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Estimating carrion biomass originating from Red deer *Cervus elaphus* and its ecological effect on vertebrate scavengers in Vestland county, Norway.

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Abstract

Aim Ungulates make up the majority of carrion in numerous terrestrial ecosystems. Humans have removed large carnivores from many ecosystems, and carcass waste from human hunting has taken over as the most important source of carrion. Understanding the availability of carrion is therefore crucial for comprehending its ecological impact, and my goal was to assess carrion availability in Vestland county in western Norway.

Methods I used literature to calculate the amount of red deer carrion biomass from several different causes, harvest, traffic accidents and other causes of death. I conducted a questionnaire to investigate how hunters use offal and how they treat waste from the harvest. Additionally, I investigated which scavengers that utilized carrion from red deer in an area of Vestland county that had low numbers of apex predators using eleven camera traps.

Results I found that across Norway, a significant amount of biomass from red deer is left available for the scavengers from both the annual hunting season and from other causes of death. I found that the hunters often leave waste from harvest available for the scavengers. Based on camera traps, I found that the three corvid species; crow, raven and magpie are the most abundant scavengers with 95% of all visits.

Main conclusions This study showed that hunters in Norway and particularly Vestland county contributed with large amount of carrion through harvest of red deer, in addition to traffic accidents and death by other causes. Carrion is often left available for scavengers and that the most observed scavengers in the study site were corvids. Based on the findings, I expect increased survival of corvids due to large amount of carrion available.

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1 Introduction

Big game hunting subsidies natural ecosystems with large amounts of carrion (dead animal matter) which is utilized by a wide range of scavengers, from the smallest microbial consumers to large vertebrate consumers (Olea et al., 2019; Mateo-Tomás et al. 2015; Bartel et al. 2024). Instances of carrion exploitation can be found in nearly every biome worldwide and many vertebrate predators engage in scavenging to some degree (Wikenros et al. 2013; Mattisson et al., 2016; Cortès-Avizana et al. 2009). This highlights the critical role of carrion in understanding ecological processes within ecosystems, particularly carrion originating from big game hunting. In northern ecosystems, particularly in Scandinavia, ungulates are the most favoured big game for hunting due to their abundant populations, easy accessibility, and high-quality meat (Directorate for Nature Management, 2009)

Humans have eradicated large carnivores from many ecosystems. Together with provisioning of carcasses from hunting, this may have consequences on the dynamics of the ecosystem (Estes et al. 2011, Ripple et al. 2014). Low numbers of large predators can lead to reduced top-down effects and potentially lead to a mesopredator release (Crooks et al. 1999). The low numbers of top predators in combination with the bottom-up boost from increased carcass resources could lead to increased populations of mesopredators (Elmhagen and Rushton 2007, Henden et al. 2014). The use of carrion as subsidies during prey shortages can significantly affect predator and prey population dynamics (Wikenros et al. 2013). This suggests that humans may unintentionally provide a temporary resource increase for scavenging mesopredators, such as corvids and red fox (*Vulpes vulpes*), which helps maintain high populations. This, in turn, affects other prey species, such as grouse and other ground-nesting birds (Henden et al. 2021; Rees et al., 2020).

Three main mortality factors contribute to the availability of ungulate carcasses for scavengers (Selva et al. 2005): (1) Natural deaths, which provide scavengers with large quantities of intact carcasses, typically at the end of winter in northern ecosystems; (2) predation by large carnivores, which continuously subsidizes scavenger communities with the remains of their kills (Wilmers et al. 2003); and (3) human-caused mortality, primarily from hunting, which has become a significant source of carcasses in many regions, along with vehicle-wildlife collisions (Wilmers et al. 2003; Selva 2003).

Human harvesting of terrestrial animals generates biomass in the form of carcasses and other waste, which are often exploited by scavenger species (White, 2006). This nutritional boost to scavengers can lead to population increases and potentially impact other species within the ecosystem (Gomo et al. 2017). In European boreal forests, monthly estimates of carrion supply from moose (*Alces alces*) have been conducted in south-central Sweden (Wikenros et al. 2013), while bimonthly estimates for all ungulates have been carried out in the temperate Białowieża Primeval Forest in Poland (Selva 2003). In south-central Scandinavia, Wikenros (2011) and Wikenros et al. (2013) reported that the largest food source for scavenging species was the waste left after moose hunting in the autumn. In areas with wolves (*Canis lupus*), the biomass of waste from hunting was nearly double that of wolf kills.

The population of moose in Norway has been continuingly decreasing since the start of 2000's while the red deer (*Cervus elaphus*) population is growing in numbers and expanding its distribution range. In 2008, the number of red deer harvested in Norway surpassed that of moose, with 35 620 moose and 35 686 red deer taken (Baklien, SSB, 2024). Since then, red deer harvest numbers have increased further. In 2023, 26 000 moose and 52 500 red deer were harvested during the hunting season, with 26 200 red deer taken in Vestland county alone (SSB, 2024). Of the four cervid species in Norway, consisting of red deer, moose, reindeer (*Rangifer tarandus*) and roe deer (*Capreolus capreolus*), the red deer is now the most abundant and its numbers are particularly concentrated in Vestland county, a county with a «No large predators»- policy (Rovviltnemnd region 1, 2022).

The objective for this study was to estimate the amount and use of carrion from red deer in Vestland, Norway, as a basis to understand the effects human created subsidies might have on the scavenger populations. First, I calculated how much waste from red deer is available for scavengers through traffic accidents, annual hunting and natural causes of death in the whole of Norway. Secondly, I conducted a questionnaire to hunters in Norway, with the aim to determine the utilization pattern of deer parts among hunters in addition to investigating how hunters treated waste from the harvest. Lastly, I investigated scavenging patterns on carrion, with eleven camera traps placed at red deer carcasses in Vestland county.

2 Methods

2.1 Study-area

The study area was in Vestland county located southwest in Norway 59.4°-62.2°N and 4.5°-8.3°E and consisted of 31 969 km² land area (figure 1). The landmass is influenced by high mountain ridges in the east and large number of long fjords in the west. Vestland county can be divided into two parts, north and south, which are separated by one of the largest fjords in the world, Sognefjorden.

The climate in Vestland is strongly oceanic at the coastline and in larger parts close to the fjords before changing into a moderate oceanic climate further inland. The most eastern parts of the county have a weak oceanic climate. The climate sections indicate strong influence of precipitation, high humidity and small temperature gradient between summer and winter (Moen, 1998). Average annual precipitation is 2000-6000 mm a year and average temperature during winter among the coast is 2°C compared to -10°C in the east. The average summer temperature at the coast is 15°C and 10°C in the east (Norwegian Meteorological Institute, 2022; Thorsnæs, 2024).

Figure 1. Bait sites are represented by red dots.

The vegetation in Vestland is mainly in the boreonemoral zone and the natural forests are dominated by deciduous trees like birch (*Betula* spp.) and grey alder (*Alnus incana*), and Scots pine (*Pinus sylvestris*) with shrubs juniper (*Juniperus communis*), bilberry (*Vaccinium myrtillus*) and heather (*Calluna vulgaris*). In Vestland county, the human population is scattered with higher densities around the largest cities. In the south, Bergen have 45% and Førde in the north have 2% of the total human population in the county.

Agriculture in Vestland county is characterized by livestock husbandry, mostly sheep, cattle and goats and some parts with high production of fruit and berries. In this area there is as much as 30% of the whole population of domestic sheep in Norway and therefore low numbers of predators are prioritized (Thorsnæs, 2024). Norway has 8 regions for large carnivores. Vestland is located in region 1, where livestock husbandry is prioritized and none of the larger carnivorous species are allowed to stay in the area (Rovviltnemnd region 1, 2022).

2.2 Calculation of carcass numbers

To enable calculation of number of carcasses from red deer, I first reviewed the available literature for mortality causes and rates and I based my calculations on the numbers presented in the report on harvest, traffic accidents and other causes of death for the four wild cervid species in Norway by Solberg et al. (2022).

2.2.1 From the annual hunting season

During the hunting season 2023-2024, 52 490 red deer were harvested in Norway. The number of red deer harvested in Vestland county were 26 176, resulting in an average of 0.81 red deer harvested per km^2 (SSB, 2024). On average 15-25% of the summer population is harvested during the hunt (Meisingset, 2008), indicating that the summer population of red deer in Vestland county spans from 104 700-174 500 individuals which means there is an average of 3.3-5.5 red deer per km^2 in the summer.

To determine how much harvest waste from the annual red deer hunting season, I used pre-collected data from Statistics Norway (SSB, 2024). For all hunters in Norway, it is mandatory to register number of harvested animals and for red deer it is also mandatory to register weight, sex and age. The statistic for the number of harvested red deer along with their sex, weight and age are open to public and can be downloaded directly from Statistics Norway (SSB).

2.2.2 From traffic collisions and other causes of death

Red deer that die from other causes than harvest represent only 4% of the total number of registered dead red deer each year, of which 55% are reported in Vestland alone. The most common cause of death is traffic accidents, then other causes and thirdly are pest control (Solberg et al 2022). Other causes of death are starvation, disease, and broken bones. I based my calculations on that if red deer die from other causes than harvest or traffic accidents, the whole carcass is then available for scavengers.

Roughly 55% of all traffic collisions with red deer lead to the deer's immediate death or them being euthanized after a search by a qualified "wounded game recovery crew". The rest are never found or reported to be uninjured (Solberg et al. 2022). A study from Sweden found that 40% of vehicle-killed moose were left available for scavengers and that the remaining 60% were retrieved for human consumption (Wikenros et al. 2013). Red deer killed by traffic in Norway are not considered suited for human consumption and therefore are treated as waste (The Norwegian Food Safety Authority, 2024). There are different practises across Norway with how the carcass is handled but the most common practises are delivering the carcass to foxhunters or to indoor collection points before it is delivered to waste sites (Karstad, E. personal communication, leader of Ytre Fjordane wounded game recovery crew). Individuals injured by traffic and later euthanized by a "wounded game recovery crew" with large distance between the road and the kill site are sometimes left in the terrain and therefore available for scavengers (Kvalvåg, H. personal communication, leader of Bergen wounded game recovery crew). I based my calculations on the numbers presented by Solberg et al. (2022), where 4% of all dead red deer died from other causes than harvest and 55% of them were caused by traffic accidents. Additionally, I assumed that half of red deer killed by traffic remained available to scavengers, either left at the site of the kill or placed at bait sites, and that the other half were kept at unavailable locations for the scavengers.

2.3 Calculation of carcass weight

I used calculation methods from other studies to determine how large proportions of the animals were left available for the scavengers. On August 4th, 2024, I conducted a literature search in Google Scholar to obtain scientific articles containing the following keywords: "scavengers" and "carrion biomass", "ungulates" and "scavenging", "red deer" or "ungulate" and "carcass characteristics".

Table 1. Body composition of red deer based on available literature.

	Body part	Percentage of live weight	Source
	Dressed carcass	55-60%	Meisingset 2008, Serrano et al. 2019, Bokor et al. 2023, Czajkowska et al. 2021, Kim et al. 2015, Drew et al. 1990
Internal	Heart	0.71 %	Czajkowska et al. 2021
	Liver	1.29 %	Czajkowska et al. 2021
	Kidneys	0.56%	Czajkowska et al. 2021
Inedible	Head	6.02%	Czajkowska et al. 2021
	Feet	4.28%	Czajkowska et al. 2021
	Skin	4.7-5.8%	Czajkowska et al. 2021, Kay et al. 1981
	Bones	15.6-22%	Bokor et al. 2023, Stanisz et al. 2015

2.4 Survey

To determine how the annual hunting season for red deer possibly subsidises scavengers in Vestland county, I constructed an online survey using the tool "Nettskjema" from UiO (www.nettskjema.uio.no).

The survey consisted of eight questions about hunter's habits around harvesting deer and their utilization of offal (internal organs used as food). I shared the survey with these groups on Facebook: *The hunters' interest organization (Jegernes interesseorganisasjon)* with 20,400 members, *Girls who hunt (Jaktjenter)* with 9,100 members, *Norwegian black elkhound (Norsk elghund sort)* with 10,800 members, *Moose hunt (Elgjakt)* with 52,800 members and *Red deer – red deer hunting (Hjort-hjortejakt)* with 42,600 members. A total of 1246 hunters participated in the survey.

The questionnaire asked participants about their hunting locations, the species they targeted, how they performed the dressing of the animal, what they did with the rumen and entrails, where they disposed of any waste, whether they used any offal or organs, and if they also participated in hunting scavengers. All questions had several options for answers and the participants could choose several options per question.

The tool "Nettskjema" provides a report after the questionnaire has ended where number of answers and percentage is provided for every question (Appendix A.). Two of the questions; routine with gutting and routine with field dressing had the option "other" as a text box answer. For routine with gutting, 54 answered "other" and 146 answered "other" on routines with field dressing. I sorted through the answers and placed them in the most suitable answer depending on the text the participant had filled in.

I analysed the result from the survey using the software R (version 4.3.0, R Core team 2024). Firstly, I filtered the dataset to only include answers from respondents who had answered that they hunted one or more of the four cervid species in the questionnaire. I used fuzzy correspondence analysis (FCA) in ade4 R package (Thioulouse et al. 2018) to explore relationship between the variables in the dataset. Fuzzy analysis was used as hunters could select more than one category for a given variable (e.g., red deer and moose for the species hunted). The dataset contained several categorial variables that were grouped based on their relevance to the question. Further, the prep.fuzzy.var function was applied to ensure the different categories were analysed as one categorical variable. To visualize the results of the FCA, scores of the different categories of each variable were plotted along the two first FCA axes. I ran this analysis on 1) all of Norway, and 2) only Vestland county.

Further, I used cross-tabulations to quantify more precisely associations between two or more variables identified using the FCA. I used Pearson Chi-squared tests with Yates' continuity correction to determine whether there was a statistically significant association between the variables.

2.5 Camera use and picture registration

Figure 2. Seven different types of bait sites used to characterise the scavenger community in Vestland county, Norway during the hunting season 2023/24. From top: bait site with only bones, open bait site on an island with no known mammal predator, covered bait site, open bait site in the forest, bait site in the intertidal sone, open ditch and gut pile.

To determine which scavengers-species that utilize the waste from harvest of red deer in Vestland county, I placed seven cameras of the type Browning, two cameras of the type Uovision and two volunteer fox hunters contributed with photos captured by their cameras. All cameras were set to be triggered by movement and placed at eleven different locations in Vestland. Firstly, I collected permission from landowners to place cameras on their property. I had five cameras in Bremanger municipality, two in Kinn municipality, three in Bergen municipality and one in Stad municipality to cover a range of environmental conditions within Vestland county. The cameras were set up at seven different kinds of bait sites (Figure 2): one bait site in the intertidal zone, one bait site at a gut pile, two bait sites were open ditches, two bait sites were large holes that were covered up with a lid after filling it with waste, one site were only bones, two sites had the waste left in the terrain but were both on an island with no registered sighting of scavenging mammals (personal communication J. Solheim, Norwegian Deer Center) and the rest of the types was bait left in the terrain in forested areas. All cameras were set up with 1-2 m distance from the bait, and height and angle were adjusted to the different surrounding terrain at every site. All the bait sites and cameras were logged with GPS-coordinates and photographed after set up.

All cameras were running on an average of 59 days throughout the year of 2023, the shortest duration was at a site in Berle, Bremanger municipality with 5 days in September and the longest duration were at bite site Blindheim, Bergen municipality with 246 days between February and October.

All photos were checked and registered manually. Animals that were detected at the slaughter waste or close to, were counted and identified to species or family level. Temperature and time/date of each photograph were logged as well.

I analysed the dataset using the software R (version 4.3.0, R Core team 2024). To explore the effect of temperature on all visits, Generalized Additive Models (GAMs) were implemented using mgcv library in R (Wood, 2017). The model was fitted using the Poisson family with a log link function and the models were evaluated through key diagnostic measures, including residual plots to assess fit quality, checks for overdispersion. Akaike Information Criterion (AIC) was used for model selection.

Further, I explored distribution over time and temperature for a selection of scavenger species in this study. To account for differences in camera activity across days, an effort adjustment was applied to each species' count by dividing the counts by the active days for each camera. The number of active days per camera was calculated by taking the difference between the first and last recorded observation for each camera and visualizations were created using ggplot2 in R (Wickham, 2016).

3 Results

3.1 Estimation of carcass biomass

In the 2023-2024 hunting season, a total of 52 490 individuals were harvested in Norway, with 26 176 individuals in Vestland county. Across Norway, the total dressed carcass weight was reported to be 2455 tons, where in Vestland county, the dressed carcass weight reached 1163 tons (SSB, 2024).

Table 2. An overview of estimated biomass from red deer based on reported numbers from the hunting year 2023-2024 in Vestland county (26176) and in Norway as a whole (52490).

		Percentage of live weight	**Biomass Norway (tons)**	**Biomass Vestland county (tons)**
Live weight of harvested individuals		100%	4091	1938
Dressed carcass of harvested individuals		60%	2455	1163
Potential waste from harvest		40%	1636	775
Internal	Heart	0.71 %	29.05	13.76
	Liver	1.29 %	52.77	25.0
	Kidneys	0.56%	22.91	10.85
Inedible	Head	6.02%	246.28	116.67
	Feet	4.28%	175.09	82.95
	Skin	5.0%	204.55	96.9
	Bones	20.0%	818.20	387.6

The dressed carcass, which accounts for 55-60% of the total live weight, represents the most significant portion of the biomass. I estimated live weight across Norway to 4091 tons, Vestland contributing 1938 tons given that the carcass weighs 60% of live weight. Table 2 breaks down the biomass distribution across different body parts.

The internal organs, including the heart, liver, and kidneys, make up a smaller percentage of the biomass but are easily edible parts of the total available resources. The liver, being the largest internal organ by weight, accounted for 1.29% of the live weight, corresponding to 53 tons in Norway with 25 tons in Vestland. The heart and kidneys followed, with Norway-wide totals of 29 tons and 23 tons respectively, and Vestland-specific estimates of 14 tons for the heart and 11 tons for the kidneys.

The mainly inedible parts, which include the head, feet, skin, and bones, represent a significant portion of the harvested biomass. The head is one of the largest parts of the waste as the head weighs roughly 6% of the live weight, but smaller portions of the head might still be consumed, such as tongue and cheeks. Bones, which account for 15.60-22% of the live weight, made up the largest proportion of inedible biomass, with a total of 818 tons across Norway and 388 tons in Vestland given that the bones constituted 20% of the live weight. Heads constituted 6% of the biomass, contributing 246 tons in Norway and 117 tons in Vestland. The skin, making up approximately 4.7-5.8% of the live weight, added 205 tons in Norway and 97 tons in Vestland given that the skin weighed 5% of live weight.

Table 3. Overview of estimated biomass from red deer from other causes of death and traffic accidents in Norway in 2023 based on harvest numbers from the annual hunting season in 2023/24.

Category	Metric	All of Norway	Vestland county
All dead red deer	Total number of all dead red deer in Norway (100%)	54 677	
	Other causes (4% of all dead red deer)	2187	1203
	Traffic (55% of other causes)	1203	601
Biomass assumed available	Assumed available from traffic accidents (50%)	601	331
	Total number of individuals available from other causes and traffic.	1586	872
	Estimated weight of carrion (tons)*	123	68

*Given that the weight of the individuals that died of other causes was equal to the body weight of harvested individuals (Live weight/number of harvested individuals=mean body weight).

Based on the harvest numbers from the hunting season 2023-24 in all of Norway (table 3), the numbers of harvested individuals constitute 96% of the total number of registered dead red deer. As traffic accidents and other causes of death were estimated to be 4% of the total numbers of reported dead red deer, 2187 deaths were calculated in all of Norway. Based on the numbers by Solberg et al. (2022) where 55% of all deaths of other causes happened in Vestland county, I calculated that 1203 individuals died in Vestland county in 2023 from other causes than harvest. With 55% of the deaths caused by traffic and with 50% of them assumed available for scavengers, I calculated the numbers of individuals of red deer that were available for scavengers to 601 individuals from traffic accidents in all of Norway with 331 individuals in

Vestland county. Therefore, a total of 1586 individuals of red deer that die from other causes than harvest is assumed available for the scavengers in all of Norway with 872 of them in Vestland county. As the whole body of the red deer is available when the individuals die from other causes of death than harvest, I estimated the available biomass to 123 tons in Norway with 68 tons in Vestland county given that the average body weight were equal to the body weight of harvested individuals.

3.2 Survey among hunters

I first provide the marginal proportions for the different variables of the survey before investigating associations between variables using fuzzy correspondence analyses and contingency tables.

3.2.1 Key patterns from survey

Table 4 highlights key patterns in the hunting behaviour and disposal of harvest waste in Norway and particularly Vestland county.

The participants answered which county they hunted in and all counties in Norway were represented. The most reported county was Vestland with 38.5% of the answers, followed by Møre og Romsdal (17.9%), Innlandet (15.8%) and Trøndelag (15.2%). There were fewer participants who answered in Viken (9.8%), Rogaland (8.8%), Agder (8.4%) and Vestfold og Telemark (5.5%). The northern counties had even fewer answers, Nordland with 3.8% and Troms og Finnmark had only 2%.

Notably, red deer is the most targeted species by hunters, with 85.7%. The second most hunted species among the participants were roe deer with 51%, followed by moose with 49.3% and lastly reindeer with 14.3%. Of the participants that answered that they hunted in Vestland (n=479), only three answered that they did not hunt red deer, i.e., 476 answered that they hunted red deer, 52 hunted reindeer, 98 hunted moose and 106 hunted roe deer.

When it comes to waste disposal, 80.4% of hunters in Vestland leave the rumen at the kill site after gutting. This is the most common practice across all groups. Field dressing routines varied significantly among the participants. The most common practice in Vestland was to leave everything in the terrain (42.8%), followed by using the harvest waste as bait for scavengers (38.2%) and leaving everything in a ditch or a hole in the ground to cover up later (35.5%). Additionally, 8.1% of hunters in Vestland dispose of waste in the intertidal zone, a practise more common in Vestland than the rest of Norway.

Interestingly, 38.2% of participants in Vestland and 47.3% in the rest of Norway report using harvest waste as bait for scavengers, but Vestland shows overall lower engagement regarding the hunting of mesopredators, with 46.4% of hunters actively pursuing mesopredators such as foxes and corvids, compared to 61.6% elsewhere.

Table 4. Result from survey among hunters in all of Norway (n=1244), Norway excluding Vestland (n=765) and in Vestland county alone (n=479), and how they treat carcass remains, which body parts they utilize and their preference for scavenger hunting.

Question	All (n= 1244)	Norway excl. Vestland (n=765)	Vestland county (n=479)
Routine with gutting			
Do not take the rumen out	24.8%	21.7%	29.9%
Leave the rumen at kill site	82.7%	84.2%	80.4%
Take the rumen to another location	11.1%	10.5%	12.1%
Routine with field dressing			
I leave everything in the terrain	38.6%	35.6%	42.8%
I leave it in a ditch/hole in the ground	30.6%	27.6%	35.5%
I use it as bait for scavengers	43.8%	47.3%	38.2%
I deliver it to a waste site	8.7%	10.1%	6.7%
I leave it at the intertidal zone	5.4%	3.7%	8.1%
Give it to dogs.	0.3%	0.04%	0.02%
Use of offal			
Lungs	3.3%	3.8%	2.7%
Heart	88.2%	87.8%	88.9%
Liver	23.3%	21.1%.	26.9%
Kidneys	3.3%	3.7%	2.9%
Tongue	41.2%	45.6%	35.7%
Feet	18.5%	21.30%	14.0%
Skin	6.7%	7.5%	5.4%
None	9.8%	10.5%	8.8%
Hunt mesopredators?			
Yes	55.8%	61.57%	46.4%
No	24.3%	20.92%	29.9%
Yes, but only if they pass by	19.9%	17.52%	23.8%
Which scavengers do you hunt?			
Red fox	62.2%	65.8%	56.6%
Badger	19.1%	27.5%	5.8%
Mink	13.4%	13.5%	13.4%
Stoat	6.0%	6.4%	5.4%
Corvids	33.9%	38.2%	27.14%
Pine marten	21.2%	23.1%	18.2%
I only hunt scavengers if they pass by	16.2%	15.6%	19.0%
I don’t hunt predators	20.9%	18.7%	24.4%

3.2.2 Fuzzy correspondence analysis - Norway

Figure 3 shows the fuzzy correspondence analysis (FCA) of responses categorized into six functional variables each representing different aspects of the data collected. Each panel in the figure represents a distinct functional variable, mapping individual responses based on their similarity in relation to specific categories.

Species illustrates the distribution of responses related to species type, differentiating among moose, red deer, roe deer, and reindeer. **Counties** shows the distribution of responses associated with geographical location, represented by various counties. Red deer hunting is more prevalent in Vestland (99.4% vs 76% for other counties; χ^2 =121.79, all tests with 1 d.f. and n=1244 $p<0.001$), roe deer hunting is associated with Trøndelag county (Tr) (83% vs 45% in other counties, χ^2 =88.45, $p<0.001$) and with Rogaland (80%) and Agder (92%). Moose hunting was as expected the preferred species of cervid in the northern counties (Nordland and Troms/Finnmark) with 97% of hunters hunting moose.

Gutting represents gutting practices, differentiating between practices performed at the kill site or another location. **Slaughtering** examines practices around disposal of waste from slaughter, with terms such as "Terrain" and "Waste site" representing different methods or locations associated with disposal of waste. Gutting practices as performing the gutting at the same site as the field dressing (Slau) were associated with the species of cervid hunted, with 28% of red deer hunters using the slaughtering place, 22% for reindeer, 21 % for roe deer, and only 16% for moose. For reindeer it showed no statistically significant association (χ^2=0.48, p=0.48), indicating that the use of the slaughter place did not differ from the average of other species. For reindeer, the site of the kill was used more often than for other species (95% vs 80%; χ^2=44.8, $p<0.001$.

Hunting red deer was associated as expected with the western counties (Rog[aland], Møre og Romsdal (MR) and Vestland [Vest]). Leaving waste from slaughtering at the sea and pit was more common in western counties Rogaland 7 %, Møre og Romsdal 7% and Vestland 8% compared to e.g. 4% in Trøndelag and 1% in Agder.

Organs focuses on organ retention and usage. Using different organs was not related to the other variables, except for the category "not using any organ", but that was linked to one species hunted; 9.9 % of red deer hunters used no organ, 10.1% of reindeer hunters used no organs, 10.2% of roe deer hunters used no organs, but only 5.5% of moose hunters used no organ. Use of organs was also linked to counties, hunters in Nordland always used some organs, and 4% in Troms and Finnmark used no organ, whereas using no organs was more frequent in southwestern counties: 12 to 13% in Møre og Romsdal and Rogaland. As moose is the dominant ungulate species hunted by hunters from northern counties (97% of hunters from Troms og Finnmark and Nordland hunted moose, whereas only 28% hunted red deer; proportions for other counties were 48% and 87% resp.), one cannot distinguish geographical traditions from species differences using this approach.

Predators represents the hunters' preference for predator hunting. Placing waste at bait sites and hunting corvids shows strong association between them (48% of hunters placing waste at bait sites hunted corvids, vs 23%; χ^2=89.51, p<0.001). This tells us that those who placed waste at bait sites actually did hunt for scavengers, such as corvids. Hunting corvids and hunting red fox had high statistically significant association (χ^2=234, p<0.001): 50% of hunters hunting fox hunted corvids as well, whereas only 8% of hunters that did not hunt fox hunted corvids. Hunting corvids was less frequent in Vestland than in other counties (27% vs 38%; χ2=15.5, p<0.001). This was not linked to an association between hunting red deer and corvids (34% of red deer hunters hunted corvids vs. 33% for hunters hunting other species, χ^2=0.026, p=0.87), this is likely caused by the high percentage of red deer hunters in Vestland. Out of the participants who hunted red deer did 20% hunt predators opportunistically, for moose, reindeer and roe deer hunters it was 17%, 14% and 16% respectively. Further, 20% of hunters who hunted red deer did not hunt any predators at all. For moose, reindeer and roe deer hunters the numbers were lower with 16%, 14% and 12% respectively.

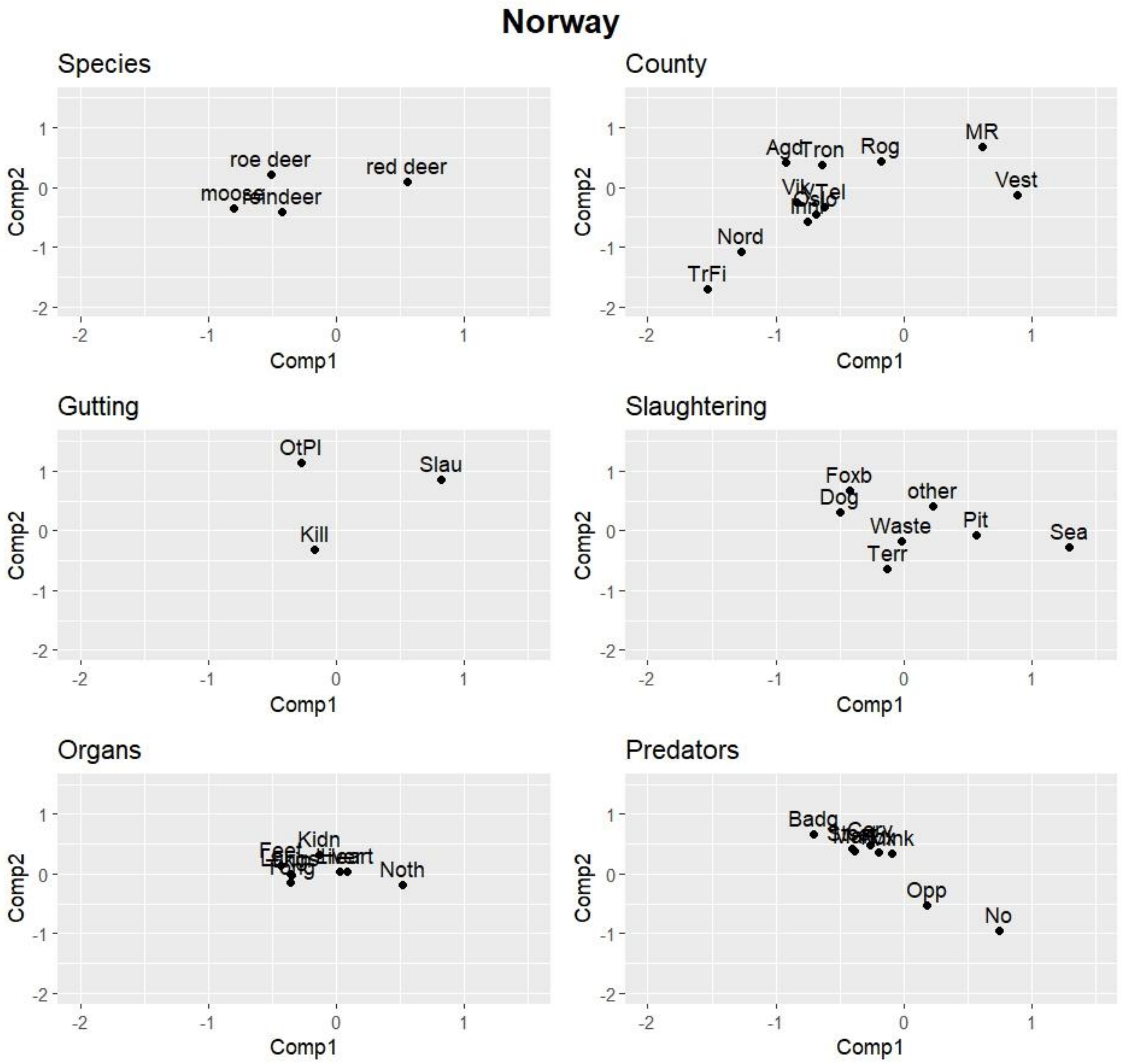

Figure 3. Fuzzy correspondence analysis (FCA) of six functional variables, showing the distribution of survey responses across different categories in all of Norway. Each panel represents a separate functional variable, with labels indicating the most significant response categories in each. Species is species of cervid the participants hunted, County is what county the participants hunted in, Gutting is gutting practises, Slaughtering is disposal of slaughter waste, Organs is utilization of organs and other body parts and Predators is what predators the participants hunted.

3.2.3 Fuzzy correspondence analysis - Vestland

Figure 4 presents the results of a fuzzy correspondence analysis (FCA) on five functional variables derived from the participants that answered in the survey that they hunted in Vestland county. Each panel represents one functional variable, showing how individual responses to specific categories.

Species corresponds to species of cervid hunted. As nearly all hunters were red deer hunters in Vestland (99.6%), the category "Red deer" was located close to the origin and could not be linked to any other category. Additionally, 52 hunted reindeer, 98 hunted moose and 106 hunted roe deer. **Gutting** shows gutting practices in Vestland. There was a positive association between hunting moose, reindeer and roe deer and gutting at the kill site. A total of 92% of roe deer and reindeer hunters did use the kill site (for roe deer: χ^2 = 4.45, df=1, P=0.035), while 80% for red deer and 95% for moose.

Slaughtering represents disposal practices of waste from harvest in Vestland. There is a strong association between performing the field dressing in the terrain [Terr] and gutting at kill site. A total of 95% of hunters dressing in the terrain were gutting at the kill site, while 70% not dressing in the terrain gutting at the kill site (χ^2=44.6, p<0.001). Additionally, there was weak evidence for an association between hunting predator opportunistically and gutting at the same location as field dressing. A total of 21% of hunters hunting predators opportunistically gutted at the same location, while 32% for hunters not using the same location (χ^2=3.8, p=0.051).

Organs focuses on utilization and **Predators** addresses predator hunting. There is a significant association between no utilization of organs [No] and no predator hunting [Noth] (χ^2=5.5, df=1, p=0.02). There is also a significant association between leaving waste at sea and no predator hunting (χ^2=9.6, df=1, p<0.001). There is however no statistically significant association between use of no organs and leaving waste at sea (p = 0.9).

Delivering waste to waste sites and fox hunting showed no association ($p=1.0$). This tells us that those who leave waste unavailable for the scavengers does not engage in management of the scavengers. Leaving gut piles at kill site and using no organs ($df=1$, $n=479$, $\chi^2=0.84$, $p=0.35$), indicating no significant association. Interestingly, there was a highly significant association between leaving waste at bait sites and no predator hunting ($df=1$, $N = 479$, $\chi^2 =21.52$, $p<0.001$). This indicates that participants may leave waste available for scavengers while not hunting scavengers.

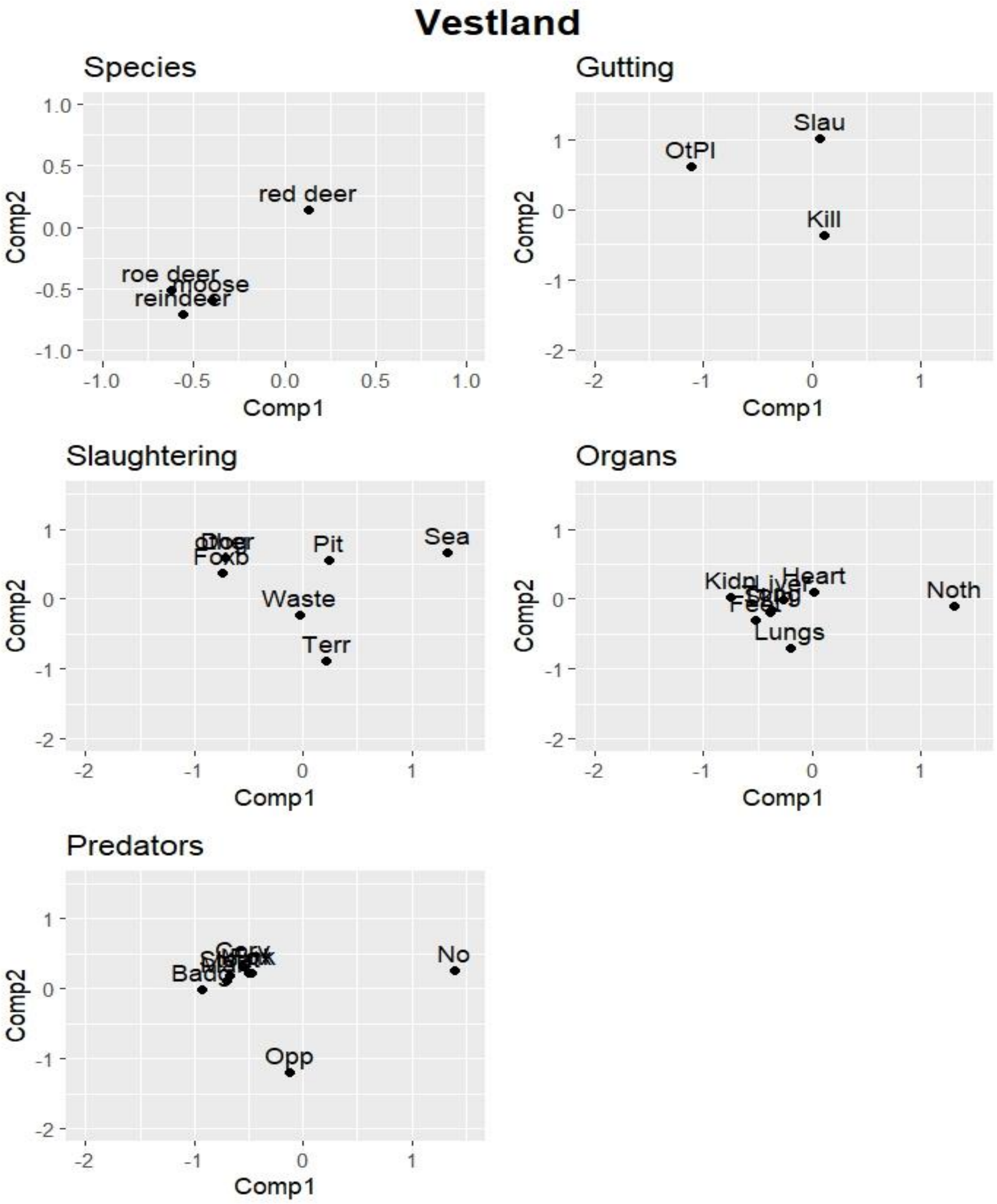

Figure 4. Fuzzy correspondence analysis (FCA) of five functional variables showing the distribution of survey responses across different categories in Vestland county. Each panel represents a separate functional variable, with labels indicating the response categories in each. Species is species of cervid, Gutting is gutting practises, Slaughtering is disposal of slaughter waste, Organs is utilization of organs and body parts and Predators is what predators the participants hunted.

3.2.4 Estimated biomass and utilization rates

Table 5 presents the estimated biomass from harvested red deer across Norway, with a focus on utilization rates for various body parts. The data are divided into two categories: the overall potential biomass and the amount utilized, both for all of Norway and specifically for Vestland County. The table provides a detailed breakdown of the biomass by body part and highlights the extent of utilization, offering insights into waste and resource use.

The total potential waste across Norway is estimated at 1636 tons, of which approximately 186 tons (11%) is utilized according to survey data. Vestland County shows a similar trend, with a potential waste of 775 tons and an estimated utilization rate of 10%, corresponding to 77.48 tons. These values suggest that only a small proportion of the available biomass is utilized, leaving a substantial amount of potential waste.

The utilization of internal organs by hunters shows considerable variation between Vestland and Norway overall. The heart was the most utilized organ, with 88% of hunters in Norway and 89% of hunters in Vestland retaining it. This corresponds to roughly 26 tons of heart utilized across Norway with 12 tons in Vestland. The liver, used by 23.3% of hunters in Norway and 27% of hunters in Vestland, accounted for 12 tons overall and approximately 7 tons in Vestland. Kidneys and lungs show particularly low utilization, with only 3.3% of kidneys utilized in Norway and 2.9% in Vestland County. Lungs are similarly underutilized, at 3.8% and 2.7%, respectively, for Norway and Vestland.

The mainly inedible parts, such as the head, feet and skin also showed varied levels of utilization. The use of head is primarily for specific purposes like tongue consumption and 41% of the participants answered that they utilized tongue. Feet accounted for 175 tons in Norway and were retained by 14% of hunters in Vestland, resulting in 11.6 tons of biomass being used in Vestland. The inedible body parts contribute significantly to the total biomass, but utilization is minimal. Only 6.7% of skin (13.70 tons) are utilized across Norway. In Vestland County, skin utilization is 5.4%.

The overall utilization rates across body parts indicate substantial waste, with an estimated 1449.72 tons of biomass left unused in Norway with 697.52 tons in Vestland County.

Table 5. Biomass from harvest and utilization of red deer in Norway and Vestland county based on survey among hunters.

Body part	**Biomass all of Norway**	**Utilized in all of Norway**	**Biomass in Vestland county**	**Utilized by hunters in Vestland County**
Potential waste harvest	1636 tons		775 tons	
Heart	29.05	88.2% 25.62 tons	13.76	88.9% 12.23 tons
Lungs	-	3.8%	-	2.7%
Liver	52.77	23.3% 12.30 tons	25	26.9 6.73 tons
Kidneys	22.91	3.3% 0.8 tons	10.85	2.9% 0.3 tons
Head*	246.28	41.2% 101.47	116	35.7% 41.41
Feet	175.09	18.5% 32.39	82.95	14% 11.61 tons
Skin	204.55 *	6.7% 13.70	96.9	5.4% 5.2 tons
Bones	818.20**	-	387.6	-
Overall utilization of waste from harvest		186.28 tons 11.39%		77.48 tons 10%
Estimated harvest waste after utilization		1449.72 tons		697.52 tons

* given that the skin weighs 5% of live weight

**given that bones weighs 20% of live weight

3.3 Camera at bait sites

In total I had 2377 pictures of scavengers and other species. All cameras had photographed several species and a total of nine different scavenger species visited the bait sites along with other non-scavenging species. The non-scavenging species were categorised into two groups: other and herbivore. The other-group were thrushes, woodpecker and robin and the herbivore group were sheep and red deer. Hooded crow (*Corvus cornix*), raven (*Corvus corax*) and magpie (*Pica pica*) were the most common avian scavengers, and the most common mammal species was the red fox. Other registered scavengers were various seagulls (*Laridae* spp.), mink (*Neovison vison*), pine marten (*Martes martes*), eagles (*Accipitridae* spp.) and grey heron (*Ardea cinerea*). I pooled the seagull species into one group as well as the eagles since they were the least observed avian species. The corvid species had a high visiting rate and often occurring at the site in groups with numbers up to 30 individuals. Mammals were present only one individual at the time and were usually the last scavenger species to occur at site.

3.3.1 Spatial distribution

As seen in table 6, crows were the most observed scavenger on most types of bait site. The exception was for the sites with waste left directly on the ground in the forest, where foxes were the most observed animal. The two sites with covered ditch had the least number of observations overall, with crows and magpies making up the majority of the observations. No mammals were observed at these sites. There were also 16 observations of other species, mostly thrushes, robin and woodpecker and 42 observations of herbivores that passed by (sheep and red deer).

Interestingly, the site with only bones attracts a notable number of scavengers, particularly crows (802 observations) and ravens (131 observations). This indicates that even bones, which are usually less attractive to many animals, are scavenged by certain species.

Crows are by far the most abundant species across all the sites, with 67.75% relative abundance. They are particularly dominant at the site on an island with no known mammal scavengers, where over 5000 crows were observed. Ravens make up 23.54% of the total observations, second only to crows. Ravens are particularly prevalent at the sites with open ditches, and on the island with no known scavenging mammals with over 2254 sightings on that site alone. Mammals such as foxes, mink, and pine martens show much lower observation counts than avian species. Foxes were observed 87 times, predominantly at the sites in the forest and at the shore.

Table 6. Observations of scavengers

Type/site	Crow	Magpie	Raven	Heron	Eagle	Seagull	Fox	Mink	Pine marten
Covered ditch Two sites	173	170	0	0	0	0	0	0	0
Open ditch Two sites	1933	160	662	1	3	0	0	0	0
In the forest Two sites	7	3	0	0	2	0	45	0	5
Only bones One site	802	131	13	0	0	0	32	2	0
Island with no known mammal scavengers Two sites	5315	23	2254	0	0	0	0	7	0
Shore One site	475	33	100	51	3	379	10	0	0
Gutpile One site	13	3	0	0	0	0	0	0	0
Total observation	8718	523	3029	52	8	379	87	9	5
Relative abundance	67.75 %	4.06%	23.54 %	0.4%	0.06%	2.95%	0.68 %	0.07%	0.04%
Largest group	30	6	13	3	1	15	1	1	1

3.3.2 Temporal distribution

As seen in figure 5, the observation of avian scavenger peaks during daytime with the highest observations between 10:00 and 16:00, and another peak around 21:00 to 00:00. For the mammalian scavengers the majority of the observations were foxes who were observed between 02:00 and 06:00 as seen in figure 5. This indicates that the scavenging mammals have a nocturnal pattern and that avian scavengers exhibit a diurnal rhythm with peak activity during daylight. All groups have low numbers of observations between 06:00 and 09:00 as well as between 16:00 to 19:00, this could be explained by human activity in the area surrounding the bait sites.

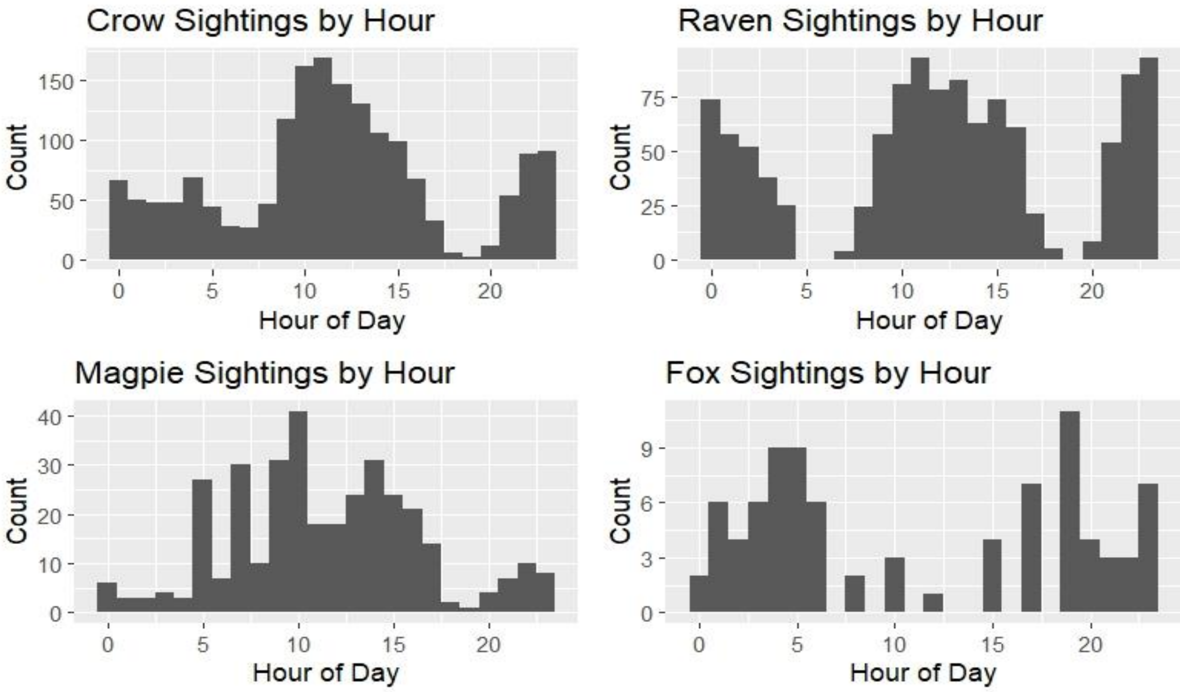

Figure 5. Distribution of Sightings for Crow, Raven, Magpie, and Fox. Each panel displays the count of sightings per hour of the day for crows, ravens, magpies, and foxes. Each panel has different numbers on their y-axis due to difference in number of sightings.

The distribution of recorded observations across time is shown in Figure 6. Observations were collected from February 2023 until the end of December 2023, with significant temporal variability. The data reveal a distinct peak in observation frequency during September and October 2023, with the highest concentration in October, while other months displayed substantially fewer recordings. This trend suggests a possible seasonal effect, as observation rates are highest during the autumn period.

The sharp decline in observations following October may reflect either a seasonal decrease in observable scavenger activity or a reduction in monitoring intensity.

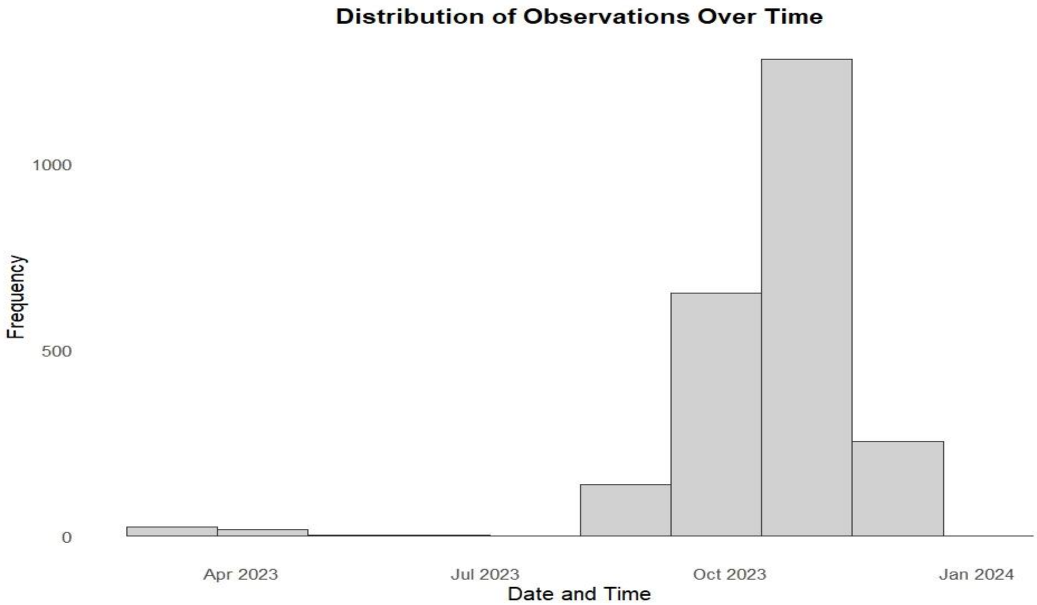

Figure 6. Distribution of all observations captured by the cameras from January 2023 until January 2024. The histogram shows the frequency of recorded observations by date. The x-axis represents the timeline, while the y-axis shows the frequency of recorded observations within each time bin.

Figure 7 illustrates the monthly variation in observations for four species—crow, raven, magpie, and fox—across the study period from September to December 2023.

The crow was observed consistently throughout the months, with the highest median observation count occurring in November 2023. This month also displayed the widest range of observations, suggesting increased crow activity or visibility. In contrast, observations decreased sharply in December, indicating a potential seasonal change in behaviour, migration patterns or detectability.

Fox observations were sparse, with low counts recorded each month. Observations were slightly higher in November and December compared to earlier months, though the counts remained very low overall. The limited fox activity could be attributed to their behaviour or detection probability as foxes were mainly observed during night hours.

For magpies, sightings were also relatively low but showed a slight increase in October and November. This trend may suggest that magpies become more visible or active during these months, though observations dropped again in December, aligning with seasonal patterns seen in other species.

Raven observations showed a notable increase in November. The broader distribution in November indicates that ravens were more frequently observed. Observations for ravens then decreased in December, following a pattern similar to that of crows and magpies.

Overall, the data indicate a general trend of increased observations for all four species in November, followed by a decline in December. Crows and ravens showed the highest levels of monthly variation, while foxes and magpies remained relatively low in observations.

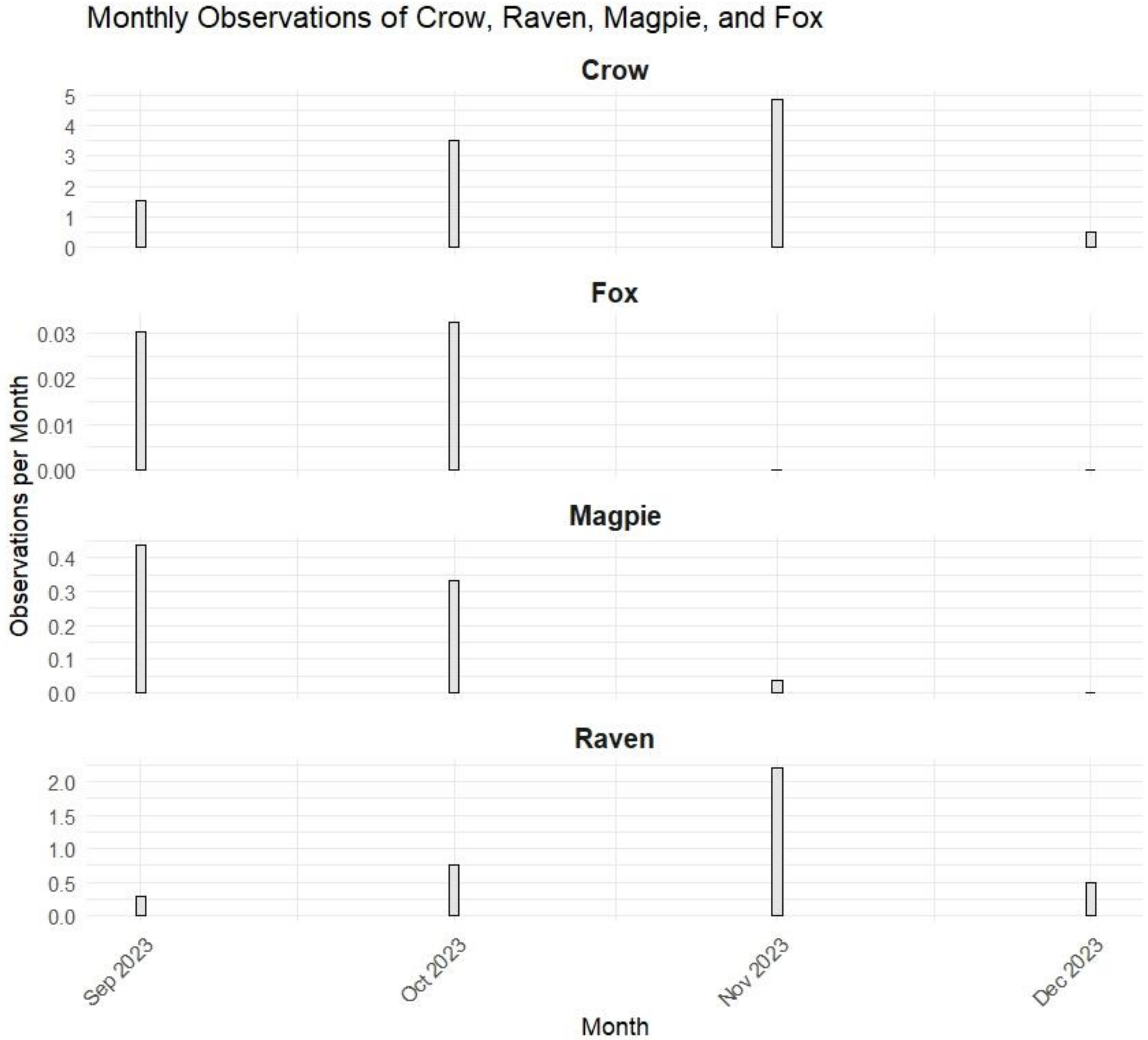

Figure 7. Monthly Observations of Crow, Raven, Magpie, and Fox from September to December 2023. This figure displays the mean monthly observations for each species over four months. Each panel represents one species and observations are displayed as box plots.

The distribution of observations for crow, raven, magpie, and fox across temperature ranges is displayed in Figure 8. Each species demonstrates distinct patterns in relation to temperature, which may reflect species-specific activity levels or temperature preferences.

Crow observations were widely distributed across temperature bins, with notable activity in temperatures between -4°C and 10°C. There was a consistent number of observations up to approximately 8°C, after which sightings gradually declined. This suggests that crow activity remains relatively high within a moderate temperature range, with fewer sightings recorded at more extreme temperatures.

Fox sightings, in contrast, were predominantly observed in colder temperatures, specifically from -12°C to -4°C. Observations decreased substantially as temperatures rose above 0°C, indicating that fox activity, or at least detectability, may be higher in colder conditions.

Magpie observations showed a broader spread across temperature bins, with notable peaks between -2°C and 8°C. While sightings were recorded across a wide range of temperatures, the most consistent observations occurred within this narrower temperature range. This suggests a potential preference or greater activity within moderate temperatures, though magpies were occasionally observed in both colder and warmer conditions.

Raven sightings were more evenly distributed across a wide range of temperatures, with observations recorded from -10°C to 16°C. Although there was a slight increase in sightings around 0°C to 10°C, the distribution suggests that ravens may exhibit a relatively high tolerance for a broad range of temperatures. The data does not show a strong preference for any particular temperature range, indicating that ravens may adapt their activity levels to varying environmental conditions.

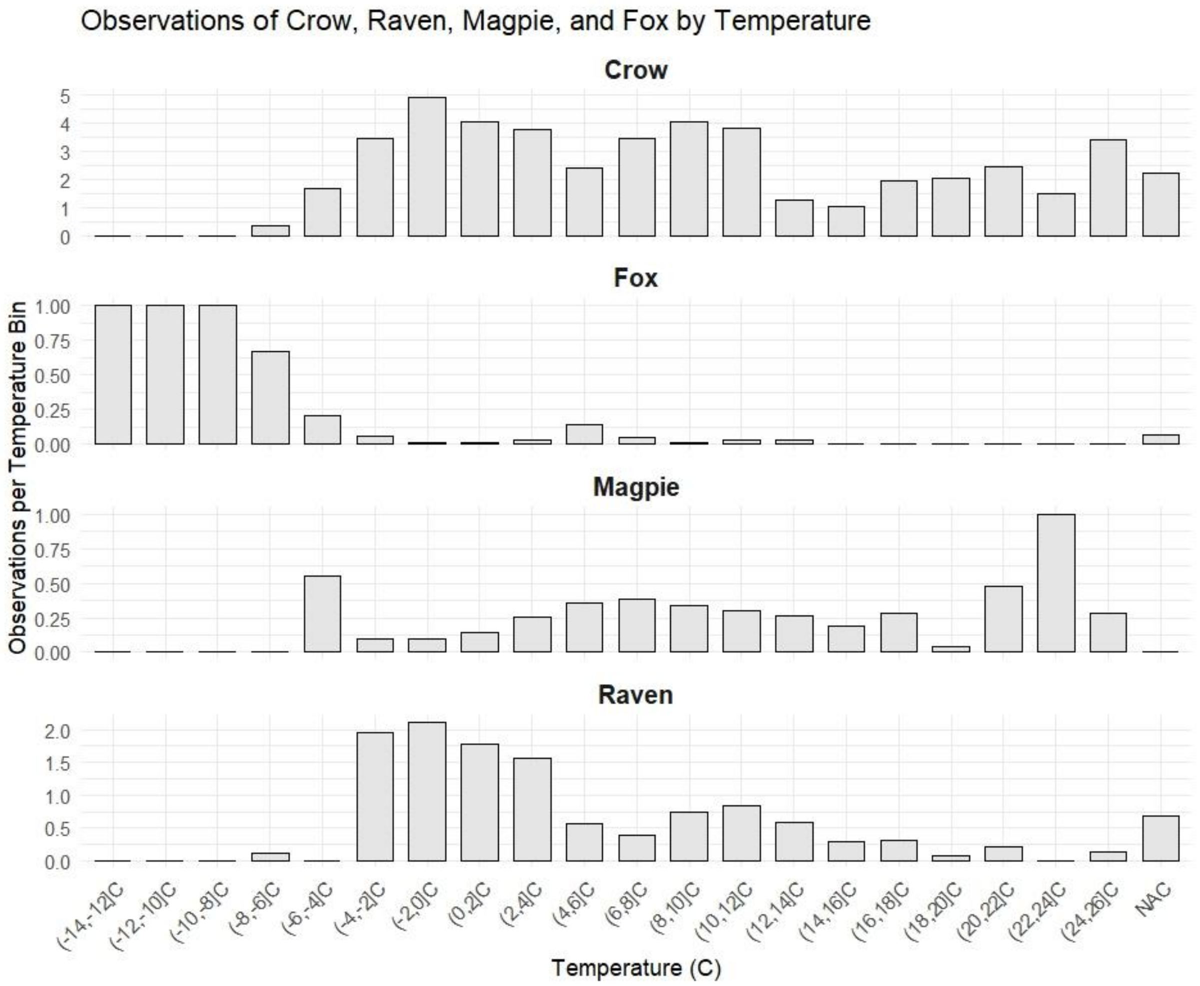

Figure 8. Observations of Crow, Raven, Magpie, and Fox by Temperature. This figure presents the distribution of observations for each species across temperature ranges, grouped in 2°C bins. Each panel represents one species, with box plots indicating mean observations per temperature bin.

Generalized Additive Models (GAMs) were used to assess the influence of temperature on adjusted sightings of both crows and ravens (figure 9) as they were the most observed scavengers. The smooth term for temperature had an estimated degrees of freedom (edf) of 7.879, with a highly significant p-value ($p < 0.001$), confirming a substantial non-linear effect of temperature on crow sightings. The model explained approximately 6.02% of the deviance with an adjusted R-squared of 0.0425. The low explained deviance and R2 suggest that while temperature has an impact, other factors contribute significantly to the variability in crow sightings.

GAM for raven showed that temperature was highly significant (edf = 8.097, $p < 0.001$), demonstrating a non-linear effect of temperature on raven sightings. The model for raven sightings explained a higher proportion of variability compared to the crow model, with an adjusted R-squared of 0.125 and a deviance explained of 16.8%, signifying that temperature plays a more prominent role in influencing raven sightings.

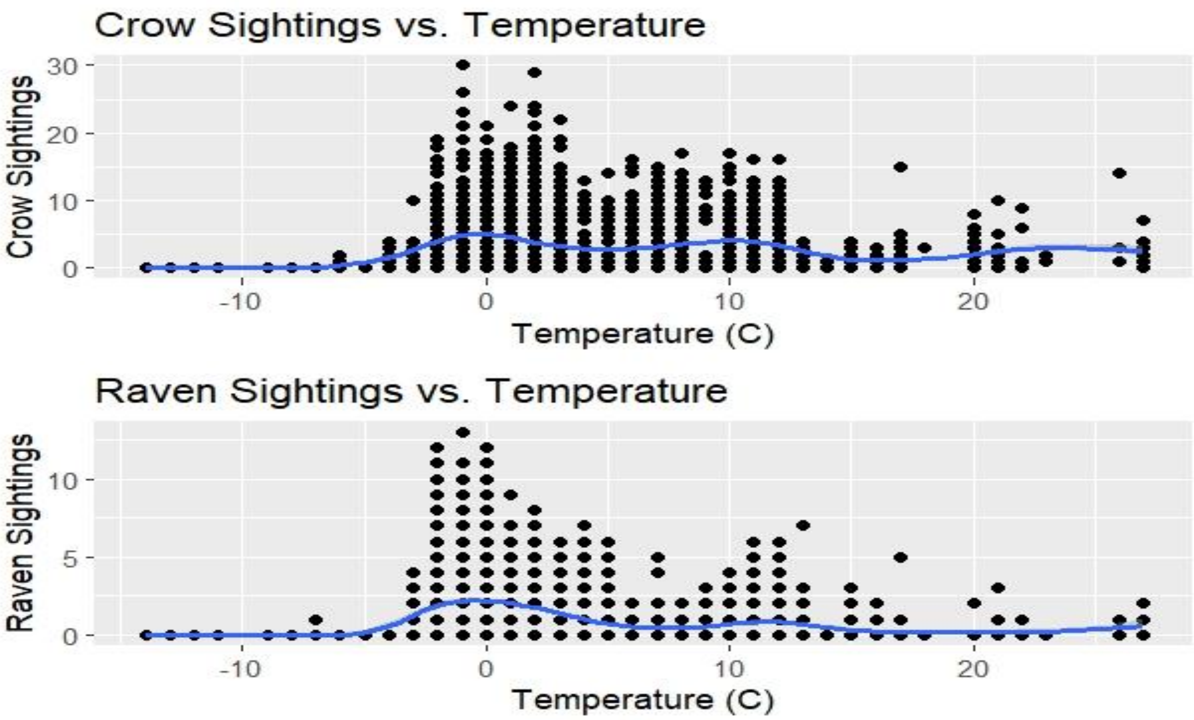

Figure 9. GAM plots for crow and raven sightings versus temperature. The crow GAM trend line indicates a peak of observations of crow slightly below and near 0°C, followed by a tapering as the temperature rises or falls. The GAM trend line for raven suggests higher activity around 0°C, with a decline as temperatures increase or decrease beyond this central range.

4 Discussion

In the absence of large predators, human-created subsidies from harvest of ungulates are likely to be an important food source for scavengers. The red deer is now the most abundant cervid in Norway, with the majority of the population located in Vestland county. The estimates of red deer carrion biomass reveal substantial resources available to scavengers, amounting to approximately 1450 tons from hunting alone and an additional 123 tons from red deer deaths due to traffic and other causes (table 3 and table 5). This totals 1573 tons of carrion, with a significant portion located in Vestland. The amount of carrion in Vestland alone reflects the region's important role in supporting scavenger populations due to the high density of red deer and hunter activity. These estimates underscore the critical contribution of red deer biomass to ecosystems, particularly in regions with high hunting activity and traffic-related mortality. While hunters in Norway utilize a portion of the biomass, around 11% on average, the remainder becomes a food source for scavengers. This can also be seen in the study by Wikenros et al. (2013) where they found that moose hunting in Sweden provides the greatest amount of carrion, even in areas with top predators.

The amount of carrion from red deer, both from traffic accidents and waste from harvest, might serve as a bottom-up effect and have central role in supporting scavenger populations due to the high amount of food provided. Additionally, large predators have been removed from the large parts of Norway's land area and thus top-down pressure on scavengers are reduced, which can cause mesopredators release. A study conducted by Elmhagen and Rushton (2007) in Sweden found that reduced predator populations led to mesopredators release, but also that the baseline of ecosystem productivity set an upper limit for the impact. This means that when top predators are diminished, mesopredators experience a surge in numbers due to less competition and predation. However, the extent to which these mesopredators can increase in numbers are constrained by the productivity of the environment itself. In highly productive ecosystems, the populations of mesopredators may increase more compared to ecosystems with low productivity. This is supported by the findings in a study from Finnmark, Norway, by Henden et al (2014) and a study from northern Sweden by Carricondo-Sanchez et al (2016) where they found that the occupancy of mesopredators were higher in areas with increased access to carcasses of reindeer who had died from harsh winter conditions. As the red deer population in Norway continues to grow one can assume that the amount of carrion in the ecosystems increase as well through waste from harvest, hunters' utilization and other causes of death and thus supporting higher numbers of mesopredators.

In Europe, the annual harvest of ungulates is about 7 million of which red deer constitute roughly 730.000 (Linnell et al. 2020). Understanding hunter behaviour is important due to their role in controlling cervid populations and creating revenue (Brown et al. 2000; Andersen et al. 2014), but few have studied the treatment of carcasses. The survey among hunters provides valuable insights into resource utilization practices. It shows that most hunters leave rumen at site and leaves waste from harvest in the terrain, which suggests a significant opportunity for scavengers to access these resources. Fewer hunters in Vestland deliver waste to designated disposal sites (6.7%) a method being less common compared to leaving waste in the terrain or using it as bait for both Vestland and Norway. When Vestland is excluded, still only 10% deliver waste from harvest to waste sites. This disposal practices may be influenced by factors such as the proximity of waste disposal facilities. Additionally, hunters in Vestland county often leave waste in the terrain (42.8%), a practice more frequently in Vestland than in other parts of Norway (35.6%). This practice is notable as it creates localized feeding opportunities for scavengers, which could lead to increased scavenger densities and potentially alter local scavenger populations. The study's findings on hunters' preferences for mesopredator hunting highlight a lower tendency for active scavenger hunting in Vestland compared to the rest of Norway. Although hunters in Vestland were less likely to hunt mesopredators, there was a higher prevalence of leaving carcass waste in the field, inadvertently supporting scavenger populations. This finding suggests that hunters unintentional could supplement scavenger populations, potentially leading to increased populations of mesopredators. Further studies are needed to understand whether hunter treatment of carcasses is related to age, level of education, or different between urban and rural hunters, as this is shown to influence other aspects of hunter behaviour (Zinn 2003; Pettis 2016).

Camera trapping has revolutionized the possibility for monitoring vertebrate populations continuously, and this is very efficient when cameras can be deployed at “hot spots” of use (Burton et al. 2015). Camera monitoring at bait sites across Vestland revealed that corvid species, particularly crows and ravens, dominated scavenging activity. These birds appeared at bait sites in high numbers, especially on islands with limited mammalian predators, and their abundance emphasizes their adaptability and capacity to exploit available resources. In this study, the majority of all visits at the bait sites were from crows and ravens, which is also found in other studies (Lacombe et al. 2024, Henden et al. 2014, Wikenros et al. 2013), where they found that the most frequent avian scavenger on carcasses was common raven. However, foxes represented a larger part of the visits in all studies, whereas in this study foxes only represent 0.68% of the visits. My study demonstrated that placement of carcasses affected the relative visitation of mammalian versus avian scavengers as is also seen in a study on ravens from Poland (Rösner et al. 2005) where they found that ravens located 79% of exposed baits within 24 hours and that all exposed bait sites were visited by ravens within 72 hours. This likely reflect differences in perception of fear by the different vertebrate groups and their willingness to expose themselves.

In northern environments, there is a strong seasonality, and winter is often a critical time for survival of many species. The fall is important for many mammals to restore fat reserves (Mautz 1978). The majority of the carrion originates from the annual hunting season, which is between 1 of September and December the 23. Hence, there is a strong seasonality in the availability of carcasses from hunting, which may limit their value compared to a more stable food source. Death by other causes happens throughout the year. Most natural mortality of cervids are either right after birth, with a neonatal mortality percentage of 23$\pm$34% for red deer in areas with predators and 18% in areas without (Linnell et al. 1995) or increased predation in winter (Brodie et al. 2013) or starvation (Solberg et al. 2022), but also death by traffic is more common during the autumn and the winter months with lower numbers of accidents reported in the summer months (Rivrud et al. 2020). A study from Varaldskogen, Norway, found that remains of ungulates were present in the diet of red foxes through the year with the highest amount between December to April and the lowest in July to August (Needham et al. 2014). When the amount of ungulate in the diet were low, the amount of smaller prey, like birds and rodents, were higher. A study from Białowieża Primeval Forest found that carrion from ungulates constitutes the majority of the winter diet in ravens (Rösner et al. 2005). Both foxes and particularly corvids are nest predators (Ims et al. 2013), and the support through subsidies from hunting and the low level of population management could have negative consequences for breeding success of ground nesting birds.

In areas like Vestland, where waste disposal methods often leave carrion accessible, hunters indirectly support scavenger populations. As the hunting season occurs during autumn, a critical period for many scavengers, especially juveniles, the survival rate for the scavengers might increase. Holyoak et al (1971) found that corvids have high autumn mortality their first year, this could indicate that the availability of carrion during this period could be crucial for their survival. A study from Trøndelag, Norway, found that corvids were the first scavengers to visit the gut piles and could therefore utilize the most nutrient dense parts first (Gomo et al., 2017). The corvids in their study also usually occurred at the gut piles in groups. In this study, corvids occurred in large numbers and often in groups and could therefore potentially utilize most of the nutrient dense parts of the gut pile before the mammalian scavengers. Reducing the corvid populations could therefore potentially benefit the mammalian scavengers as the availability of more nutrient dense carrion could be available for a longer period. How the seasonal differences in timing of carcass provisioning depending on source can affect the different scavenger populations warrants further study.

Hunting of cervids in Scandinavia has a strong tradition as a harvest of meat as is seen in a study from Norway (Andersen et al 2014), they found that Norwegian hunters mainly hunted ungulates for meat and recreation with only 13% hunting for trophies. The survey in this study also highlighted the parts of red deer that are most utilized by hunters. High-value organs like the heart and liver are commonly retained, while other parts, such as lungs and kidneys, are rarely used. The low use of lungs, often damaged by bullets, may explain why hunters discard these organs. Traditionally, organs such as kidney and liver were utilized by most hunters. However, due to increased pollution the level of heavy metals is high in these organs (Petrović et al. 2013; Durkalec et al. 2014), and it is not recommended to eat in particular kidneys from adult individuals. Further, the low use of offal for human consumption could also be linked to the high harvest numbers of red deer, where hunters may choose to prioritize to utilize muscles as a food source rather than internal organs particularly as 75% of a dressed carcass is muscle (Kwiatkowska 2009). The remaining inedible components, such as bones and tendons, are valuable for scavengers, as observed in this study, and may therefore constitute a significant portion of biomass left for scavenger consumption.

The active hunting of mesopredators could potentially counter any positive effect of waste from red deer on their populations. The hunters' approach to mesopredator management in Vestland, with only 46.4% of hunters actively pursuing scavengers compared to 61.6% elsewhere in Norway, suggests a lower level of direct predator control in the region. This difference may be due to variations in predator densities or local hunting priorities, but it implies that scavenger populations, particularly corvids and foxes, may benefit from low hunting pressure. Corvids were the second most hunted group of scavengers in this study, with 33% of the participants of the survey answered that they intentionally hunted them. Traditionally in Norway, there were bounties on mesopredators to support hunting of them (e.g. Henden et al. 2009). The extent to which this worked as intended is not well documented, but this management practise is less common today.

4.1 Concluding remarks

The estimates of red deer carrion biomass in Norway reveal substantial resources available to scavengers. These high estimates suggest that red deer biomass may change ecosystem dynamics, promoting an indirect feeding that supports various scavenger species. I documented with camera monitoring at bait sites that corvids, particularly crows and ravens, were the dominant scavenger species. This could imply that red deer in Norway can enhance corvid survival and potentially increase their populations. Further studies are required to document if this has led to increases in the scavenging population. It also remains to be documented whether hunting mesopredators can counter such increases. The findings in this study also showed that active hunting of mesopredators was less common in Vestland (46.4%) compared to the rest of Norway (61.6%). This lower hunting pressure may contribute to higher densities of scavengers, especially corvids, due to reduced top-down control.

The indirect feeding of scavengers through carrion left in the terrain may influence predator-prey dynamics. Increasing scavenger populations could lead to greater predation pressure on prey species during times when carrion is scarce. Studies have shown that reductions in fox and corvid populations can improve ground-nesting bird breeding success, highlighting the need for targeted predator management in regions with high scavenger support. While hunters' waste disposal practices aid scavenger populations, balancing these practices with conservation goals may require more structured waste management. This scavenging activity underscores the ecological significance of hunting practices, and this thesis provides a background to guide further studies to assess these complex relationships.

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Appendix A. Report from Nettskjema.

NETTSKJEMA

Slakteavfall fra hjortevilt

Oppdatert: 5. september 2024 kl. 13:53

Tar du vare på organer?

Antall svar: **1246**

Svar	Antall	% av svar	Diagram
Lunger	42	3.4%	3.4%
Hjerte	1100	88.3%	88.3%
Lever	291	23.4%	23.4%
Nyrer	43	3.5%	3.5%
Tunge	521	41.8%	41.8%
Føtter	230	18.5%	18.5%
Skinn	83	6.7%	6.7%
Jeg benytter ikke overnevnte kroppsdeler eller organer	122	9.8%	9.8%

Rutiner ved slakting av hjortevilt

Antall svar: **1246**

Svar	Antall	% av svar	Diagram
Jeg slakter i terreng og lar slakteavfallet ligge på skuddplass	467	37.5%	37.5%
Jeg legger slakteavfall i en slaktegrop som fylles med jord ved jaktens slutt	359	28.8%	28.8%
Jeg legger slakteavfallet på reveåte	479	38.4%	38.4%
Jeg leverer slakteavfallet til avfallsmottak	90	7.2%	7.2%
Jeg legger slakteavfall i sjøkanten	62	5%	5%
Annet	146	11.7%	11.7%

☑ Rutiner ved vomming av hjortevilt

Antall svar: **1246**

Svar	Antall	% av svar	Diagram
Jeg tar dyret til slakteplass uten å ta ut vom først	302	24.2%	24.2%
Jeg lar vommen ligge på skuddplass	1009	81%	81%
Jeg vommer på skuddplass, men tar vommen med meg til en annen lokasjon (slaktegrop /reveåte ol.)	130	10.4%	10.4%
Annet	54	4.3%	4.3%

☑ Hvilket fylke jakter du hjortevilt?

Antall svar: **1246**

Svar	Antall	% av svar	Diagram
Agder	105	8.4%	8.4%
Innlandet	197	15.8%	15.8%
Møre og Romsdal	223	17.9%	17.9%
Nordland	47	3.8%	3.8%
Oslo	3	0.2%	0.2%
Rogaland	110	8.8%	8.8%
Troms og Finnmark	25	2%	2%
Trøndelag	189	15.2%	15.2%
Vestfold og Telemark	69	5.5%	5.5%
Vestland	480	38.5%	38.5%
Viken	122	9.8%	9.8%

Hvilken hjortevilt art jakter du på?

Antall svar: **1246**

Svar	Antall	% av svar	Diagram
Elg	614	49.3%	49.3%
Rådyr	636	51%	51%
Hjort	1068	85.7%	85.7%
Rein	178	14.3%	14.3%

Predatorjakt

Antall svar: **1246**

Svar	Antall	% av svar	Diagram
Ja	695	55.8%	55.8%
Nei	303	24.3%	24.3%
Ja, men kun om de dukker opp på storviltjakt .	248	19.9%	19.9%

Hvilke predatorer jakter du på?

Antall svar: **1246**

Svar	Antall	% av svar	Diagram
Rev	775	62.2%	62.2%
Grevling	238	19.1%	19.1%
Mink	168	13.5%	13.5%
Røyskatt	75	6%	6%
Kråkefugler, ravn, skjære, nøtteskrike	423	33.9%	33.9%
Mår	265	21.3%	21.3%
Jeg jakter kun på predatorer om de dukker opp på storviltjakt	210	16.9%	16.9%
Jeg jakter ikke på predatorer	260	20.9%	20.9%

Rutiner ved vomming

Antall svar: **88**

Svar
Vommer på skuddplass. Er skuddplass på åpen åker eller tursti e.l. tas det med i skogkant/inn i skogen.
Ved bøjakt blir vomb tatt ut på slakteplass og kjørt til privat avfallsplass der vi legger alt slakteavfall.
Ved skutte dyr på innmark, havner vom sammen med resten av slakteavfallet.
Dyr skutt på innmarktas hel til slakteriet, vom annet avfall blir dumpet på en fast plass.
Fjerner vom og tarmer
Viss det er langt til fjells, uten transportmuligheter, blir det liggende på skuddplass.
Forskjell på vom og organer over mellomgulvet.
De dyr som blir skutt i skogen eller fjellet blir vommet på stedet. De som blir skutt på innmark blir vommet der de blir flådd.
Vommer dyret på skuddplass og lar vommen ligge!
For real blir slakteavfallet liggende igjen på skuddplass. For hjort blir dyret fraktet til slakterom uten å vomme dersom det ikke så langt unna. Er dyret skutt langt oppe i skogen blir vomma liggende igjen på skuddstedet.
Av og til vommer jeg på skuddplass, av og til vommer jeg på slakteplass.
På et jaktlag gjør vi slik : Vi tar med oss lever og hjertet fra utvomming på skuddplass, resten legges igjen. Så drar vi ned dyret, flår det på låve og kjører bort og graver ned skinn, hode og bein. På andre jaktlaget jeg er med tar vi med hele dyret til slakteplass, vommer ut og legger alle rester (vom, hode, skinn osv) på reveåte. På jaktlag 2 er det mye lettere å komme til med atv derav tar vi med alt "hjem". På jaktlag 1 er det bratte lange lier hvor vi må vomme ut på skogen for å få til å dra ned dyret. Langt og bratt.
Vommer ut og lar avfall ligge på skudfplass dersom dyret skal drages langt før slakting. Om dyret skytes nær vei bommes det ut ifm slakting og avfallet graves ned. Ved mistanke om vomskudd/avskutt tarm/spiserør vommes det alltid ut på skuddplass. Avfall legges igjen på skuddplass.
Elgvom i Trøndelag ligger på skuddplass
Dyr jeg skyter på innmark blir vommet på slakteri. Avfall blir kjørt på åte.
Slakter på låve. Slakteavfall går tilbake til naturen etterpå
Legge igjen utmark, prøver å grave ned innmark..
Vommer på skudd plass. Vom blir så flyttet til egnet sted slik at den ikke blir liggende til sjenanse for evt. turgåere etc.
Kommer ann på skuddplass. Eller om det er fallvilt fra trafikk.
Det varierer litt om jeg vommer ut ved skyteplass eller der jaktlaget har slakteplass. Blir hjorten skutt langt fra vei og jeg må dra hjorten et stykke, vil jeg vomme ut ved skyteplass.
Dyr skutt på innmark blir dumpa i eiga slakteafallshole, og dyr skutt i terreng vert utvomming gjort på plassen og det blir liggende igjen i terrenget.
Delvis svar 2 og4 pga terreng og slakteplass lokalt
Innmark; Vomming på slakteplass Utmark; Vomming på skuddplass
Vommer ut om det er høgt til fjells ,er det under 1 time å dra dyre tar vi med tilvi heile dyre til slakte plass.
Spretter opp magen å drar ut magesekk og alt av involler og blod. Og knytter igjen blæretarmen så ikje det renner urin inn i dyret.
Kommer sefølgelig snn på hvor dyre ligger
Dyr som skytes i utmark vommes på stedet. Innmarksdyr vommes på slakteplass
vommer i skogen men hvis dyret blir skutt på jorde eller innmark eller nære hus tar vi dette gjelder stort sett hjort og rådyr
Egen kniv
Passe på at det ikkje ligger i nærheten av vannkilde
Tar kun ut magesekken
I utmark blir vomb liggende på skuddplass
Utmarksjakt: vommen ligger igjen i skogen Innmarksjakt: dumpes på fast plass
Skyter i terreng, utvomming en fordel med tanke på dragning av slakt(vekt). Ravn og rev er raske på og ordner renovasjon.
I noen tilfeller flytter jeg på vom med tilbehør slik at den ikke ligger midt i synsfeltet til eventuelle turgåere.
Åpner magen kutter bort organene spretter halsen og får med pusterøret og endetarmen

Varierer fra skudd plass til slakte plass

Reinsdyr blir slaktet på fellingsplass.

Tar vi ikke med avfallet til slakteplass vimmer vi ved skuddplass og graver ned vomma.

På hjort og rådyr bruker jeg å ta det med til slakteplass(mindre dyr=lettere å ta me med innvoller) Elgen blir vommet i skogen...

Det er litt forskjellig, blir dyret skutt i skogen så blir vom og. Indre organer igjenn på skuddplass, blir dyret skutt på innmark så blir indre organer lagt på reveåte. Skal vi ha dyret selv så blir pels/skinn, hode og føtter lagt sammen med dette på reve åte, men leverer vi det til mottak så flir pels/skinn, hode og føtter lagt i avfallsgrop på mottaket

Hode føtter og skinn leveres inn, lever og hjerte spises, føtter brukes til blodsporslutt før innlevering

Ved skyting i utmark, blir vomma liggende. Ved skyting på bøen, tas hjorten heil inn på "slakteriet"(loven)

Lar det ligge i nærheten av slakteplass, men steiner det ned hvis mulig.

Vestland blir vom etterlatt i skog/fjell ved/nær skuddplass I Viken blir rådyr vom kastet i søppel. Hjort og Elg blir om langt fra vei etterlatt ved skuddplass. Er diskusjon i jaktlag om å endre på dette til å ta med.

Rutiner ved slakting av hjortevilt

Antall svar: **150**

Svar

Hundemat, hundebein. Blod blir også brukt til trening av hund til ettersøk.

Graves ned.

Graver det ned og dekker til samme dag eller dagen etter

Se over.

Finner en plass med lite turgåere og dumper slakteavfall rett i lynga.

Slakter i hjemme i slaktehus og henger dyret i kjølerom

Kaster som regel avfallet i skog og mark eventuelt sjø

Slakter dyret hjemme og kjører avfallet opp til en slags åte

Har ein dumpe plass i skogen

Klauvene gir jeg til folk i jaktlaget som har jakthunder under opptrening

Reinsjakt- alt ligger igjen Elg / hjort, hode og føtter blir med hjem.

Flår hjorten i redskapshus, slakteavfalet blir enten gravet ned eller senket i sjø.

Innvoller blir lagt igjen på skuddplass, hode, føtter og skinn blir levert i en felles container for denslags som viltstellområdet setter ut.

Indre organer blir igjen på slakteplass. Hode, føtter og skinn graves ned i en grop som fylles igjen

Skogkanten

Slakting og flåing utover å ta ut vom og tarmer blir utført på egen slakteplass. Avfall (hode, skinn, bein, etc) kjøres til skogs (avsides)men begraves ikke.

Legges i skogen på egnet område (er grunneier)

Vi dumper slakteavfall (skinn, hoder osv.) utfor ett stup og dekker ikke over.

Tipper det utfor fjellet på egen grunn hvis det er fullt på åta

Tilbake i naturen.

Tarmer og vom lar vi ligge på skuddplass. Slakteavfall kjører vi i skogen til rev, ørn og andre rovdyr.

Legges i kråkefelle

Legg i ei ur hol

Graves ned i skogen, dekkes til umiddelbart

Bruker noe til trening av hund.

Jeg kjører slakteavfallet opp i skogen, da det ikke er avfalls mottak som tar i mot slakteavfall.

Legg det på ein bålplass der heile jakt laget hiv det

Skogen

Vommer på skuddplass og lar det ligge der. Tar med resten hjem, flår skinnet av. Tar vare på leggene til hundetrening, kaster skinnet og hodet i ei steinur langt fra bebyggelse

Slakter heime Legger avfallet ut i skogen

Ved elg, voksnedyr medbringes kjønsorgan. Samt lever og hjerte. Skinn legges samlet ved åkerkant hvor det ferdes grevling/rev kråke

Slakter i slaktebua. Så kjører vi slaktet på heia.

Slakter på slakteplass og ligger ut avfall til fugler

Hjerte tar jeg vare på til mat. Lever blir det laget hundemat av. Resten blir reveåte.

Tar med meg det meste hjem til hundene våres. Lunger og lever tørkes. Bein, ører og tunge

Slakteavfall graves ned direkte etter slakting.

Utfordring, med store kvoter burde kommunen stille slakte avfallscontainere til disposisjon. Men kvoter opp til 12 dyr hvert år, er det mye som må graves ned hvert år. Uten tilgang på gravemaskin er dette også vanskelig.

Kjøre det ut i skogen på egnet plass

Avhengig av vilt: ved kontroll blir indre organer tatt med til kontroll. Det gjelder også hode. Da er det egen fallvilt grop som blir avfallsplass i etterkant

Søppelbøtte

Indre organer legges igjen på skuddplass, hode, føtter og skinn går i søpla eller til reveåte

Har en fast plass det blir samlet på, legges ilag med skog, kvist greiene jord osv

Blir lagt på sjønær utmark langt fra bebyggelse. Spises av rev og fugler.

Graver ned etter kvart dyr

Slakter, annet enn vom og tarm, hjemme, og håndterer slakteavfallet fra rådyr som matavfall, og fra hjort til egen avfallsplass/jordgrop.

Dette er og en plass som blir brukt til avfall fra sau

I Møre og Romsdal legger vi slakteavfallet ved sjøkanten. I Telemark dumpes det i skogkanten og i Innlandet vommer vi ut og legger det på fallsted

Graver det ner

Elg blir i terrenget. Og i grop. Rådyr har de laget mottak vom og skinn

Slaktegrop ved åkerkant som ikke dekkes over

Jeg legger slakteavfall i en slaktegrop som rev, ørn og annet tømmer i løpet av høsten. Forblir åpen, men ligger utilgjengelig til i skogen.

Dumper det over steingarden til naboen med traktoren

Kjører til havs og dumper det.

Dette går til hundene. Skinn ender i skogen igjen.

føtter går til hunden, hjerte går i stekepanne, lever selges og resten går i grop

Det hender jeg kaster slakteavfall som ordinært avfall, men når det ikke var et alternativ her, antar jeg at jeg har bommet litt på hva som er lov og ikke, kanskje...

Avfall av hjort vert nedsenka i sjøen

Legger på egen plass i skog

Kaster i elven

Legger slakteavfall i elvekant

bruker tunge som pålegg, resten av indre organer blir bikkjemat/godbiter. Skinnet kastes som regel, mens føttene blir gitt til bikkjene

Jeg legger det på avfallsplass i skogen

Gjør litt av hvert. I tillegg til overnevnte legger jeg også litt i kråkefelle

Legg ut til mat for ravn kråker og skjere!

Graver av og til ned, og legger det av og til på åteplass.

Kokes og brukes som hundemat

Dumper på egnet plass i skogen, blir skjelden brukt som reveåte til revejakt

Slakter dyret i eit redskapshus, med tillaga slaktebenk at og -utstyr. Slakteavfall et blir deretter trilla bort til ei slaktegrop i nærleiken. Ville dyr forsyner seg av avfallet, samstundes som vi bruker det til jakt på kråke og rev.

Du per i steinur/kratt.

Legger avfallet i èin vegskråning inne i skogen

Kompostbinge

Legges tilbake i skogen

Graves ned

Vi har en fast plass der reven spiser det som blir kastet der.

Fast «dumpingplass» i en ur med grov Stein

Langt til fjells blir slakteavfall liggende igjen. Er det mulig å få dyret ut helt blir slakteavfallet lagt på reveåte.

Vi har kvote på rundt 20 dyr. De fordeles på 3 lokalitere. Legges i skog, utenom ferdselsårer som folk går. Dekkes ikke til med mold. Fluer, rev og ravn forsyner seg. Normalt lite kjøtt igjen å se etter 2 uker. Skinnet løses opp over 1 god vinter. Hårene borte etter 2 sesonger. Bein grinder mulig 3-5 år.

Om vi skyte en plass kor vi skal jakte meir i nærmaste framtid drar vi dyret lenger vekk å slakter der

Hode, skinn og føtter leveres på avfallsmottak. Andre organer legges på skuddplass.

Graves ned

Det er bare involler som blir lagt i nærheten av skuddplass

Har det på ein plass ved innmark. Alt er vekk på 3-4 uker.

"avfallet", det vil si det som er igjen av dyret forutenom tarmer og vom, som resten av jaktlaget gir utrykk for at de ikke vil ha, tar jeg med meg. Indre organer blir brukt til å spe på både maten til hønene, katta og bikkja, samt noe til eget bruk ved anledninger (lungemos av elg kan anbefales). Alt av bein havner i en 200 l gryte bak låven for å få kraft. Beinrester havner i kompostbingen etter at de er kokt ut. Skalle legges i flis til fluelarver har spist den ren. Deretter kokes disse og gis bort til barnehager og skoler. Klover brukes til å trene spor med hund. De klover jeg ikke bruker selv er det ofte stor etterspørsel etter, selv blant hundeeiere som ikke trener spor men som vil ha en oppmerksomhet til hunden sin. Skinn tørkes og de beste stykkene for fluebinding og sitteunderlag skjæres ut. Restene av skinnet havner i kompostbingen.

Hode, skinn og ben tas av i slakteriet for så å legge det i skogen / egnet sted.

Jeg slakter hjemme, men kjører slakteavfallet til skogs, eller dupmer det i tallehaug på gården.

Legger slakteavfall slik at rovdyr også kan få sin del, gi noe tilbake

Jeg jakter elg sammen med ett helt jaktlag på Vikna i Trødne. Ofte blir avfall fra elg lagt ut til revåte. Desverre blir det ikke jaktet nok på åte i ettertid. Det er kan egentlig heller kalles koldtbord for rovdyr. Det er mye kråke, ravn og skjære som forsyner seg på dagtid. Reven er der på natta og forsyner seg. Jeg finner ofte rester av bein fra elg og rådyr rundt der åte/koldtbordet er. Jeg har foreslått at vi graver det ned for å unngå å mate rev og kråke. Dette blir desverre ikke gjort.

Alt av avskjær blir til hudemat

Enkelte ting blir liggende utenfor garasjen

Tømmes på «myra». Fast plass på grunneigers eigedom. Bøjakt

Hjertet, lunger og tunge spises. Føtter gis til hunder. Skinnet tørkes og brukes som underlag i div utendørsaktiviteter. Hodet kokes og blekes for så å henges opp. Det som er igjen av slakteavfall legges i slaktegrop.

Når terrenget tillater det tar jeg dyrene med og slakter de hjemme, når terrenget er for bratt og avstanden blir for langt så grovparterer jeg dyret og la restene ligge til reven og andre åtseletere.

Legges i komposthaug som dekkes løpende av greiner/ gras etc.

Dumpet og gravd ned så lenge det ikkje er tele i gjorda (bakken froset)

Jeg koker alt avskjær og bruker det til fôring av hund samt bein

Noe leveres som restavfall.

Det samme gjelder som på forrige spørsmål.

Skinn og bein leveres til Norsk Protein

Blir brukt som hundemat

Tar det med til slakteriet

Elg leveres vommet på slakteri, organer feks rådyr kjøres på heia.

Kaster det i skogen etter slakting på slakteplass

Vi tømmer det på en fast plass legger ikke no på det

Legger slakteavfall i kråkefelle

Vi har fast plass for kasting av slakteavfall. Det blir ikkje dekka til men blir ete av åtseldyr

Dumpes på en fast plass i skogen, litt unna bebyggelse og vei (på grunneiers grunn)

Lokal avfallsplass tilhørende gården

noen steder har de dumpeplass for avfall

Skinn, hoder og bein blir lakt i slaktegrop. Annet slakteavfall blir hovedsaklig åte

Etter avtale med bønder leveres avfallet i kontainer som brukes til kadaver fra husdyrprodusenter.

Slakter hjemme og hiver det i skogen

Slakteplass og hjemme på reveåte

Kun magesekk og tarmer

Har fast plass hvor vi dumper avfall

Hode, føtter og skinn leveres mottak, resten ligger på skuddplass

Kjører det på tippen, hvor vi dumper alt mulig gammel silo, Høy osv osv

Skaukanten i nærheten av slakteplass

Vi gir alt slakteavfall til de 17 hundene våre.

Innmat ligger igjen i naturen, føtter skinn og hode graves ned.

Grev det ned med hravemaskin.

Jaktlaget har laga eit avgrensa område /boks på ca 4x4meter. For at det Ikkje skal bli dratt så mykje utover. I felles utmark. Her deponere vi slakteriavfall og utvomming av det som er skutt på innmark. (Det som blir skutt i utmark blir vomma ut på skuddplass om mulig.)

Indre organer blir igjen på skuddplass. Hode, føtter og skinn blir gravd ned på stedet hjorteviltet blir hengt til mørning.

Grunneier håndterer dette. Antar det dumpes i en steinrøys en plass

Graver ned/dekker til avfallet på skuddplass.

Kaster det i skogen, selv om jeg slakter hjemme.

Slaktegropen er nesten tom ved jaktslutt.

Jeg har slakteavfallet i kråkefella.

Tipper det på en tipp som ofte blir fylt over med andre masser / avfall

Har ikke en fast rutine for all jakt, men kombinerer de 3 første alternativen

Hodet, skinn,vein og annet skrap, havner på reveåta. Hjerte, lunger, lever og tunge brukes til mat. Noen bein går til hundenknask og hundetrening. Bein i fra kroppen ellers til kraftkoking.

I jordekanten

Innmat spises av både meg og hundene

Graves ned på grunneiers eiendom

Graver dette ned for hvert slakt

Jeg driver ett viltmottak og det er egene regler for bioprodukter og håndtering av disse.

Til lokal lagringsplass for det som ikkje går til reveåte. Blir fortere av ymse rovdyr og rovfugl. Ørna registrerer fet fort

Hvis det er mulig, så steiner vi ned slakteavfallet

Lunger lever mm legges igjen på skudd plass. Klover, hode og skinn legges ved sjøen. Plass hvor hageavfall ifra øya legges også