. 2017, National parks & wildlife service 2011). According to a study from Spain and France investigating the impact of pesticides on *Milvus milvus* population only 3 % of all poisoned cadavers are discovered, consequently estimating 16,200 intoxicated *Milvus milvus* between 1992 and 2002 in both countries (Coeurdassier & Scheifler 2010). If this statement was true also for Austria, we would have to assume an actual victim number of around 10,000 within twenty years.

Raptor persecution is a very complex and far-reaching issue where a lot of stakeholders are involved (ornithologists, hunters, poultry keepers, farmers, authorities *etc.*). As a result, gaining, evaluating and merging data and information from different parties is very challenging on the one hand, but also limiting on the other hand as the dependence on external data can never be ruled out completely. Furthermore it must be confessed that it is impossible to detect and document every single case in Austria, thus a certain amount of dark figures will always remain.

A lot of ornithologists were involved collecting data about relative abundances of raptors in Upper and Lower Austria during raptor monitorings. Although the methods were clear and all persons were experienced, nevertheless inter- and intra-observer reliability tests were not performed and probably would have improved the data.

To gain further insight in raptor persecution, focus needs to be on the problem areas and perpetrators to help understand the underlying intentions and prevent future cases as far as possible.

Comparison between raptors with potential shot marks and proven cases of persecution

The findings of this study show a significantly positive correlation between raptors with potential shot marks and proven cases of persecution indicating that these shot marks are really a result of gunshots and thus related to persecution of raptors. Shot marks are expected to occur when a bird has been shot with firearms, on purpose or by accident when flying off during battues, although other reasons like inter- or intraspecific fight cannot be ruled out completely without an X-ray.

Although birds with shot marks do not necessarily have to be shot in the same region in which they were observed, as they can fly long distances and some species migrate (*e.g. Buteo lagopus*) (Richardson 1990, Forsman 2006). Nevertheless *Buteo buteo*, a species which is known to remain in its habitat, has the highest occurrence of all documented shot marks in this study.

It has been shown, that among the reported cases of persecution, gunshots play an important role. Thus, the correct identification of shot marks could contribute to the quantification of persecution. The significantly positive correlation between raptors with shot marks and cases of persecution involving shooting could underline the assumption, that shot marks are valid signs of persecution and might as well be used for interpolation of persecution.

In general shot marks are easy detectable and may be suitable as an indicator, because also amateurs can recognise them, therefore expecting higher number of reports and a wide reach.

Identifying shot marks correctly however, a high number of observers and/or observations, might lead to a bias, as this would mean a larger number of shot individuals (*e.g*. Horn). This is difficult to counteract, since the birds can not be individually identified, unless shot marks are collected during standardised counts like conducted during this study's monitoring, which nevertheless must be validated more thouroghly and checked for inter- and intra-observer repeatability. Consequently data base evaluations alone, *e.g.* of ornitho.at, cannot be used for interpolation, because the activity of birders cannot be considered.

Comparison between relative abundances and proven cases of persecution

Relative abundances of raptor species, evaluated during this study in six districts of Upper and Lower Austria, are in concurrence with previous studies (Bieringer & Laber 1999, Weissmeier & Brader 2014). However, a significant correlation between relative abundances per district and persecution victims per district could not be found, thus indicating, that raptors are persecuted regardless of their abundance. A possible bias towards the relative abundances is likely generated due to low number of investigated districts and the short time period. As it is applying for many field studies, the outcome of the survey is additionally influenced by weather. This is not only true for observational issues, such as visibility, but also for presence of birds, since it has shown that harsh weather forces raptors to temporarily evade into more suitable habitats (Richardson 1990).

Comparison between shot ground game and proven cases of persecution

The findings of this study revealed a positive correlation between numbers of shot ground game (hare and pheasant) and the persecution of raptors meaning that in regions with higher numbers of shot ground game there is also a higher number of persecution. Villafuerte *et al.* (1998) also found a correlation between high rabbit density areas and the persecution of raptors, particularly *Milvus milvus*, in Spain. Raptors are sometimes held responsible for the declining ground game populations as some species also feed on ground game, especially on hare (Hamberger 2013). Furthermore hunters are besides poultry breeders the main perpetrators (Hirschfeld et al. 2017), when trying to protect the ground game through reducing predators like raptors. In Germany the biggest group of convicted offenders with around 40 % of all cases are hunting license holders and around 57 % of all known ammunition of shot raptors is from shotguns (Hirschfeld et al. 2017). In Scotland 86 % of all convicted offenders are gamekeepers (RSPB Scotland, 2015), thus disproving the common opinion that hunters are a minority within the perpetrators. Hunting motives also can be suggested when traps, poisoned baits and even shot raptors are found next to pheasantries or pheasants or ducks recently abandoned for hunting purposes (Hirschfeld et al. 2017). Although this study did not evaluate judgements and offender groups, the correlation between raptor persecution and ground game assumes that the main motives of offenders are hunting motives.

Conclusion

This study tried to investigate the magnitude of illegal persecution of raptors in Austria, especially in the North-eastern part of the country. Within 20 years 237 cases of persecution, *e.g.* poisoning or shooting, have been reported, with the assumption of higher dark figures. Furthermore 196 reports of potential shot marks, which are asymmetrical gaps in the plumage of wings and/or tail of raptors which differ from regular, symmetrical moulting, and which thus can be suspected to be a result of gunshot, have been documented between 2013 and 2019. Shot marks might serve as indicators for persecution as we found a significant correlation between the occurrence of potential shot marks and persecution cases. Moreover the density of ground game (hare and pheasant) is correlated to the number of persecution cases. Both findings might be due to the fact that hunters are perpetrators due to obsolete beliefs of raptors as pests or competitors. In addition the results show a regional clumping, where the vast amount of cases occurred in Lower Austria (LA). Particularly three districts show a very high prevalence rate of persecution, which are Gänserndorf (LA), Mistelbach (LA) and Neusiedl (Burgenland). This could be counteracted by a campaign to protect raptors. As an example in Rhineland and Westphalia, Germany, campaign work throughout years and more than forty final convictions lead to a strong decline of persecution cases from 71 to 29 in 2010 (Hirschfeld et al. 2017).

Fortunately raptors are protected by law – although in the regional hunting laws instead of the nature conservation laws – in Austria, nevertheless the existing legislation needs to be adequately implemented in order to sustainably rule out illegal persecution of raptors.

5 Zusammenfassung

Obwohl illegale Verfolgung nach wie vor eine der Hauptgefahren für Greifvögel weltweit ist, ist dieses Thema noch nicht ausreichend erforscht. In den letzten 20 Jahren wurden in Österreich 237 Fälle von Greifvogelverfolgung, wie z.B. Vergiftung oder Abschuss, mit 293 Opfern dokumentiert, die Dunkelziffer liegt wohl noch viel höher. Daher befasst sich diese Studie einerseits mit den Beweisen für Verfolgungen und andrerseits mit zuverlässigen Anzeigern wie Schussmarken. Schussmarken sind asymmetrische Lücken im Gefieder von Flügel und/oder Schwanz von Vögeln, welche sich von gewöhnlicher, symmetrischer Mauser unterscheiden und daher als Folge von Beschuss vermutet werden. Da das Auftreten von Vögeln mit Schussmarken regional stark variiert, testete diese Studie den Zusammenhang von der Anzahl erwiesener Verfolgungsfälle mit dem Auftreten von Vögeln mit Schussmarken. Weiters wurde getestet, ob ein Zusammenhang zwischen der Niederwilddichte (Abschusszahlen von Feldhase und Fasan) und der Anzahl der Verfolgungsfälle besteht, da in Deutschland und Schottland vorwiegend Jäger als Täter identifiziert werden. Die Ergebnisse zeigen einen klaren Zusammenhang zwischen den Verfolgungsfällen und dem Auftreten von Greifvögeln mit Schussmarken, wodurch bestätigt wird, dass Schussmarken geeignete Anzeiger für Greifvogelverfolgung sein können. Weiters wurde gezeigt, dass die Anzahl der Verfolgungsfälle mit der Niederwilddichte korreliert. Im Allgemeinen zeigen die Ergebnisse ein deutliches West-Ost-Gefälle, wobei die allermeisten Verfolgungsfälle und –opfer in Niederösterreich dokumentiert wurden. Im Speziellen haben die Bezirke Gänserndorf, Mistelbach und Neusiedl die höchsten Meldungen verglichen mit allen anderen Bundesländern. Diese Ergebnisse zeigen das Ausmaß illegaler Verfolgung von geschützten Greifvögeln in Österreich, vor allem in Niederösterreich, und verdeutlichen den dringenden Handlungsbedarf in Form von höheren Verurteilungsraten und strengeren Strafen für die Täter.

6 Abstract

Illegal persecution is one of the most severe threats to diurnal raptors worldwide. Within the last 20 years 237 cases of raptor persecution, *e.g.* poisoning or shooting, with 293 victims have been reported in Austria, although dark figures might be higher. Therefore this study investigates the magnitude of persecution and trustworthy indicators like potential shot marks. Shot marks are asymmetrical gaps in the plumage of wings and/or tail of birds, which differ from regular, symmetrical moulting, and thus can be expected to be a result of gunshot. A strong correlation between persecution cases and shot marks could be found, which shows that shot marks might serve as a valid indicator for persecution. In addition the results show a correlation between the density of ground game and persecution cases. In general, the obtained data show a regional clumping, where the vast majority of cases and victims was reported in Lower Austria. Particularly the districts Gänserndorf, Mistelbach and Neusiedl had very high numbers of persecution cases and victims compared to all other districts of Austria. The findings of this study show the large scale of persecution of protected raptors in Austria, especially in Lower Austria, and emphasize the urgent need for better protection.

7 Abbreviations

SPEC	Species of conservation concern
UA	Upper Austria
LA	Lower Austria
c	controlled
nc	not controlled
KO	Korneuburg
HO	Horn
LL	Linz-Land
HL	Hollabrunn
GF	Gänserndorf
MI	Mistelbach
WT	Waidhofen an der Thaya
ND	Neusiedl
BL	Bruck an der Leitha

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9 List of tables

10 List of figures

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12 Appendix

Appendix I: Hunting law

- Salzburg

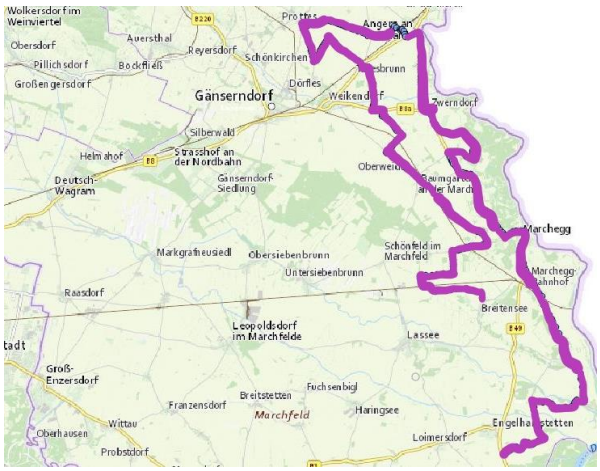
In the Hunting Law of Salzburg 1993 (Jagdgesetz 1993) the following raptor species are defined as game: *Aquila chrysaetos*, *Pernis apivorus*, *Buteo buteo*, *Accipiter gentilis*, *Accipiter nisus*, *Falco tinnunculus*, *Falco subbuteo*, *Falco peregrinus*, *Milvus migrans*, *Gypaetus barbatus*, *Gyps fulvus* and *Circus aeruginosus* (RIS 2018).

- Upper Austria

According to the Upper Austrian Hunting Law (Oberösterreichisches Jagdgesetz) from 1964 § 3 "Huntable animals" are, among raptors, *Buteo buteo*, *Accipiter gentilis*, *Accipiter nisus* and *Aquila chrysaetos* (RIS 2018).

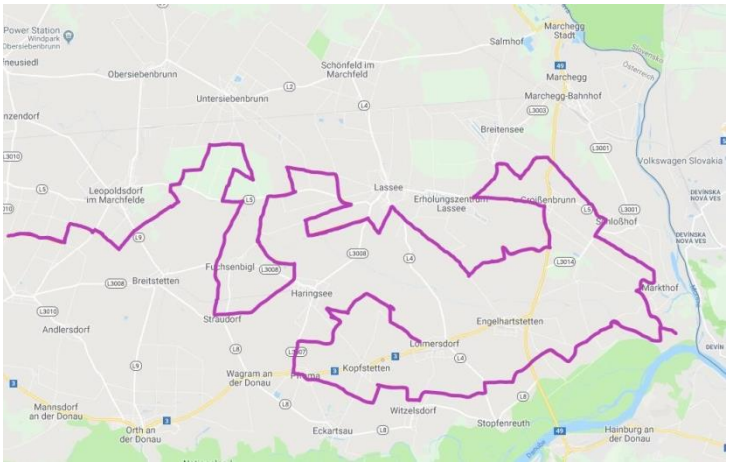
Appendix II: Routes

Supp. Figure 1: R1 Mistelbach

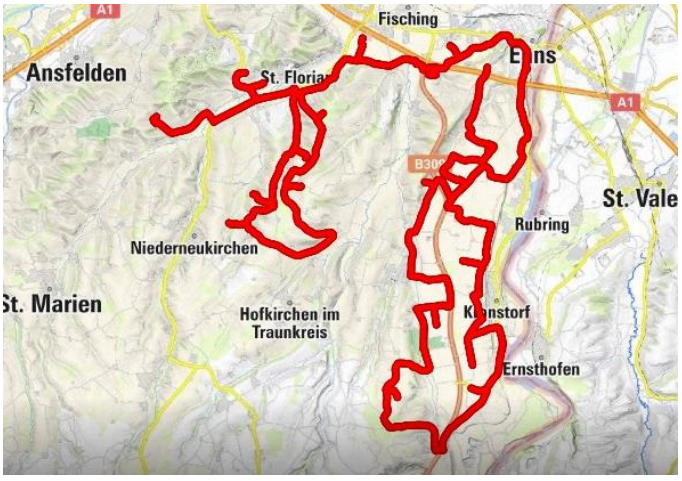


Supp. Figure 2: R2 Gänserndorf

Supp. Figure 3: R3 Hollabrunn, Korneuburg, Tulln



Supp. Figure 4: R4 Gänserndorf

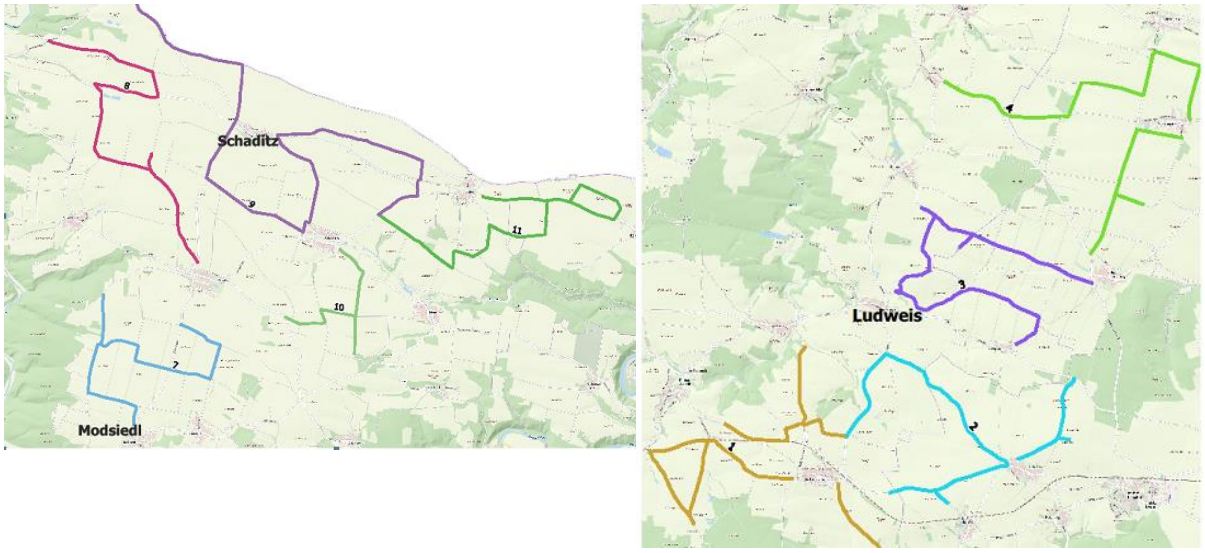


Supp. Figure 5: R5 Linz-Land, Steyr-Land

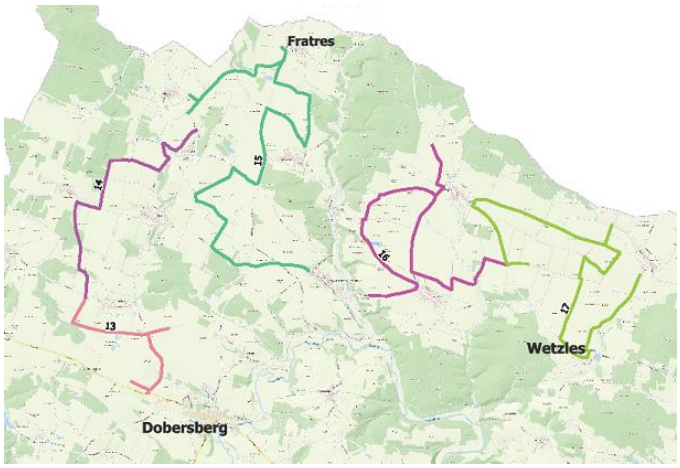
Supp. Figure 6: R6 Horn, Hollabrunn

Supp. Figure 7: R7 Horn

Supp. Figure 8: R8 Horn, Hollabrunn



Supp. Figure 9: R9 Waidhofen an der Thaya, Horn



Supp. Figure 10: R10 Waidhofen an der Thaya, Zwettl