THESIS WORK

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Comparative Analysis of the Habitat Use and the Diet Composition Between the Red Fox *(Vulpes vulpes)* and the European Badger *(Meles meles)*

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Abstract:

A research question related to the red fox (*Vulpes vulpes*) and the European badger (*Meles meles*) will form my university thesis work. Two commonly known animals throughout Europe are the European badger (*Meles meles*) and the red fox (*Vulpes vulpes*).

The red fox itself is even considered a Apex predator in some countries. As both species primarily rely on predation to balance many animal and prey species, this is crucial if we are going to also touch upon the concepts of good game management practices as well as healthy ecosystems in nature. This thesis will objectively compare and contrast the habitat and diet of these animals.

This paper evaluates ecological niches and dietary specialization of the red fox and European badger, thereby providing insight into their coexistence and possible interactions. Some sub-section will be particularly relevant to disentangle the two native omnivores carnivore species of Europe and apply this knowledge to future management initiatives.

This thesis aims to improve knowledge of the ecological role and interaction potential between the red fox and European badger, by further understanding of their habitat preferences and dietary composition. The results of this study can help drive conservation strategies and management practices to enable the long-term persistence of each species in its environment.

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Chapter 1: Introduction

1.1 Background:

Among the most recognizable mammalian species we get to see in various European landscapes are the red fox (*Vulpes vulpes*) and European badger (*Meles meles*). Both species has versatile habits and occur in many kinds of environments, from woods with low vegetation to grasslands, the edges of urban and agricultural areas. They were both Canidae and Mustelidae members. Their co-occurrence in these ecosystems has caught the attention of ecologists and wildlife managers, because knowledge of habitat selection and food habits is essential for the management and conservation of these important carnivores. Both species range widely but their ranges overlap throughout much of Europe meaning they compete, coexist and influence local ecosystems together. The red fox and the European badger both occupy a vital niche in their respective ecosystems. In addition, they also prevent the populations of small mammals and insects from becoming problematic through predation and in turn help plants as well as soil health. Areas where they scavenge carrion in addition to scavenging provide these birds with good nutrient cycling. This species is a burrower, benefiting from the aeration and mixing of nutrients in the soil that they provide, as well as acting as habitats for other species. These species also pass seeds in their droppings, which helps ensure the diversity of plants and resilience of habitat. Although these species frequently occupy the same habitats, they feed differently and exhibit different behaviors so there is not direct competition, allowing them to coexist even as important components of European biodiversity and ecosystem health.

1.2 Research Objectives:

The primary objectives of this thesis are:

To determine and contrast the red fox and European badger's preferred habitats across various ecosystems.

To research both species' foraging habits and dietary diversity.

To investigate the elements affecting their coexistence, rivalry, and future niche division.

To evaluate their ecological contributions and the effects of their actions on the functions and dynamics of the ecosystem.

To suggest conservation and management measures to guarantee these species' long-term survival.

1.3 Scope and Methodology:

To learn more about the habitat and food of the red fox and the European badger, this study will combine a literature review and data analysis. Their habitat distributions and overlaps will be mapped using study materials and research papers from the past. Food preferences will be carried out by the help of research papers and literature.

Chapter 2: Literature Review:

2.1: Red Fox (*Vulpes Vulpes*):

2.1.1: Taxonomy of the Red Fox:

The red fox (*Vulpes vulpes*) belongs to the following taxonomic classification:

Kingdom: *Animalia*
Phylum: *Chordata*
Class: *Mammalia*
Order: *Carnivora*
Family: *Canidae*
Genus: *Vulpes*
Species: *Vulpes vulpes*

On its back, sides and head the red fox has orangish-red fur. It has a patch of white fur underneath its neck and chest. With long bushy reddish tail with white tip, pointed black ears and black legs and feet. Finally below represents the entire taxonomic classification of the red fox:

Kingdom: Animalia (Animals) All multicellular, eukaryotic organisms that obtain their food by ingestion.

Members from the phylum Chordata: Animals that at some time in their development have a notochord (flexible rod-like structure); other characteristic features include dorsal nerve cord and pharyngeal slits.

Class, Mammalia (Mammals) As warm-blooded vertebrates, red foxes belong to the class of Mammalia. They have hairy or furry cheeks. They have diverse teeth suited to dietary requirements and their youngsters are nourished with the milk produced by mammary glands.

Order: Carnivora (derived from Latin for "meat devourer") - Red foxes belong to this order of carnivorous mammals, categorized into two suborders known as Feliformia and Caniformia, and has evolved many adaptations in its digestive tract that are specific for the predation of animal flesh.

Family Canidae (Canids) Members of the family Canidae, carnivores that also include wolves, domestic dogs, coyotes and other species of foxes Canids are identified via their dog-like behavior & appearance.

Red fox is one of the most famous species among the genus from *Vulpes* which contains a number of fox members.

Scientific name: *Vulpes vulpes* the first would make it another species of animal in the genus of the red fox (know as *Vulpes*) and the second half is a reference to that same fox genus this makes the red fox *Vulpes vulpes*, a species of the Kingdom animalia and its taxonomical connection to other canids.

2.1.2: Habitat Preferences of the Red Fox:

Figure 1

Distribution map of the red fox (*Vulpes vulpes*) (Group C. S.)

The red fox occurs in a wide range of environments including grassland, woodland and city habitat. This indicates a preference for habitats that are open with adjacent cover, such as woodland edges, hedgerows and meadows. Dens under sheds and other structures built by people along with burrows and hollow logs can all be used as den areas for red foxes. This signifies that the adaptivity of red foxes to its environment is very different. They have a high degree of adaptability in numerous environmental environments such as the urban and rural areas. Red foxes have an amazing ability to adapt and thrive in just about every environment and situation you can imagine, which is basically why you can find them in just about every habitat throughout Europe.

The red fox, a relatively docile animal, thrives best in suburban and city environments. Below are some habitat preferences of the red fox:

Red fox habitat is the edges of forests, tilled fields, and marshes. They like to have a variety of vegetation types in the locations they inhabit.' (Mammals)

Woods:

Mixed woods, as well as deciduous woodlands and coniferous forests that commonly contain these types of habitats are also utilized by the red fox (*Vulpes vulpes*). There are small mammals and birds there too, making up a significant percentage of their food, but they can find cover and places for denning and access in those places.

Savannas, meadows, open grasslands:

Which all can be settled habitats for red foxes. Hunting for insects, rabbits and small rodents is possible in such areas.

Farmlands:

The red fox population can thrive even in agricultural regions that have crop fields and pastures, as long as there are forested areas adjacent to these fields that provide shelter and denning sites. Urban and Suburban Areas: Red foxes are extremely adaptable, and will occupy urban and suburban matrixes provided there is sufficient green space characterized by gardens, parks and fragments of native vegetation. They would tap into food-derived access linked to people and hunker down in parks or other green spaces. “These clever critters are, in fact, hyper-adaptable generalists and just as comfortable in city or suburbs as they are in the country.” (Natural History Museum, 2019; Osterloff of the Natural History Museum)

Marshes and swamps:

Red fox can thrive on marshes and swamps which are an example of wetland habitats. These habitats can be rich in prey animals, such as amphibians, fish and birds, but is also a viable habitat for smaller mammals.

Mountains:

Red foxes inhabit mountain areas, from lowest foothills to greatest of mountains. There they may fashion dens from burrows or rock crevices providing a comfortable residence and breeding site for the species (Weber, 1996). Tundra: In the far north of their

distribution, red foxes can be present in Arctic tundra habitat where they can endure in colder climates while seeking out prey resources such as lemmings and Arctic hares but have a reduced density than other biomes.

Wetlands:

Red foxes live also in estuaries and coastlines where they scavenge seafood and marine invertebrates for food.

As generally scavengers and opportunistic predators, red foxes can exploit a wide range of habitats and prey types. That is why they constitute some of the most successful and prevalent carnivores in the world, due to their ability to adapt and react to changes in their ecology. Remember, however, that local factors such as prey availability, competition from other predatory species and human activity can influence the distribution and abundance of red fox populations in specific locations.

2.1.3: Ecological Factors Influencing Habitat Selection of the Red Fox:

There are various ecological factors affecting the den site selection of red fox. Their choice of habitat is primarily dictated by the food source availability (small mammals, birds, insects, fruits and carrion). That also means what other things they need to live, like land for their habitat, proximity to bodies of water, suitable denning sites and protection from predators. The red fox makes trade-offs in their habitat selection based on a variety of physiological and biological traits that help them find suitable areas to create dens, establish territorial boundaries, and access prey (Doncaster, "Drifting territoriality in the red fox *Vulpes vulpes*.), 1991). Although these factors vary by region and with local conditions, some general ecological determinants of red fox den site selection include:

Food Availability:

As an omnivore and opportunistic predator, the red fox will eat practically anything—fruits, insects, small mammals, birds, carrion. Especially habitats with abundant food sources, such as ground-nesting birds and insects, as well as small mammals like mice, voles and rabbits. Red foxes are a habitat generalist, and they base their home range selection primarily on the availability of food
(Dell'Arte G. L., "Variation in the diet composition of a generalist predator: Patterns and mechanisms of individual specialization in the red fox." , 2007).

Cover:

Red foxes with an extensive area of heavy cover forest, thicket, brushy field, tall grass require these types of places for protection from predators and the weather. They also need sufficient

places to den and whelp their young, which can be underground tunnels or rock crevices, or even old dens of other animals. (Kurki, 2003).

Water Sources:
Red foxes need water, even in the desert. Not only do these habitats provide drinking opportunities but may serve as an attractant of prey species as well, so they usually prefer the ones with more permanent water (i.e. streams, rivers and ponds or wetlands).
(Dell'Arte G. L., "Effects of habitat composition on the use of resources by the red fox in a semi-arid environment.", 2005).

Quality of territory:
Red foxes are territorial and their home-range size and quality may be a factor in habitat selection. And whether there's other foxes there, and how many of them, and competing for food and all that good stuff, and probably density dependent population dynamics
(Doncaster, "Drifting territoriality in the red fox *Vulpes vulpes*.", 1991).

Climate and Seasonal Changes:
Because red foxes are so adaptable, their habitat ranges expands over most climatic zones. Though they might be seasonal, reacting to fluctuations in climate and food sources. However, some of the densest nests from during winter may be in more northern habitats
(Sidorovich, "Seasonal variation in the diet and habitat selection of the red fox (*Vulpes vulpes*) in Belarus." , 2001).

Human Disturbance:
There are also indications red foxes can adapt to new environments, and urban or suburban life with an abundance of food and shelter but sans larger predators is actually preferred by some foxes. They can adapt and tolerate human disturbance so some extant (Baker P. J., 2006).

Prey Abundance and Diversity:
In addition, prey availability and diversity may be important factors in habitat selection for the red fox. They will likely exist in places of high diversity of potential food sources. (Dell'Arte G. L., "Variation in the diet composition of a generalist predator: Patterns and mechanisms of individual specialization in the red fox." , 2007).

Competition:
For example, red foxes refrain from locations where the odds of being eaten by larger predators like wolves or coyotes (golden jackal in Hungary) are high . They may select habitats in which they do not have to compete with or be hunted by these larger apex predators (Theuerkauf, 2003).

Generally, red foxes are highly versatile and choose their dank location based on ecological factors that guarantee their survival and reproductive success in a variety of habitat classes. Understanding these factors in particular are needed for conservation and human-management issues especially where red foxes overlap with humans.

2.1.4: Diet Composition of the Red Fox:

Figure 2

This diagram represents the frequency of occurrence (%) of food categories in the scats of red foxes collected in different sampling periods and years in Varaldskogen, southern Norway.(*n*) =Number of scats examined.

Category	April 2005 (50)	July 2005 (50)	May 2006 (50)	August 2006 (50)	February 2009 (40)	Winter[a] 2010 (42)
Small rodents	56	64	31	48	35	60
Ungulates[b]	60	14	38	2	77	74
Other mammals[c]	12	16	18	2	8	5
Birds[d]	16	38	22	30	13	21
Amphibians and reptiles	8	14	64	26	0	0
Invertebrates	28	68	33	68	3	5
Berries and seeds 50	50	70	71	98	5	43

[a] Winter, December 2009 to April 2010

[b] Mainly moose, only few roe deer (<10 %)

[c] Mountain hare, red squirrel and unknown mustelid

[d] Mainly Capercaillie and black grouse

Figure 3

Hunting attempts (71 times) and scavenging (25 times) recorded

This diagram represents hunting attempts (71 times) and scavenging (25 times) recorded along 62 different red fox tracks followed in a total of 71 km during winter 2009 at Varaldskogen, SE Norway.

Species	Hunting attempts (%)	Scavenging (%)
Rodent	64 (90)	
Frog	2 (3)	
Black grouse	3 (4)	
Capercaillie	2 (3)	
Moose		15 (60)
Roe deer[a]		8 (32)
Grouse		2 (8)

Figure 4

"Seasonal changes in the major food groups in the diet of the red fox in the Varaldskogen study area in 2005–2009, expressed as proportions of recognized material in scats. Ungulates mainly moose, Small rodents field voles and bank voles, Birds mainly capercaillie and black grouse." (Robert Needham, Research Gate, 2014)

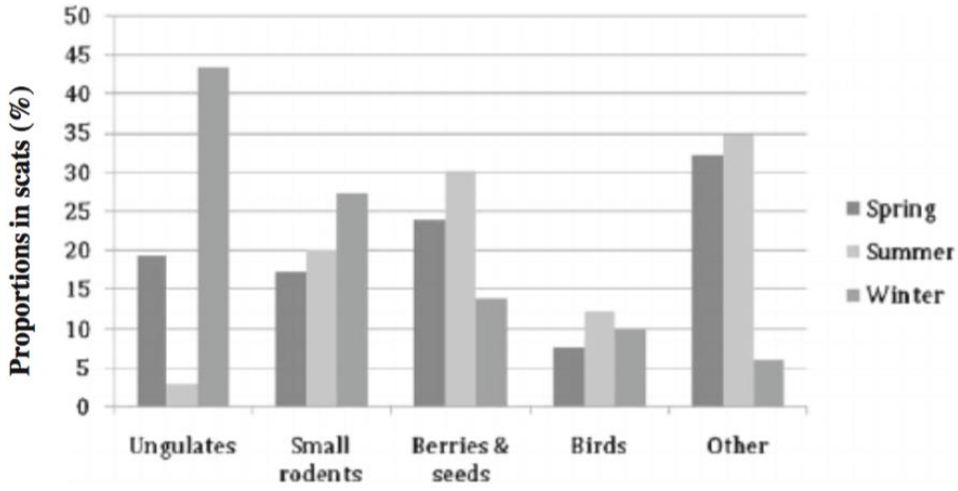
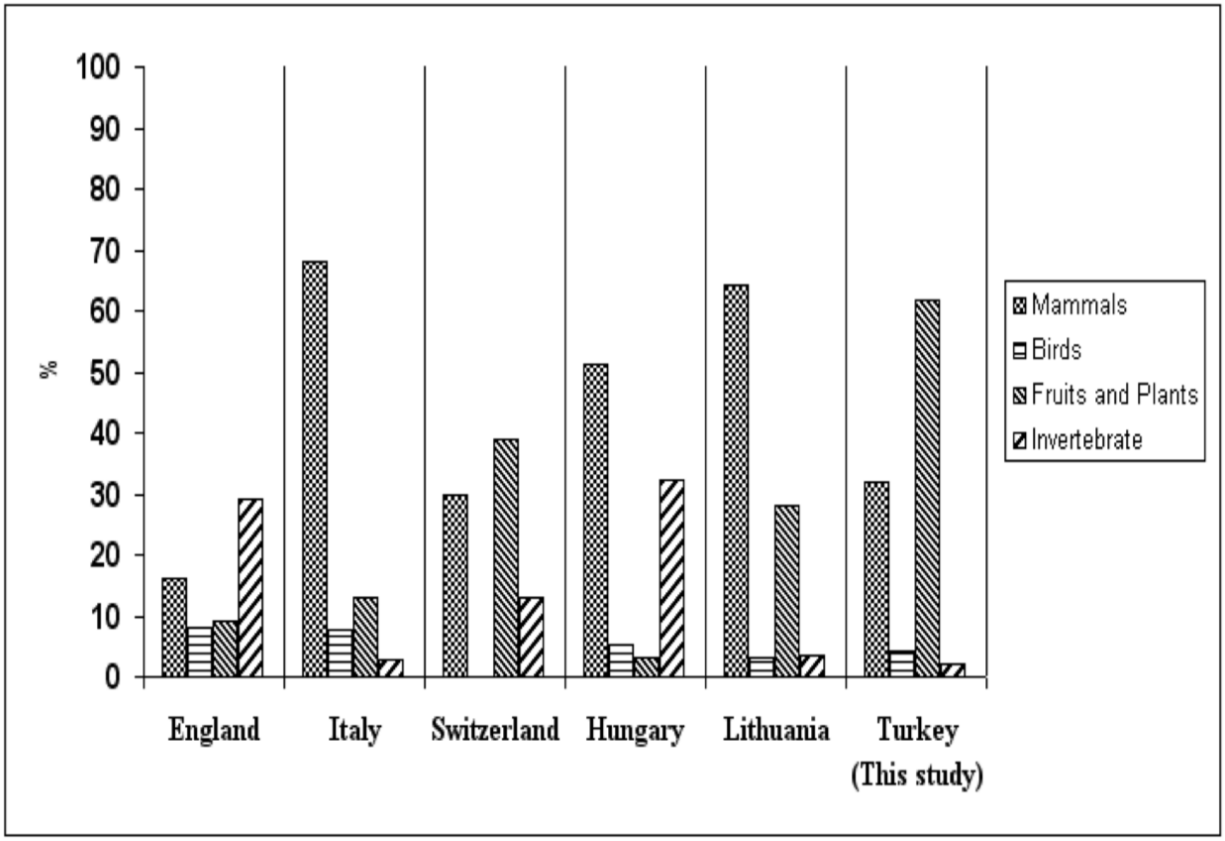


Figure 5

"Comparison of diet components frequency data of red foxes in England, Italy, Switzerland, Hungary, Lithuania and Turkey" (Derg, 2009)



Being carnivores, red foxes eat just about anything. Their diet consists mainly of hares, rabbits and rodents. As opportunistic feeders, they will also rapidly consume birds, reptiles, amphibians, insects and even plant type things like fruits and berries. Everyone knows red foxes like to scavenge, and they often eat carrion and leftover human food. The red fox (*Vulpes vulpes*) is an opportunistic and widely adaptable omnivorous predator, and some studies have revealed that its diet differs with geography, season or both. Red foxes are typically great hunters and scavengers, eating almost everything including: (Jędrzejewski, 1993).

Small Mammals:

Small mammals such as mice, voles, shrews, rats, rabbits and hares are the typical meals of red fox. They eat a lot of these little rodents though, especially where they are numerous (Sidorovich, "Seasonal variation in the diet and habitat selection of the red fox (*Vulpes vulpes*) in Belarus.", 2001).

Birds:
Many of the ground nesting birds, of which pheasants, grouse and ducks are a few examples, comprise a large portion of the red fox's diet. They will kill and eat eggs, chicks and adult birds if given the opportunity. They are well known for their swift movements, which also comes in handy when hunting birds in the wild.
(Sidorovich, "Seasonal variation in the diet and habitat selection of the red fox (*Vulpes vulpes*) in Belarus.", 2001).

Insects:
During the summer months, insects can be an extremely important component of a red foxes diet. They would be munching on caterpillars, beetles, grasshoppers and the other readily available insects they can find (Jędrzejewski, "Food niche overlap in a predator guild of the Białowieża Primeval Forest, Poland.", 1993).

Fruits and Vegetables:
Red foxes also consume fruits, berries and other vegetable matter. Okay, really when it's fall and summer — the seasons those crops are available. Seasonally these fruits and vegetables can also comprise a large portion of their diet
(Sidorovich, "Seasonal variation in the diet and habitat selection of the red fox (*Vulpes vulpes*) in Belarus.", 2001).

Carrion:
As scavengers that eat carrion, red foxes fill this ecological role thanks to the fact that they are opportunistic and adaptive hunters who will munch on dead animals. They will eat road kill, anything of a dead animal that another animal killed. More often in winter seasons when live prey is less abundant. *(Sidorovich, "Seasonal variation in the diet and habitat selection of the red fox (Vulpes vulpes*) in Belarus." , 2001).

Fish:
Red foxes that inhabit areas nearby a body of water are known to subsist on fish. Maybe they live on dead fish that have come with the tide, maybe they eat small fish? This also demonstrates their adaptability to nature and the environment
(Sidorovich, "Seasonal variation in the diet and habitat selection of the red fox (*Vulpes vulpes*) in Belarus.", 2001).

Invertebrates:
Red foxes have been flagged for eating many invertebrates, from crabs to snails and worms, in coastal and marsh habitats and forests where nature supports the abundance of such species (Lucherini, 1995).

Amphibians:

However, these animals are less frequent in their diet and red foxes may also eat reptiles (such as snakes or lizards) and amphibians (such as frogs or toads) when they encounter them.

Diet of the red fox may vary based on the type and volume of a given prey species available to them in their habitat. They're skilled predators who use exceptional hearing, smell and sight to locate and slay their prey. They are diligent opportunistic predators in a variety of habitats, hardy and highly adaptable, able to switch prey base based on seasonal and geographical availability.

2.1.5: Foraging Behavior of the Red Fox:

Red foxes use many different foraging methods depending on the abundance of prey. They hunt little things in the grass or under the snow with their super hearing and smell. They are good stalkers and pounce-catchers of prey, and they can also jump up to catch flying birds or insects. Red foxes are also know to cache extra food, like bury it, and then come back and eat it when they need food, usually when food is scarce. It is the opportunistic and adaptive foraging behavior that sets the red fox (*Vulpes vulpes*) apart from other species. Red foxes are adept hunters and scavengers, and their foraging tactics can change based on the availability of prey, the kind of environment, and the season. The following are some essential elements of red foxes' foraging habits:. (Macdonald D. W., 1987), (Harris, 2008).

Red foxes are very efficient hunters and use many techniques to catch their prey. They rely heavily on hearing, smell, and sight to detect possible prey. They might use a stalking strategy while pursuing small mammals like mice, staying low to the ground and hiding under cover to get near to their target before pounce. They also have the amazing ability to find prey exactly beneath the snow or in thick foliage using only their unbelievable sense of hearing. They preferably hunt during the nighttime since their excellent eyesight allows them to see in the dark, however since they are opportunistic hunters it is also common to see them hunt during the day. “Most of its activity takes place at night or at twilight, but occasionally during daylight. Foraging during the day is more frequent when adults are hunting food for their young” (ESF), (Lloyd, 1980)

Red foxes are opportunistic scavengers who readily consume, such as the remains of larger animals that other predators have left behind or roadkill. Scavenging allows them to supplement their food intake when hunting is limited. (Macdonald D. W., Running with the fox, 1987)

Nocturnal and Crepuscular Activity: Red foxes are also a nocturnal animal, they are most active during the night and twilight. They are good hunters in low light with their night vision adaptation.

Red foxes often do a weird pounce where they jump straight up in the air as high as possible and then land on whatever small mammal or bird they are hunting. They can catch agile prey like flying fowl or little rodents this way. This hunting method is most common during the winter seasons when they have to catch live prey under the snow. “In the snow, a red fox will often move along, listening for rodents. If prey is heard under the snow, the fox leaps into the air and dives in, often emerging with an unlucky mouse.” (Miller, 2021)

Red foxes' nutrition and foraging habits can fluctuate with the seasons due to seasonal adaptations. They might eat more berries and insects and fruits in the spring and summer, but when other food starts to become more scarce in the winter they probably eat a lot more small mammals (Sillero-Zubiri, 2004). “Foxes have a really diverse diet (Brittanica, 2024). They are expert hunters, catching rabbits, rodents, birds, frogs and earthworms as well as eating carrion. But they aren’t carnivorous - they are actually omnivores as they dine on berries and fruit too.” (Varela, 2019)

Red foxes are able to adapt to urban situations, and they may scavenge through trash cans for leftover human food or hunt for tiny animals that live in cities (Osterloff, 2023). Their flexible foraging behavior partly explains why they are able to live in conjunction with human habitation. “In urban areas meat only makes up around half of their diets, the other half being household refuse.” (Osterloff, Natural History Museum, 2019)

Red foxes tend to be omnivorous (Burrows, 2010), combining hunting, scavenging, and caching behaviors in their foraging activity, which allows them to exploit a wide variety of food resources and do well in a wide variety of habitats. They are so successful as predators because they are so adaptable and opportunistic, and as a result have a very wide geographic distribution.

2.2 : European Badger (*Meles meles*)

2.2.1 Taxonomy of the European Badger:

The European badger (*Meles meles*) belongs to the following taxonomic classification (Pearce, 2014):

Kingdom: *Animalia*
Phylum: *Chordata*
Class: *Mammalia*
Order: *Carnivora*
Family: *Mustelidae*
Genus: *Meles*
Species: *Meles meles*

In summary, the European badger's full taxonomic classification is as follows:

Kingdom: Animalia (Animals) - European badgers are part of the animal kingdom, Animal or Metazoa refers to a kingdom of multicellular, eukaryotic organisms that mostly obtain their nutrients by ingestion (Neal, 1986).

Phylum: Chordata (Chordates) - European badgers belong to the phylum Chordata, Chordata (characterized by a notochord at some stage of development, dorsal nerve cord and pharyngeal slits (Neal, 1986).

Class: Mammalia (Mammals) - The European badger is a warm-blooded vertebrate, and as such it belongs to the class of mammals which are covered with hair or fur. They suckle their young with milk from mammary glands and have specialized teeth for various dietary needs (Neal, 1986).

Order: Carnivora (Carnivores) - European badgers are categorized under the order Carnivora, which involves a diverse group of carnivorous mammals that have modified for hunting and eating animal flesh (Neal, 1986).
Family: Mustelidae (Mustelids) - European Badger Species of Carnivora The European badger belongs to the family Mustelidae that includes many carnivorous mammals such as weasels, otters, ferrets and other species of badgers. (Neal, 1986).

Genus: *Meles* - *Meles* is a genus of the badgers, notably the *Meles* species and so including the European badger (Neal, 1986).

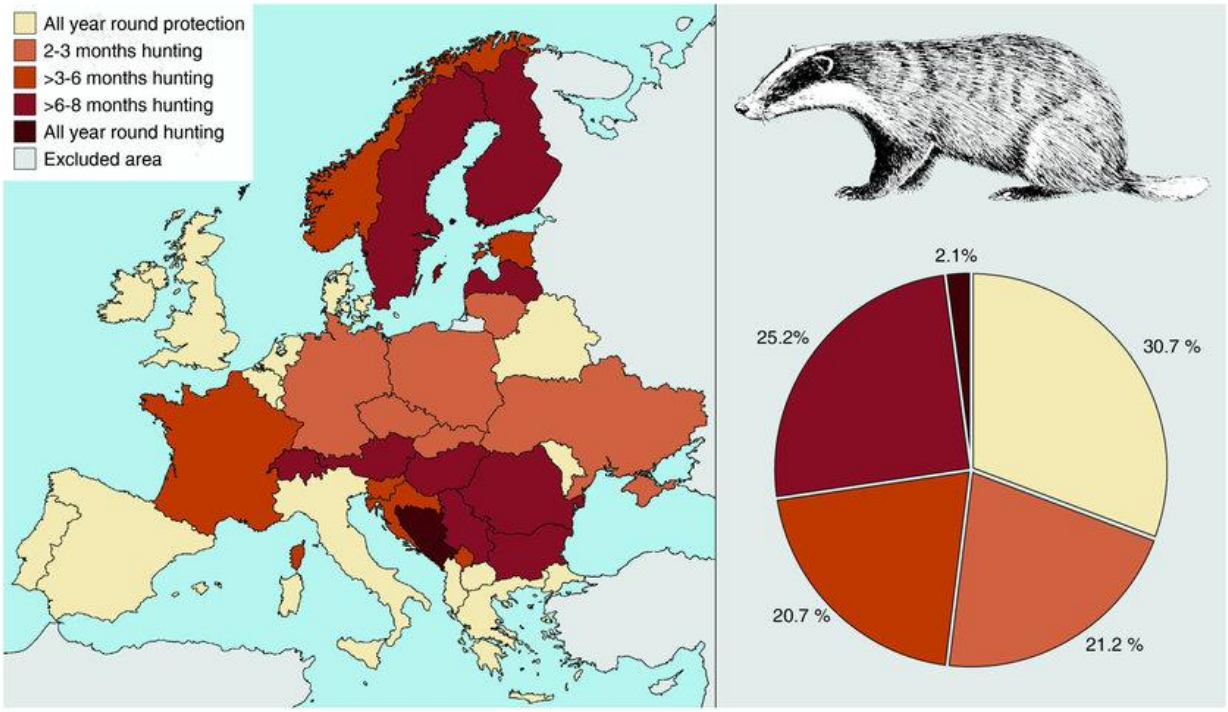
Species: *Meles meles* - The species name "*meles*" instead refers to the European badger as a separate, specific entity in the tradition of the genus *Meles* (Neal, 1986).

Consequently, the European badger is known by the scientific name *Meles meles*, because of his place in the animal world and its taxonomic relation to each other family member of a mustelidae. (Neal, 1986).

2.2.2: Habitat Preferences of the European Badger:

Figure 6

"General hunting season of the European Badger in Europe". (Przemysław Kurek, 2022)



The European badger is primarily a terrestrial species associated with a broad spectrum of habitats, such as woodlands, hedgerows, pastures, grasslands, agricultural fields and rural and suburban environments. They make elaborate underground burrow systems dubbed as setts which are considered their best home and abode. Halfway to the homestead, Hal had to stop and click through his camera: we could make out these setts they provide dormitories, nurseries and shelter for badgers across Europe. Badgers feel a powerful affinity to their setts, and often return to the same place for generations. The European

badger (*Meles meles*) is a very widely distributed species that occupies different habitat types in Europe and western parts of Asia. While those badgers are fexible and can thrive in many different places, they do have particular habitat preferences (Ferris, 1988), (Stubbe, 1993). Here are some of the key habitat preferences of the European badger throughout Europe:

"They live in a wide variety of habitats such as scrub, hedges, riverine areas, farmland, grassland, steppes, and semi-deserts (Sterry, 2008) . However, their preferred habitat is a conifer, deciduous and mixed woodlands, adjacent to open fields. European badgers also occur in mountainous areas." (htt)

Woodlands and Forests:

Badgers are usually found in wooded areas, most often deciduous and mixed forests. The latter offer shelter, breeding places and a greater adaptation of the diet based on insects, small mammals or fruits and roots. (Trusts, 2023).

Hedgerows:

Badgers are discovered in hedgerows, for instance, mix shrubs, bushes and trees to form natural corridors in many agricultural landscapes. Several studies have shown that badgers use hedgerows as a source of cover, but it can also be an important travel corridor between areas rich in foraging opportunities. (Trusts T. W., 2023).

Pastures and Grasslands:

Open habitats, such as pastures and grasslands near woodlands, are typical environments for badgers. Such zones allow for the harvesting of earthworms, insects and small mammals (Web, 2009).

Agricultural Fields:

When foraging, badgers are also known to enter agricultural lands crop fields and orchards specifically also in search of food: earthworms, insect larvae and fallen fruits. ("European Badger - Facts, Diet, Habitat & Pictures", 2023).

Rural and Suburban Areas:

However, some European badgers have successfully adapted to more disturbed habitats and are found in rural and suburban landscapes where both natural habitat availability and human food resource exploitation opportunities can overlap. (Trust, 2021).

Wetlands:

They are less frequently recorded in wetland habitats, such as marshes and riverbanks but may be present where suitable denning sites are nearby (Baldwin, 2023).

Slopes and Hillsides:
They tend to favor sloping either due to well-drained soil or providing locations from which the sett (a system of underground burrows) can be dug.(Team, 2022).

However, the habitat preferences of European badgers can differ in different countries around Europe due to food availability, human activities and competitive or other predatory species. Because badgers are also territorial, their habitat selection may be influenced by the presence of other badger groups. In short, the European badger is a highly adaptable animal, able to occupy habitats from natural woodlands through to human-dominated landscapes and has proven successful over large parts of its range.

2.2.3: Ecological Factors Influencing Habitat Selection of the European Badger:

Various ecological factors determine the habitat selection of European badgers. There needs to be soil types appropriate for the burrows, reasonably close to a number of foraging areas, proximity to water and areas sheltered from extreme climatic events. They tend to favor a mosaic of grasslands, shrub and nearby woodland cover that allows them to forage while being sheltered and protected. European badger (*Meles meles*) habitat selection varies with different ecological factors, i.e., providing appropriate area setts to establish their underground/ burrow system and food resource availability. Habitat selection of European Badger: The influence of ecological factors: (Elisa Torretta, 2024).

Food Availability:
Habitat selection of European badgers is largely driven by food resources. Badgers are omnivores that mainly eat earthworms, insects, small mammals, fruits, and roots; they will also eat carrion. Animals are also attracted to areas where food is plentiful, including those woodlands with a thick leaf litter layer for earthworms or grasslands with abundant insect activity. (Team S. , 2023).

Cover and Denning Sites:
European badgers are nocturnal, secretive and relatively cryptic with respect to their habitat use; when able European badgers tend to inhabit areas providing abundant cover from potential predators as well as from human disturbance. Badgers like to cover up in the woods, hedgerows, or anywhere with thick vegetation. They also need appropriate dens to raise their offspring, so they will often favour regions with good drainage for digging their setts (Filipa Loureiro and colleagues, 2023).

Water Sources:
European badgers, although not strictly reliant upon aquatic habitats for survival, can greatly benefit from access to water sources, such as streams or ponds (especially in arid regions) (Team W. N., 2022).

Soil Quality:
Badgers are proficient diggers and the soil type in an area will definitely have a large impact on where they burrow, because they require well-drained, sandy or loamy soils which can easily be excavated for their underground setts. (Baldwin, European Badger Habitat, 2023).

Territorial Considerations:
The European badger is a tightly territorial species and selection of habitat may vary both temporally and spatially based on the location of neighboring badger groups.
Habitat that has sufficient room to allow groups of pandas the territorial range necessary to avoid over-competition with one another (Team N. , 2023).

Human Disturbance:
European badger (*Meles meles*), European Badgers are able to adapt to areas modified by people but will normally thrive in habitats where there is very little human disturbance. Badgers were more likely to be chosen from zones with less human presence, including quieter woodlands or rural farmlands. (Baldwin, European Badger Habitat, 2023).

Predation Risk:
Larger carnivores and apex predators, such as wolves or domestic dogs (in urban areas) and golden jackals etc. are able to kill European badgers. Consequently, they might choose habitats that may have lower predation risk and quantity, such as areas with a lot of vegetation cover offering concealment (Lee, 2021) .

Seasonal Changes:
Seasonal variation in food availability and climatic conditions could affect habitat preferences of European badgers. Depending on the time of year, they may simply move their activities to other habitats (WildCRU, 2020).

The ecological correlates of European badger habitat use are therefore inter-related affording a trade-off between food, cover, availability of den sites and risk from predators/human disturbance. Their adaptability of environmental conditions enables them to be highly successful and distributed through virtually all habitats within their native range.

2.2.4: Diet Composition of the European Badger:

Figure 7

"General diagram about the diet composition of the European Badger". (Group)

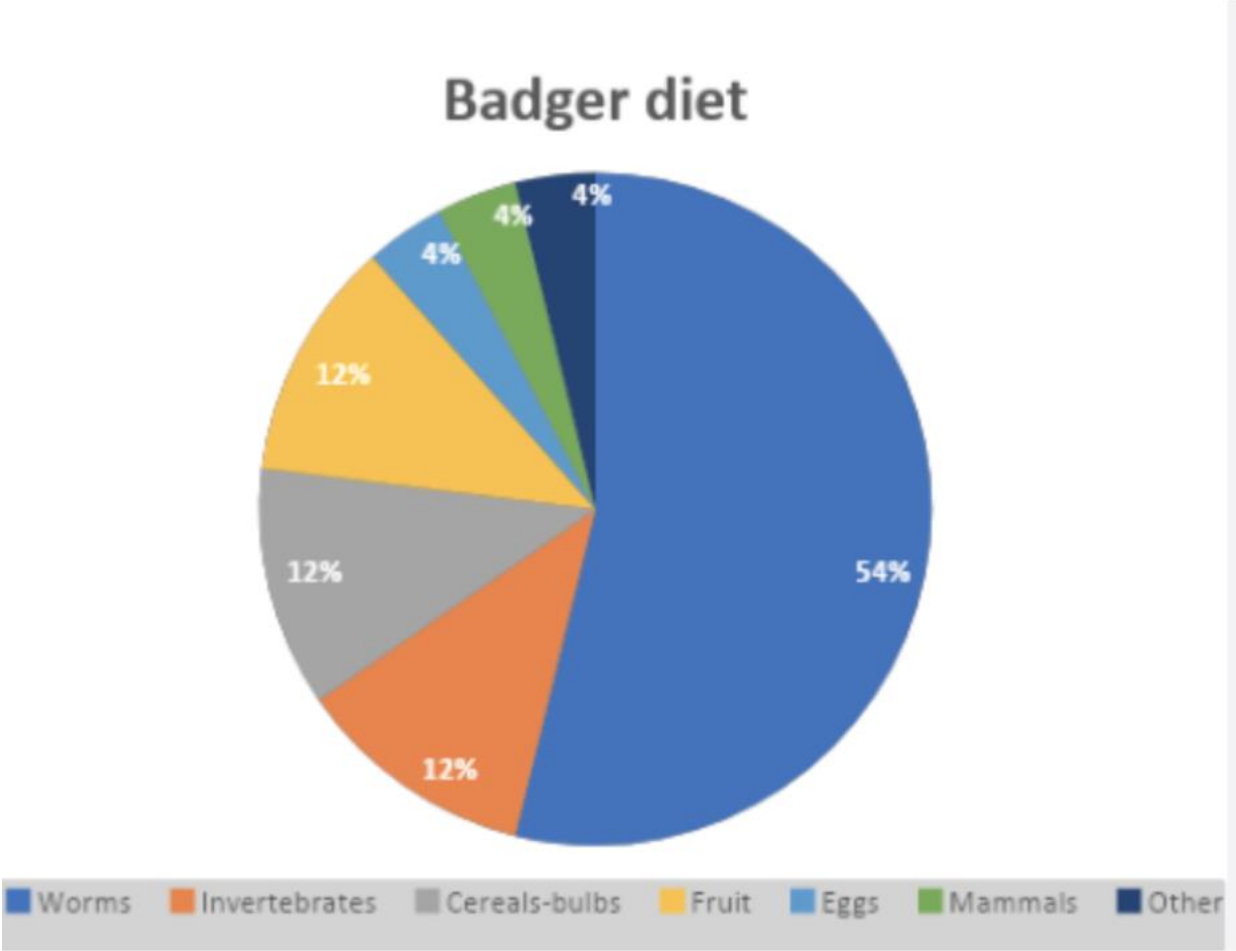


Figure 8

"Seasonal variation in badger diet. Pooled data of the study period are expressed in percentage of frequency (F%); number of feces samples in bracket" (Remonti, 2005)

Food items	F% winter (83)	F% spring (79)	F% summer (19)	F% autumn (18)	χ^2	P
Fruits	8.4	22.8	52.6	22.2	20.3	0.0001
Maize	44.6	38.0	21.0	27.8	4.6	n.s.
Molluscs	8.4	11.4	5.3	0.0	2.8	n.s.
Earthworms	81.9	88.6	52.6	88.9	14.2	0.0002
Insects	27.7	45.6	31.6	11.1	10.5	n.s.
Amphibians	22.9	24.0	5.3	11.1	4.6	n.s.
Reptiles	1.2	0.0	0.0	0.0	1.4	n.s.
Birds	3.6	5.1	15.8	5.6	4.4	n.s.
Mammals	12.0	10.1	10.5	22.2	2.1	n.s.
Rodents	7.2	3.8	5.3	22.2	7.7	n.s.
Lagomorphs	3.6	3.8	5.3	0.0	0.8	n.s.
Carrion	1.2	6.3	0.0	0.0	5.0	n.s.

European badgers are omnivores; about 85 percent of their diet consists of earthworms and other invertebrates, such as insects. Earthworms form an important part of the diet of these animals and are often eaten on daily basis. Small mammals, amphibians, reptiles, birds fruits nuts and some carrion are also consumed. One of the most important factor that influences their food and foraging behavior is the abundance of earthworms. *Meles meles* are opportunistic predators and are omnivorous, their diet being highly variable both temporally and spatially due to differences in resource availability. The following are the primary components of their diet:

"Badgers are good foragers and their diet tends to consist of earthworms, slugs and snails and wild fruits, nuts and seeds. They are also known to eat small mammals, such as mice, rats and squirrels and rabbits and amphibians, such as frogs and toads." (Matthews, 2020)

<u>Invertebrates:</u>

We all know (or at least, most of us do) that European badgers love earthworms. They eat mainly earthworms and are particularly reliant on those animals in habitats with well-drained soils (typically grasslands and agricultural fields). They have an excellent sense of smell and strong front claws to find earthworms while digging in the soil (Kruuk, 1989).

Insects:
Besides earthworms, badgers also eat many kinds of insects such as beetles, ants, termites, and insect larvae. In grasslands and woodlands, they can forage for insects as well. (Roper, 2010).

Small Mammals:
The European badger typically hunts voles, mice, rats and shrews, but will also opportunistically hunt small mammals such as the rabbit. Their hunting is done through stealth and a pounce, which means they can step on the foor lightly but with the soles of their rear feet raised making them quiet and efficient in the dark night. (Barrett, 1993).

Fruits and Berries:
Most years fruits and berries are available to badgers in the summer and autumn, so they identify them as a supplementary food item. For example, they can eat blackberries, raspberries, apples and fruits that grow in their living environment (Corbet, 1977).

Roots and Tubers:
European badgers will dig up roots, tubers and bulbs especially when other foods are less available. And this behavior can be crucial during the winter (Gloor, 2001).

Carrion:
Badgers are opportunistic scavengers and will eat carrion such as carcasses they encounter (Claudio Sillero-Zubiri, 2004).

Amphibians and Reptiles:
Though rarely included in the diet, European badgers may also eat some amphibians such as frogs and toads, or reptiles such as lizards and snakes.(Chanin, 1985).

However, the composition of the diet of European badgers changes greatly according to availability in their habitat, season and/or region. This opportunistic feeding behavior makes them an adaptable species, with dietary patterns that change depending on the availability of food sources as the year progresses. European badgers are primarily nocturnal, feeding mainly by scent and relying on their formidable digging ability to procure preferred foods.

2.2.5: Foraging Behavior of the European Badger:

Foraging is mostly done at night when European badgers will use their keen sense of smell and hearing to find prey. Their powerful forelimbs and ten-inch-long claws allow them to dig into the earth, exposing worm burrows and insect homes. They will overturn rocks and logs to get at invertebrates. Badgers are known for a behavior called snuffling, where they use their snout to root around in the dirt and search for hidden prey. Although they are notorious to make latrines close to their setts for territorial purposes and as a possible secondary food resource by consuming invertebrates attracted with feces.
The European badger (*Meles meles*) is an omnivorous and opportunistic feeder that exhibits some fascinating foraging behaviors.
(Team B. , 2022). Here are some notable foraging behaviors of the European badger:

Earthworm Predation:
European badgers are particularly well known for their foraging behavior, with earthworms being a key element to their diet. They have an acute smeller which helps them to know about the vibrations caused by the movement on earthworm in burrows below. After spotting a worm, badgers quickly and skillfully dig through the ground with their powerful front claws to catch it. (Team W. T., 2023).

Pouncing on Small Prey:
Pouncing behavior is exhibited by European badgers when hunting small mammals, such as mice, voles and rats. They creep up on their prey, then spring into the air and drop down on top of it with their front paws to catch and effectively subdue their prey quickly (Nouvellet, 2009).

Rooting and Digging for Food:
European badgers have claws that are specially adapted for digging and will use their formidable forelimbs to claw through soil and leaf litter in a search for insects, insect larvae and plant roots/tubers. This has resulted in a foraging behavior that enables them to feed on hidden food items which are not accessible from the surface.(Gorman, 1990).

Feeding on Fruits and Berries:
European badgers eat fruits and berries during the warmer seasons. They will eat many available ripe fruits in their environment, such as blackberries and raspberries or apples and other reachable fruits (Rosalino, 2009).

Scavenging and Carrion Consumption:
European badgers are opportunistic scavengers that eat carrion when they find it. To help supplement their diet, they might eat the remains of dead animals roadkill or carcasses not finished by other predators.(Martín, 1995).

European badgers are predominantly nocturnal so much of their foraging takes place at night. Their senses of smell, hearing and touch are quite advanced and they use them to find food and navigate in the dark. This diversity in foraging behavior enables them to exploit a variety of resources, and these solitary omnivores are successful and opportunistic foragers across many different landscapes.

Chapter 3: Material and method

3.1 Usage of sources throughout the Thesis Work:

Throughout my thesis work I used a vast variety of ways to find the most relevant and reliable sources to form a coherent and well-structured research work. For this reason I based my thesis work on different sources to compare and contrast previous research works based on my research topic and to find the best possible information what I could use to base my topic on. For this reason one of my methods included previous research works based on this topic on Google Scholar. With the help of key terms and words like: *Vulpes vulpes*, *Meles meles*, Red fox, European Badger, habitat, diet, distribution and preferences I could find interesting and relevant topics on Google Scholar. The main and most useful part was to find nice, well-structured and relevant diagrams based on my research topic. I also found many study material and publishment on Google Scholar from different European courtiers. Examples would be: Hungary, France, Belarus and Italy. I also used many articles and journals found on the internet. These research articles and journals helped me to use relevant references in my thesis work based on my research question. I also found my articles from other European countries like: The British Isles, Switzerland and Poland. Throughout my investigation I also used many old research books from the National Széchényi Library (Hungary) that were based on the red fox and the European badger. Finding relevant parts and sections in these books were challenging and time consuming but in my opinion I gained most of the used up information and knowledge based on these books. I also found information and publishments from various European courtiers like Belarus, Hungary, Britain and Poland. With a good variety of research material and different sources from many European countries I gained enough knowledge to write an overlapping and structural thesis work in my thesis question based on the European preferences of the red fox and the European badger.

Chapter 4: Results and their Evaluation

4.1 Comparative Analysis of Habitat

4.1.1 Overlapping Habitat use

Both the red fox and the European badger show some habitat overlap, especially where there is a mixture of open areas and cover. Examples might include woodland edges, hedgerows, and grasslands with these species overlapping their habitats.
In some cases, they may meet each other in locations where human beings have modified the herbal surroundings to create city or suburban habitats. The red fox (*Vulpes vulpes*) and the European badger (*Meles meles*) are among some of the most typical mammals in Europe, and many other regions. Despite having some similarities in habitat preference and diet, their ecological niches do not overlap significantly and there is little functional redundancy in foraging behavior. (Lanszki, 2010). Here are some factors that contribute to the overlapping habitat use of these species:

Mixed Woodlands:
Likewise, red foxes and European badgers are typical of mixed woodlands, broadleaved forests and other wooded habitat types. These habitats offer cover, denning locations, and diverse food resources such as small mammals, birds, insects, and fruits (Lanszki, Den Site Selection of the European Badger, *Meles meles*, and the Red Fox, *Vulpes vulpes* in Hungary, 2010).

Hedgerows and Edge Habitats:
The two species inhabit hedgerow, grassland–forest edge, and agricultural landscapes all over Europe.(Wallach, 2019).

Pastures and Grasslands:
In pastures and grasslands, red foxes can coexist with European badgers, especially if these habitats are adjacent to woodlands or hedgerows. These clearings provide hunting grounds for small mammals and insects (Hromada, 2003) (Goszczyński, 1999) .

Scavenging Opportunities:
Red foxes, *Vulpes vulpes* and European badgers, *Meles meles* are both opportunistic scavengers that can potentially meet while foraging at carrion or human-associated food sources exploited by other species.

Urban and Suburban Environments:
Both species have shown adaptability to urban and suburban areas. They might be able to adapt to these anthropogenically altered landscapes, which offer a synanthropic spectrum of natural and man-made food sources (Torretta, 2024) (Sadlier, 2004).

Even so, within contexts where food is limited, competition also occurs between red foxes and European badgers when they overlap in habitat use. Badgers and red foxes are potential competitors for small mammal prey and may compete with each other in urban areas. (Van den Berge, 2022),

Nonetheless, these two species have developed mechanisms to coexist and utilize different resources in overlapping habitats. Badgers are likely more nocturnal and the activity patterns of both species also need to be explored as foxes tend to be more crepuscular with a higher tendency toward nocturnal activities. Alternatively, they can also spatially segregate by using different habitat components or avoiding direct interactions.

In summary, despite some overlap in habitat use by red foxes and European badgers, the differences in their ecological niches and behaviors enable the two species to coexist within the same ecosystems while largely avoiding competition with each other (Márton, 2014).

4.1.2: Habitat Similarities and Differences:

However, the species do have differences in habitat preference, with some overlap. Urban and/or agricultural adapted red (*Vulpes vulpes*) foxes find dens in areas close to humans. Conversely, European badgers are more closely tied to woodlands and grasslands, living primarily in setts — complex burrow systems. The red fox (*Vulpes vulpes*) and the European badger (*Meles meles*) are two speciose synanthropic mammals with widespread distribution across Europe and parts of Asia. Although they have some overlapping habitat niches, they also occupy different environmental requirements and their respective ecological niches (Gołdyn, 2003), (Torretta, "Ecological Adjustments and Behavioural Patterns of the European Badger in North-Western Italy", 2024). Here are the main habitat similarities and differences between the red fox and the European badger:

4.1.3: Habitat Similarities:

Mixed Woodlands and Forests:
Red foxes and European badgers are both species normally found in mixed woodlands and deciduous forests. They provide cover, denning sites, and access to a diversity of foods

used by both species (Márton, Niche Segregation Between Two Medium-Sized Carnivores in a Hilly Area of Hungary, 2014).

Hedgerows and Edge Habitats:
Your hedges, grassland-forest edges and agricultural landscapes are likely inhabited by red foxes and European badgers. The hedgerows that run between the fields act as natural corridors and provide cover, leading them to be important travel routes for both species (Márton, Niche Segregation Between Two Medium-Sized Carnivores in a Hilly Area of Hungary, 2014).

Pastures and Grasslands:
Red foxes and European badgers can be found in pastures and grasslands, but only if those areas are close to woodlands or hedgerows. These habitats provide open areas where there are opportunities to hunt small mammals and insects.(Lanszki J. H., 2006).

Human-Altered Landscapes:
Both Species have adapted well to human-modified landscapes including suburbs, farmland and urban areas. They are likely to exploit human-linked food sources and obtain shelter in these habitats.(Huck, 2013).

Habitat Differences:
Nocturnal vs Nocturnal and Crepuscular:
The red fox is mostly active at night (nocturnal), and so is the European badger, although badgers can also be active during twilight hours (crepuscular)

Earthworm-Rich Environments:
European badgers give good meaning to habitats that have a ready supply of soil biota; namely, earthworms are the primary food source. As a result, badgers will often select habitats that have well-drained soil capable of supporting earthworm populations.(Virgós, 2004).

Water Sources:
Although not directly dependent on aquatic environments, access to water sources (e.g. streams or ponds) can be beneficial for European badgers particularly in dry areas (Sadlier L. &., 2004).

Digging and Denning:
European badgers are notorious diggers, and excavate elaborate setts in which to live and rear young. Red foxes on the other hand are more inclined to use an already made burrow or a natural structure as a denning site (Parrott, 2012).

Urban Tolerance:
Red foxes have shown greater urban and sub-urban adaptability than the European badger. Badgers also tend to avoid human disturbance, whereas Foxes can easily live in urban environments and take advantage of human food as much as they can.

Although the red fox and European badger are both flexible animals that can occupy similar habitats, differences in adaptation, behavioral strategies for foraging and physical ability to compete result in low levels of competition between these two species allowing them to coexist over a wide range of environments.

4.1.4 Habitat Interactions and Competition:

Because the home-range of both red fox and European badger overlap, competition can occur between them. They compete for the same resources, which include small mammals and invertebrates. Nonetheless, based on the presence or scarcity of several resources in their common environment, competition may be more or less intense. The interactions may vary in nature and intensity depending on food availability, size of territories, and population densities. In Europe, one of the best-known carnivorous mammals is the red fox (*Vulpes vulpes*) and its presence overlaps with that of other common predator, the European badger (*Meles meles*). Despite this both are opportunistic omnivores, and a (to some extent) resource partitioning exists between these species with interaction and competition for resources.
(Van den Berge, "Dietary Composition and Overlap Among Small- and Medium-Sized Carnivores in Flanders, Belgium", 2022), (Clutton-Brock, 1999): Here are some of the key aspects of habitat interactions and competition between red foxes and European badgers:

Food Resources:
Red fox and European badgers have some elements of their diet in common (small mammals, insects fruits and carrions). They can become competitors for the same food resources, especially if preferred prey (small rodents or insects, for example) are scarce.

Earthworms:
European badgers depend on earthworms as an important food source, and their behavior indicates that they are proficient at locating and excavating these invertebrates from the soil. Actually, many foxes have also been seen eating earthworms when they are available and plentiful. Competition for this resource can occur where earthworm densities are high.

Scavenging:
As scavengers, both species are opportunistic and competition for carrion and other leftovers from animal feeders is possible. Scavenging opportunities can be a critical resource for both red foxes and European badgers, particularly under extreme environmental circumstances

Den Sites:
Den habits differs by species (red fox and European badger are examples). The sett, which appears to be a native home range for badgers with complex burrows and tunnels for providing shelter and raising cubs is often 1m in diameter; whilst foxes usually dig existing burrows or use natural shelters with large holes as dens. Where suitable denning sites are limited, the two species may compete for nest sites.

Space and Territories:
Red foxes and European badgers are also territorial animals so will need enough area to create and maintain territory. Population densities are an important piece of the puzzle; where resources and territory may be limited, there is room for conflict.

Avoidance and Coexistence:
Although there is competition for resources between red foxes and European badgers, these two species have evolved mechanisms to reduce direct interactions and live in their habitats side by side. Both carnivores could show different activity patterns as the badgers are more nocturnal whereas foxes exhibit a stronger polarization towards crepuscular and nocturnal activities. That way, there are no resources squabbles.

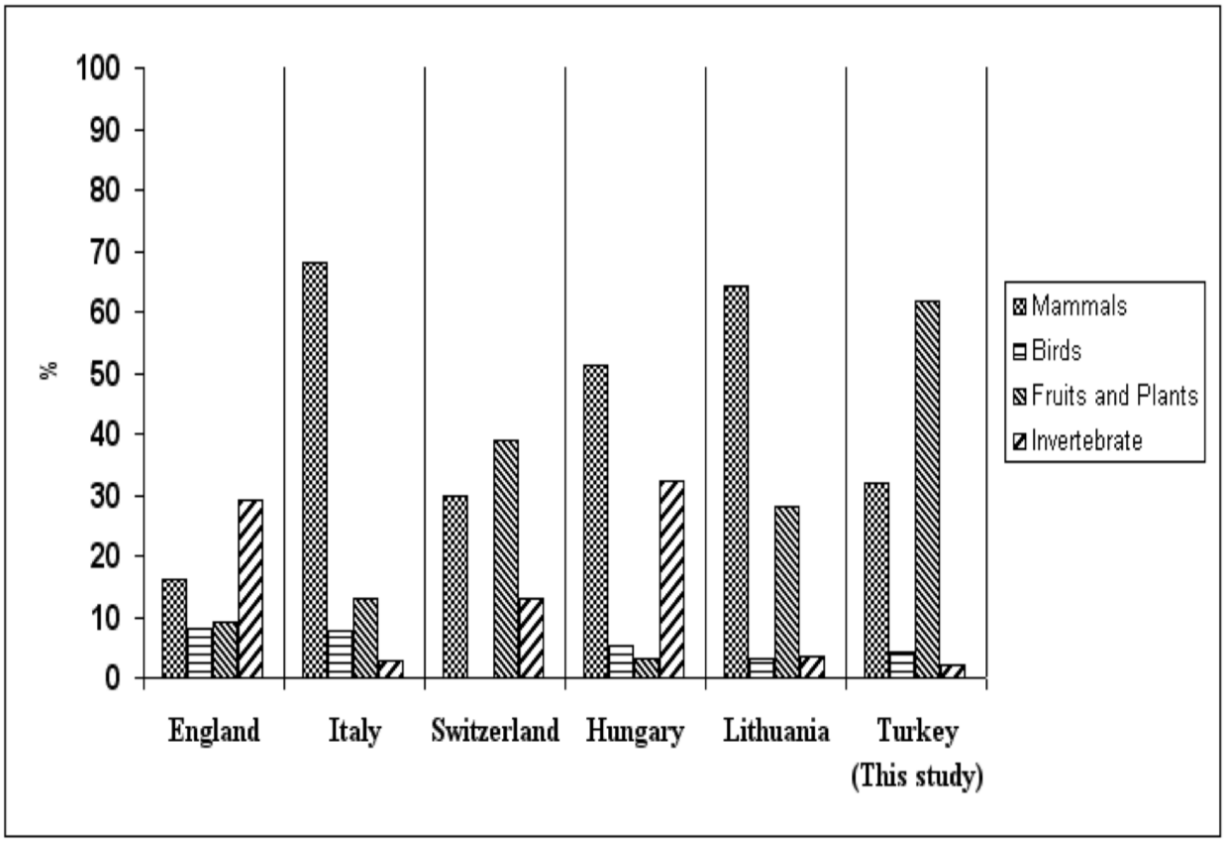
Niche Differentiation:
Red foxes may choose to alter their foraging behavior away from the more profitable prey occurring in badger-sett complexes, therefore enabling them to avoid direct competition. As an example, badgers can dig for earthworms in the soil while foxes are more likely to search for small mammals on the surface. Competition and habitat interactions between red foxes and European badgers are highly context-specific, being influenced by local factors including food resources, habitat types, and the density of each species' populations. Although historically a potential competitive threat, both species appear to be exploiting different foraging strategies and perhaps ecological niches within their coevolved habitats.

4.2: Comparative Analysis of Diet:

4.2.1: Overlapping Dietary Preferences:

Figure 5

"Comparison of diet components frequency data of red foxes in England, Italy, Switzerland, Hungary, Lithuania and Turkey" (Derg, 2009)



Both the red fox and the European badger exhibit omnivorous diets, incorporating a wide range of food sources into their consumption patterns. They share some dietary preferences, including small mammals, invertebrates, and fruits. This overlap in diet can lead to competition for resources, particularly when the availability of preferred prey species is limited (Kruuk, The Social Badger: Ecology and Behaviour of a Group-living Carnivore, 1989).

Small mammals:

Red fox:
In the case of the red fox frequent hunting for smaller mammals such as rodents like mice and rats our main source of food for the specie. they consist of a significant part of their diet especially in areas where such prey is plentiful.

European badger:
In the case of the European badger they also consume smaller mammals however they are not as dependent on these food sources as the red fox. They tend to be worst hunters than the fox but this doesn't stop them to prey on smaller mammals and rodents. they usually only hunt opportunistically rodents when the temperature plummets and the colder months reduce the source of other food sources.

Insects:

Red fox:
During the summer month on the agricultural fields different kinds of insects can be found and the number of these insects are abundant. Therefore foxes often consume different kinds of insects throughout the summer months like beetles and grasshoppers. It is considered to be a vital food supply for them throughout the mainly summer month.

European badger:
In the case of the European badger insects play a larger part of their diet than in the case of the red fox and they like to consume different kinds of insects and earthworms. Badgers are expert foragers and with the specially designed clothes for digging they are experts of digging up earthworm from the soil and also different kinds of larvae's. Mainly in wetland areas where earthworms are abundant they may take up to 50% of their diet.

Fruits and Berries:

Red fox:
Red fox is an omnivorous species and therefore they consume not only flesh based diet but also they like to consume fruits and berries. throughout the autumn season when different kinds of fruits are abundant in the forest the red fox like to forage on these fruits. Apples, blackberries, raspberries and other different kind of fruits that can be found in the forest make up a significant part of their diet throughout the autumn month. This also prepares them for the upcoming harsh winter environment.

European badger:
Similar to the red fox the European badger also realizes different kinds of fruits and berries which are abundant in the forest throughout the autumn season. These berries and fruits are high in vitamins and it's a vital energy source that can help these animals live throughout the winter season. Because both the red fox and the European badger lies to consume fruits and berries dietary overlap is noticeable throughout the autumn when these seasonal fruits are in an abundance in the forest.

Carrion:

Red Fox:
Red fox are known to be a very opportunistic feeders and therefore the remains of dead animals are a pleasant sight for them when it comes to their feeding behavior. It is none that right folks like to consume these remains especially throughout the harsh winter conditions when the life prey abundance is lower and it is also much harder to hunt for live prey.

European badger:
In the case of the European badger they are also an opportunistic leaders and it is also not a problem for them to consume carrion. Also in the case of the European badger this forum behavior can be monitored mainly throughout the winter seasons where other food sources are scarce.

Birds and eggs:

Red fox:
Red fox is a very fast and the relatively agile hunter therefore it is not a problem for them to hunt for ground nesting birds and to prey on their eggs throughout the nesting periods of the year. They like to raid nests and consume both the eggs and the juvenile hedged birds. They can cause a big problem in the European pheasant population because these birds are ground nesting birds specie.

European badger:
the badger is not as fast and agile as the folks so it is harder for them to hunt for birds species however when they can they like to consume bird eggs and young birds. This usually happens when they are foraging near areas where ground nesting birds like to nest.

Plants and roots:

Red fox:
Since the red fox is a omniverse specie they also like to utilize plants and routes throughout their feeding behavior. When other food sources are scarce it is not a problem for them to consume plant based materials like roots, tubers and different kinds of plant based material.

European badger:
European Badgers tend to consume more plant based materials than the red fox. Since they have large and strong close it is easier for them to dig up the soil and to access the roots of different plants. this behavior can be seeing more often than the other food sources are scarce.

4.2.2: Dietary Differences:

Although both species eat the same things, each has a different emphasis in its diet. The diet of the red fox has greater diversity, containing more avian and plant material as well as carrion. Beleaguered, they are opportunistic hunters and foragers and more often feeding carrion and food waste in human-dominated habitats and manmade environments. In addition, their use of human waste means that they are also more likely to adjust to urban areas and the complementary landscapes. European badgers depend heavily on earthworms as a key component of their diet, even representing a large proportion of the seasonal food intake. In late summer and autumn, when wild fruits grow abundantly in the forests and meadows, Badgers are also thought to eat a greater proportion of fruit and vegetable matter. Because they are more able-bodied, it is also much more likely to see a red fox kill live prey. More hunting strategies than could significantly enhance their hunting performance and success rate over non-foxes can be used by foxes. They are capable of using more sophisticated hunting techniques when hunting live prey, including stalking and pouncing. This efficient, independent foraging approach enables them to traverse large distances and exploit different food sources while hunting and foraging. European badgers, on the other hand, are slower with shorter legs and they prefer to make use of primary food sources more. Badgers are more likely to dig for food, relying heavily on their powerful claws to extract earthworms and other invertebrates from the soil. Their digging means they are more dependent on areas of soft soil and high invertebrate density.

4.2.3: Diet Competition:

Competition for shared food resources can arise between red foxes and European badgers, particularly when prey populations are limited. However, dietary overlap may be mitigated by differences in foraging behavior and preferred prey items. Red foxes' scavenging behavior and ability to exploit diverse food sources may allow them to occupy a broader dietary niche, potentially reducing direct competition with badgers. However throughout my studies I found three particular food sources that both species like to utilize. These food sources can raise competition between the two species mainly seasonally.

Fruits:

Throughout the late summer and autumn month to our extended variety of different fruits that can be found in the forests. Examples of these would be apple, plum, pear and also different kinds of knots like walnut and chestnut. Both the red fox and the European bachelor likes to forage on these plentiful fruit items and this could raise competition between the two species. however this is mainly a seasonal competition since these fruits are mostly available throughout the late summer and autumn month (Roper, Badger, 2010).

Eggs:

Both the European badger and the red fox are opportunistic hunters therefore it is common to see them forage after ground nesting bird species where they can consume their eggs if they find them. The most vulnerable species are the European pheasant and the different quail species which are ground nesting bird species. In the case of the European pheasant which is one of the most common ground nesting bird game species in Europe the next thing period is between April and June. therefore throughout April and June there are eggs can raise thy at competition between the European badger and the red fox since both species or scavenging for these eggs (Macdonald D. W., 1987).

Carrion:

Carrion Consumption is not a problem for both species and they grabbed the opportunity if they see a dead animal in the nature. Since both species like to use this opportunity this could raise direct competition and interaction between the red fox and the European badger. However this is most common throughout the winter season when the cold weather decimates the number of weak and unhealthy animals (Barrett, Mammals of Europe, North Africa, and the Middle East, 1993).

Chapter 5: Ecological Roles and Ecosystem Services:

5.1: Red Fox's Role in Trophic Cascades:

Red foxes play an essential role in trophic cascades by controlling populations of small mammals and birds. This chapter will explore into their impact on prey species and how their presence can influence the broader ecosystem dynamics.

5.1.1: Predation on small mammal and bird species:

The main source of food for the red fox are small mammals like different kinds of rodents and smaller bird species that they can hunt successfully. By controlling the number of these food species, the red fox can indirectly affect vegetation throughout its predation and feeding habits. An example would be if the red fox population increases than the amount of small rodents and birds consumed by the red fox will also increase. Therefor by reducing the amount of herbivores this will allow for increased plant growth, impacting the overall structure of the ecosystem (Yalden, 2008).

5.1.2: Competition with apex predators:

In countries where red fox is not the apex predator there number could decrease in two different ways. For example in Hungary Golden Jackal could be considered as the apex predator. For them red fox is a competitive specie. Golden jackal can overpower the red fox populations either through direct predation or by outcompeting them for prey. Golden jackal also like to prey on smaller birds and mammals just like the red fox. And golden jackal can also prey on red fox since they are bigger and more powerful. By decreasing the apex predator numbers the amount of red fox can increase by time. However is the opposite happens and the apex predator numbers increase this could have a negative effect on the red fox population and there numbers could decrease with time (Claudio Sillero-Zubiri, Canids: Foxes, Wolves, Jackals, and Dogs: Status Survey and Conservation Action Plan, 2004).

5.1.3: Effect on Invasive Species:

In countries where unwanted invasive species were introduced the red fox can be a benefit because red fox can prey on these invasive species ultimately decreasing its population. Therefore it is a positive outcome. However on the other hand if red fox is introduced to a country red fox will start to prey on the native mammal and bird species and which could disturb the ecosystem and the native animals population (Macdonald D. W., Running with the Fox, 1987).

5.1.4: Human Impacts and Cascades:

Different kinds of human activities like hunting, trapping and logging can decrease the population of the red fox and its habitat. Of this happens prey species like small rodents can experience a population boom and this population boom can lead to overgrazing and can have a negative effect on the ecosystem and the native vegetation (Macdonald D. W., Running with the Fox, 1987).

5.2 European Badger's Impact on Ecosystem Health:

European badgers, which are known to eat a lot of earthworms and small mammals, help aerate the soil and may reduce pest numbers. We will then examine positive contributions of wildlife to ecosystem health and functioning.

5.2.1: Soil Aeration and Nutrient Cycling:

European badgers inhabit self-dug underground burrows, known as setts. These subterranean tunnels they make can improve soil aeration that may help with nutrient cycling and it also enables better water infiltration. This could be beneficial for tree roots, plant roots but also improve general soil health (Kruuk, The Social Badger: Ecology and Behaviour of a Group-living Carnivore, 1989).

5.2.2: Seed Dispersal:

Badgers are omnivores and eat different types of berries, fruits and nuts during their lives. Through eating these and wandering around their domain, they can spread seed in the form of feces. This may augment plant revival along with preserve diversity in the ecosystem (Barrett, Mammals of Europe, North Africa, and the Middle East, 1993).

5.2.3: Control of Insect and Small Animal Populations:

Badgers eat insects, worms and small creatures like rats and mice. Managing these figures, badgers may influence the composition of the ways in which foods live and prevent other species from reaching explosiveness that could unbalance botanical associations or spread disease. (Kruuk, The Social Badger: Ecology and Behaviour of a Group-living Carnivore, 1989).

5.2.4: Symbiotic and Competitive Interactions:

The European Badger may also share its ecological niche with other species—both in a symbiotic and competing fashion. For example, their setts could provide shelter for foxes, rabbits and even hedgehogs which would all contribute to the surrounding biodiversity. Competition with other predators such as red foxes can affect both the populations of these prey species and the predator-prey equilibrium within a locality.
(Barrett, Mammals of Europe, North Africa, and the Middle East, 1993).

5.2.5: Habitat Modification:

Badgers feed and dig, altering the environment in the process and creating microhabitats beneficial to many other species. In doing so, they create small ponds or depressions that capture rainfall and provide other animals a place to drink or amphibians areas to nest. (Yalden, Mammals of the British Isles: Handbook, 2008).

5.3 Implications of Habitat and Diet Variability on Ecosystem Services:

Understanding how the habitat and diet preferences of red foxes and European badgers affect ecosystem services will shed light on their ecological significance and their potential as indicators of environmental health. This section will focus on nutrient cycle, population control, seed dispersal and implications for biodiversity and habitat modification.

5.3.1: Nutrient cycle:

A nutrient cycle is the movement and exchange of inorganic and organic matter back into the production of matter. European badger can influence nutrition cycle in a positive way. Since badgers live in burrows called setts they need to dig out a significant amount of soil and dirt in order to create suitable setts for living. By digging and creating these setts they also improve soil aeration and structure at the same time. By moving and digging the soil they also move new organic soil and organic matter to the surface that affects nutrient cycle positively. This kind of soil turnover is beneficial to the nature in a way that plants can access more fertile soil that enhance growth and growth rate. At the same time it can also supports microhabitats, and can even influence water infiltration rates (Kruuk, The Social Badger: Ecology and Behaviour of a Group-living Carnivore, 1989). Red foxes do not dig as much and as well as the European badgers but they can also increase soil aeration when hunting and digging for small rodents.

5.3.2: Population control:

Habitat degradation can cause an instable and unhealthy trophic levels in their ecosystems. A main cause of habitat degradation is rodent overpopulation. Rodent overpopulation will automatically cause overgrazing which reduces biodiversity and can have a negative effect on the nature and ecosystem (Capen, 1993). Both the red fox and the European badger can help with this problem. Since both species like to prey on small rodents like mice and rats they can decrease the booming population and create and maintain balance in the ecosystem. At the same time these small rodents area also carriers of major zoonotic diseases (Amman, 2012). By preying on these prey animals red fox and the European badger can also lower the level of zoonotic deceases in the ecosystem.

5.3.3: Seed dispersal:

The red fox and the European badger both favor wild barriers and fruits they consume a lot of these in late summer and autumn when such natural forest items grow. They use these fruits to increase seed dispersal with their excrements too. Such diversity and dynamics may help facilitate regeneration in different habitats. For example, red foxes in particular can aid urban biodiversity through natural plant dispersal which helps to keep green spaces functioning. (Barrett, Mammals of Europe, North Africa, and the Middle East, 1993).

5.3.4: Implications for Biodiversity and Habitat Modification:

Red foxes donour hunting and making burrows, change the habitat that opens possibilities for other species. By predating on small mammals, the red fox can lower overgrazing and thus provide indirect benefits to a plant species in support of an equilibrium. When badgers dig a sett they create shelters for smaller animals, insects and plants to live in, helping to support biodiversity and habitat complexity. (Yalden, Mammals of the British Isles: Handbook, 2008)

Chapter 6: Conservation and Management Strategies:

6.1: Conservation Status and Threats:

The following chapter will summarize the conservation status of both animals, detail any known species-specific threats to them (e.g. habitat destruction, persecution, road mortality and disease outbreaks), It will also address the need to think about their role in ecosystem conservation effort.

6.1.1: Red Fox:

In the case of the red fox habitat loss is a key factor that could influence the population of the specie (Macdonald D. W., Running with the Fox, 1987). Increasing urban areas and agricultural disturbance are the main cause of habitat loss. Human activity and urbanization limits the natural areas where the red fox can live and they are forced to leave those areas or adapt and move closer to areas that are occupied by humans. With the increasing amount of roads and cars the number of road mortality also increases which ultimately decreases the population number and creates a major negative interaction between humans and the red foxes. In continental Europe, foxes carry the fatal disease rabies. If a rabid fox bites a pet dog, which in turn bites a person, the virus can be passed on to man (Yalden, Mammals of the British Isles: Handbook, 2008). Should this disease ever be accidentally spread it may possibly be transmitted quickly through the fox population, particularly the urban one. Hunting for their fur has decreased throughout the years but hunting for reduction has increased.

In Europe they are hunted and trapped because humans fear that they will cease harm in their livestock like sheep and poultry. On the other hand red fox is a main predator specie throughout Europe. In many countries it is considered to be the Apex predator since its larger rivals like the wolf number has already been reduced to a minimum or whipped out completely (Claudio Sillero-Zubiri, Canids: Foxes, Wolves, Jackals and Dogs: Status Survey and Conservation Action Plan, 2004). Therefor red fox is the gateway to control the rodent species in many European countries and with this activity they have a major role in the ecosystem.

6.1.2: European Badger:

In the case of the European badger habitat loss is also a major frat that could negatively affect the species population (Sadlier L. &., 2004). Similarly to the red fox urbanization the increasing agricultural activity also creates a problem to the badger. They are also forced to adapt to the new world or leave. Is the adapt and move into the city's human and badger interactions could have a negative effect. Hunting and trapping would increase and with this badger populations will decrease. Road mortality will also increase due to more cars and roads which are new obstacles for the badger creating yet another negative interaction between them and humans. European badgers are also considered to be a major threat towards the cattle population is several countries due to the fact that they are the carriers of bovine tuberculosis (bTB) (ROBINSON, 2013). Hunting and trapping is common. Humans like to decrease their population due to the fact that they can be a threat towards livestock's like chicken and duck and also because they can carry bovine tuberculosis (bTB) which can affect the cattle population. However European badger is a key specie when it comes to the ecosystem. With their underground burrows they enhance irrigation to the plants and they can also disperse seeds with their feces which will enhance plant growth and biodiversity. They also reduce the number of unwanted rodents by hunting for them (Earth, 2022).

6.2: Management Approaches for Habitat Preservation:

To ensure the long-term survival of both species, effective habitat preservation strategies will be essential. This section will explore methods for safeguarding suitable habitats, including the creation of wildlife corridors, protected areas, and habitat restoration projects. In the case of booth the red fox and the European badger habitat loss is a key factor when it comes to population decrease and increasing human interaction. These interactions can be limited by different kinds of methods.

6.2.1: Creating wildlife corridors:

With the increasing humans activity and urbanization new roads and obstacles Had been created throughout the years. One of the methods that we could use is creating wildlife corridors that can connect fields and other habitats together. This will create a safe corridor for the European badger and also for the red fox. By creating these corridors the European badger and the red fox can move between the corridors freely and without any human interaction. This will also benefit other species and ultimately limit road mortality. These corridors would also open up new places for the animals ultimately creating new habitats for them and also new places where they can forage for food and meet other folks or badger populations and this would ultimately reduce inbreeding. Example of such a wildlife corridor would be a green boss over the highways which are covered with shrubs and vegetation and the game can move between these corridors freely and without any human interaction (Federation, 2023).

6.2.2: Protected Areas:

By creating national parks and safe reserves for the red fox and the Badgers would help to protect the numbers and it will also enhance their population growth. in these national parks and protected areas they could be monitored throughout the years which would give us a deeper understanding of each specie. It would also limit human encountering, hunting and habitat loss. In these national parks and protected areas red fox and badger could live peacefully in nature without any human urbanization and destruction. In these protected areas buffer zones could be created where both the red fox and the badger population could flourish but also keeping up with the needs of the human population (Agency). Human activity can be strictly monitored but both the humans and these species could live together peacefully in these protected areas. Legal protection is also necessary since both the red fox and the European badger is protected under various national and European laws (e.g., the Bern Convention). By ensuring that these laws are followed and no illegal poaching and hunting is present populations could thrive.

6.2.3:Habitat restoration:

Habitat restoration would be a very ideal human activity for these species mainly because the main problem is that we are taking away their natural living areas. Examples of these habitat restorations would be reforestation and rewilding as well as creating woodland edges and wetlands which would increase biodiversity and create a sustainable new ecosystem for the red fox and the European badger as well as prey species and other wild game (Europe, 2016). It would ultimately create new opportunities and living area for all living wildlife. Native vegetation could also be introduced to these restored habitats to create plant diversity and the enhance the growth of native plant species over introduced or alien plant species.

6.2.4: Reforestation and rewilding:

This kind of human activity would create new living quarters for the European badger and for the red fox and it would automatically also benefit other game species. Native vegetation could be introduced to these reforested areas and automatically these reforested areas would benefit all kinds of species when it comes to feeding, breeding and living in the nature. It could also create a divers and balanced ecosystem at the same time.

6.2.5: Woodland edges:

Woodland edges around the agricultural fields could create hiding place for red fox and for the European badger and it could also create the natural corridor which they can use to move around freely and also it is a suitable place for breeding, creating burrows and finding feeding material. It is also a good opportunity to reintroduce native shrubs and smaller trees which would ultimately be beneficial for the ecosystem by creating diversity. These edges could also reduce human-wildlife conflicts (Peterken, 1993).

6.2.6: Wetlands:

In many times badgers can be found near wetlands or near water sources where to soil composition allows them to create tunnels. It is also a nice opportunity the reintroduce native vegetation and wetlands and water areas would ultimately benefit to other species. It would create new areas for drinking water and it would also create new areas for cover. It would also benefit the ecosystem. These soils near wetlands also contain vast amounts of earthworms and insects that make up a significant part of the European badgers diet. By creating and maintaining wetlands we could also support the badger population at the same time because we are also creating new hunting and foraging territory for them. It is also a nice touch to create a more diverse and natural ecosystem that support other wild game as well (Gosselink, 2015).

6.2.7: Non-lethal Management Techniques:

Wildlife and human interactions our daily occurrence. Humans always very that animals like the red fox and the badger would harm their agricultural crops as well as damaging their livestock. Non-lethal options could be one of the solutions for these human and wildlife interactions. Electric fences could be used around agriculture or crops to protect it from Badgers as well as motion sensing lights that lights up when movement is detected could scare away foxes from livestock barns and another option would be carbide cannons that's fire Co2 canisters creating a large sound which can scare away foxes and badgers (Putman, 2011).

6.2.8: Public Awareness and Education:

Many people think that Badgers and foxes are pests and therefore they want to reduce their numbers as much as they can. A solution for this could be to raise public awareness and education about the ecological role of these animals and the reason why we need them in the nature. This public educational services could ensure that people understand nature and these animals and their role that they provide in the ecosystem and it could also limit micro human interactions between them and the wildlife like the fact that many people think that these animals are pests.

6.2.9: Agroecology and Wildlife-Friendly Farming:

We can Implement wildlife friendly farming Techniques that would ultimately support both the red fox and the Badgers. such techniques would be the preservation of hedgerows and also leaving field margins uncultivated which can create buffer zone to the wildlife and also a safe passage next to the agricultural fields where they can find shelter and also avoiding the use of harmful pesticides which could kill rodents (the main food source for red fox) and it could also poison the red fox sandy badger population (Marris, 2011).

6.2.10: Rotational Grazing and Forestry Practices:

By using sustainable grazing practices we can ensure that our grazing fields will always have enough cover and grazing opportunity for other species like the rodents (which are the main food source for the red fox and is also very important for the European badger) and with selective logging we can prevent habitat loss for both species and also deforestation ensuring that the habitats remain intact for not only these species but for other game species as well. with this we can maintain biodiversity and create a natural ecosystem for all living wildlife (Benson, 2017).

6.2.11: Population monitoring:

With the help of population monitoring we can ensure that we have the knowledge to understand these species and also to understand the different areas of nature that they use therefore we can have an idea on which places and areas need to be protected against human interactions (Robinson, 2002). we can also better understand how these species use their habitat and responds to upcoming threats like human interactions the loss of habitat and the possible outbreak of different kinds of diseases.

6.2.12: Utilizing citizens in research:

We can also use the local citizens for population monitoring. By raising knowledge about these species the local community can report sightings of badgers and foxes and can provide possible data for the monitoring programs and they can also raise further awareness among other citizens which can create public support for protecting these animals.

Chapter 7: Conclusion

Throughout my thesis work my main objective was to answer a very specific research problem based on the red fox and the European badger. My research topic was: Comparative Analysis of the Habitat Use and the Diet Composition Between the Red Fox (*Vulpes vulpes*) and the European Badger (*Meles meles*). With this research question my goal was to answer main topics that are connected to the objective of my thesis. Examples of my research was the following: dietary needs of the red fox and the European badger, the habitat selection and the facts that can influence the selection, Foraging behavior of the two mammalian specie as well as the conservation and management factors we can consider to help maintain a suitable and healthy population and ecosystem for both species. Throughout my findings I could identify differences and similarities in both species when it comes to dietary needs, foraging behavior and habitat selection that answers my research problem clearly.

My findings also highlighted the main preferences for both species therefore understanding their natural behavior in a deeper way that could help with future conservation and management efforts. By understanding these species I also found solutions about possible human and wildlife interactions and conflicts. Throughout my studies I also shed light on the fact that the red fox and the European badger play a significant role in the nature when it comes to a well-balanced ecosystem. With the special purpose in nature they have many positive effects on the suburban and forested areas. I also identified the species urban adaptation throughout my studies. Ultimately this thesis underlines the main factors that influence the red fox and the European badger in urban and suburban territories highlighting their dietary and habitat needs to understand the management scopes we need to adapt as well as understanding this common European carnivore species in their natural terrain.

7.1 Summary of Findings

7.1.1: Restatement of Objectives:

This thesis work focused on the habitat use and the diet composition between the red fox (*Vulpes vulpes*) and the European badger (*Meles meles*). With this topic my aim was to answerer relative questions relating to the dietary composition, dietary similarity and differences, dietary overlap, human-wildlife conflict, foraging behavior, denning site selection and use and possible conservation and management methods that can be utilized now and in the future.

7.1.2: Key Findings:

Throughout my research about the diet composition of the red fox and the European badger I found suitable evidence that underlines the fact that both animals share roughly the same diet but red foxes utilize live prey more whereas European badgers utilize earthworms, insects and fruits more. This slight shift in diet also influence the habitat selection since in the case of the red fox they prefer more open habitats where live pray numbers are higher whereas European badgers utilize forest habitats more where the earthworm density and seasonal fruit availability is higher.

7.1.3: Relevance to Existing Literature:

Previous relative studies, literatures and researches align with my findings and they were a major help for me throughout answering my thesis question about the red fox and the European badger.

7.2 Implications for Conservation:

Population control and game management plays a significant part in a sustainable ecosystem therefor we need to ensure that the European badger and the red fox population remains at an optimal level throughout Europe. In this section I will like to demonstrate some conservation methods we could use to enhance and maintain the population in the case of both species as well as to reduce to possible human and nature conflicts. It is our goal to ensure that wildlife and humans can live peacefully and separately from each other to limit the unwanted dangers and interactions between humans and wild animals.

7.2.1: Habitat preservation and restoration:

Due to rapid urbanization we face to problem of limiting to natural living space for the red fox and for the European badger. If we want to ensure a healthy and solid population in both cases we need to maintain their natural habitats. These preservation methods would also give us an opportunity to limit human and game encounters and problems and also to reintroduce native tree and plant species. This would not only benefit the game but also the ecosystem and to humans. Another habitat preservation method could be the reconnection of fragmented areas. By creating game bridges over highways and roads we could connect fragmented areas together to ensure that the game have more space and hunting opportunities. This would also decrease the number of road kills significantly. Another option would be to consider reforestation, grassland restoration, and hedgerow planting can create unbroken habitats for foxes and badgers allowing safe movement and hunting across larger areas.

7.2.2: Non-lethal control methods:

One of the main human and fox/badger conflict issues is the predation of livestock. By utilizing electric fences around livestock barns we Could ensure that the red fox and the European badger cannot access the livestock bonds without killing them. Another option would be to use CO2 cannons that has a large ear piercing sound whenever it goes off which scares away unwanted predator species like the fox and badger. We could also use motion sensing lights that shine up when they detect movement which scares away carnivores without killing them.

7.2.3: Legal safeguards and regulated population control:

By utilizing legal protections we can overcome unwanted killing of the red fox and the European badger. We could also implement new hunting laws that ensures that the population of both carnivore species are not dependent by human or hunting activities. in areas where the population of both species seems to be declining new hunting practices could be obtained. Examples would be daily harvest numbers and hunting season to ensure that both species have the opportunity to regenerate in population size. This is especially important in parts of Europe where the red fox is considered to be an apex predator because in those cases they have an ecological role to ensure that the rodent population also stays in control. It is also very important to ensure these new laws in places where both species face pressure from habitat loss and declining population numbers.

7.2.4: Protecting prey and food resources:

By reforestation and by the improvement of grasslands and natural corridors we are also creating a safe haven for prey species that are vital for both the red fox and the European badger. conservation strategies for these carnivore species should also include the preservation of habitats of these prey species to ensure that the amount of life prey is abundant. This way we could also decrease the appearance of these carnivore species in urban areas because they don't need to come into the towns and villages to scavenge for food.

7.2.5: Minimizing competition and predation:

As foxes are vital to regulate rodent and small animal populations, guaranteeing they face minimal competition helps maintain their ecological importance and role. Where larger apex predators have been removed, fox populations can meet some roles of ecosystem regulation, provided they have satisfactory space and resources in the nature. It is also important to keep the competition number relatively low to ensure that the red fox and the European badger number can increase and more prey species are left for them to prey on.

7.3: Future Research Directions:

7.3.1: Shifts in dietary and prey availability:

We could study the seasonal and regional differences in live prey and plant resource accessibility that could potentially have an influence on the diets of the European badger and the red fox. Findings could expose how the red fox and the European badger plays a role in the biodiversity through rodent control and seed dispersal with their feces.

7.3.2: Preferred habitats (urban or rural environment):

To study in further whether the red fox and the European badger prefers urban or rural environments. With the help of these studies we could understand these species deeper and we could also obtain new regulation and management programs which are specific for each specie. with further understanding we could also limit reduce wildlife-human conflicts and and support urban biodiversity.

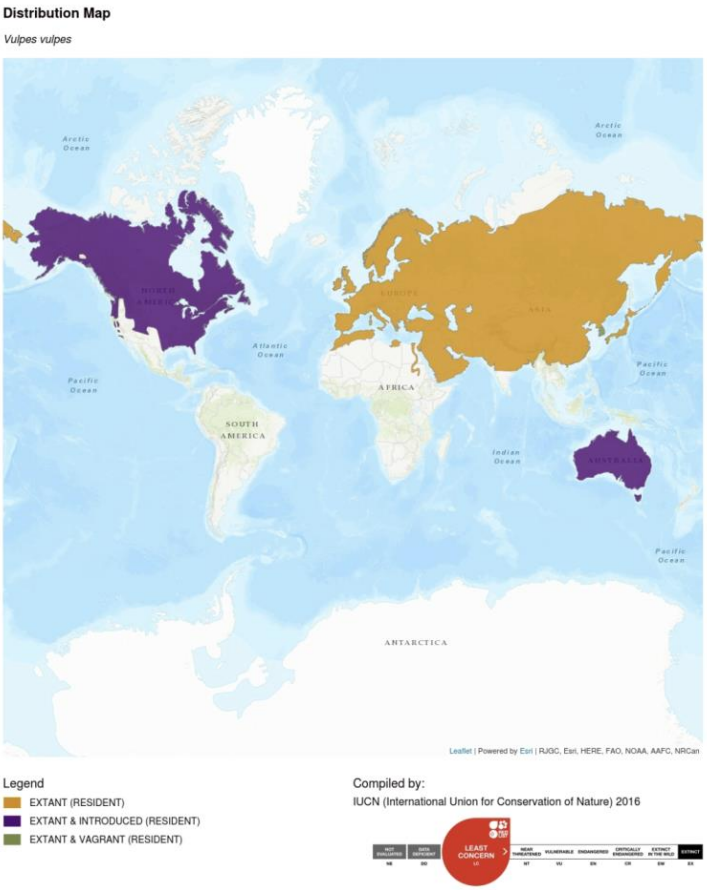
7.3.3: Effects on climate change on the diet and habitat:

Climate change can directly affect the red fox and the European badger. With shifting climates prey availability could also shift which could play a significant role for both species when it comes to habitat selection and dietary composition in the long run.

7.3.4: Genetic studies between urban and rural foxes and badgers:

We could also study red foxes and badgers who live in more rural areas and foxes and badgers who live in more urban areas. Stomach content and genetic insights could be collected to identify if there are any differences between the animals who live in relatively different surroundings and habitats.

Figure 1



Distribution map of the red fox (*Vulpes vulpes*) (Group C. S.)

On this diagram with yellow color it is clear to see that the red fox is native to the European continent as well as almost all of Asia starching from Russian all the way to Japan and also parts of Africa. This shows that the red fox can find suitable habitat and hunting territory almost everywhere on our globe where we can find suitable forest cover and water resources. It is also interesting to see that the natural spread of the specie do not extend into African only slightly. A answerer to this could be the possible habitat and prey competition with larger animals that live in Africa like the Lion, Chita, African Wild Dog and the Hyena. All of these species are much larger than the red fox and they could prey on the red fox therefor they could decimate their population if there were any. With purple color we can see the introduced red fox population into parts of the United States, almost all of Canada and Alaska. This shows that the red fox can adapt to very harsh and cold conditions in order to survive. They were also introduced to Australia and Tasmania mainly to reduce rodent populations. Due to lack of natural Apex predators there is technique no competition for the red fox in Australia and they also started to prey on native bird and mammal species causing major ecological problems. There were also a significant population boom in the number of red foxes on the continent. https://www.canids.org/species/view/preklp237241

Figure 2

Category	April 2005 (50)	July 2005 (50)	May 2006 (50)	August 2006 (50)	February 2009 (40)	Winter[a] 2010 (42)
Small rodents	56	64	31	48	35	60
Ungulates[b]	60	14	38	2	77	74
Other mammals[c]	12	16	18	2	8	5
Birds[d]	16	38	22	30	13	21
Amphibians and reptiles	8	14	64	26	0	0
Invertebrates	28	68	33	68	3	5
Berries and seeds 50	50	70	71	98	5	43

[a] Winter, December 2009 to April 2010

[b] Mainly moose, only few roe deer (<10 %)

[c] Mountain hare, red squirrel and unknown mustelid

[d] Mainly Capercaillie and black grouse

This diagram represents the frequency of occurrence (%) of food categories in the scats of red foxes collected in different sampling periods and years in Varaldskogen, southern Norway.(*n*) =Number of scats examined.

From this diagram we can see that small rodents made up a significant part of the red foxes diet throughout the year. Ungulates (mainly carrion) was also utilized by the red fox significantly throughout the winter season. This could be because throughout the wither season the amount of dead ungulates could increase due to the harsh winter weather. The cold temperature also preserves the carrions for longer periods of time without rotting and the red fox has more time to search, find and consume dead animals. In the case of birds there was a relatively stable and constant preying throughout the year with slight increases during summer months. This could be due to the increase of nest predation in the case of ground nesting birds. Amphibian predation was very high in May. Toads and frogs come out of hibernation during late spring and at that time of the year the forest is full of them making it easy for the foxes to prey on them. Throughout the winter months the research team couldn't find any sign of amphibian remains in the scats. The reason could be that the amphibian are hibernating at that point of the year the their abundance in the nature in zero. Invertebrate predation was high trough out the summer but reduced significantly for the winter. Barriers and seeds were consumed in a substantial amount during early spring. It was relatively constant during July 2005 and May 2006 with a major boom in August 2006. The reason could be that during late summer most of the barriers are ripe in the forests and red fox has to opportunity to food on them. During winter 2010 it was also relatively high showing that red fox utilize all edible resources during winter time. (Robert Needham, 2014)

https://www.researchgate.net/publication/263280789_Seasonal_diets_of_red_foxes_in_a_boreal_forest_with_a_dense_population_of_moose_The_importance_of_winter_scavenging

Figure 3

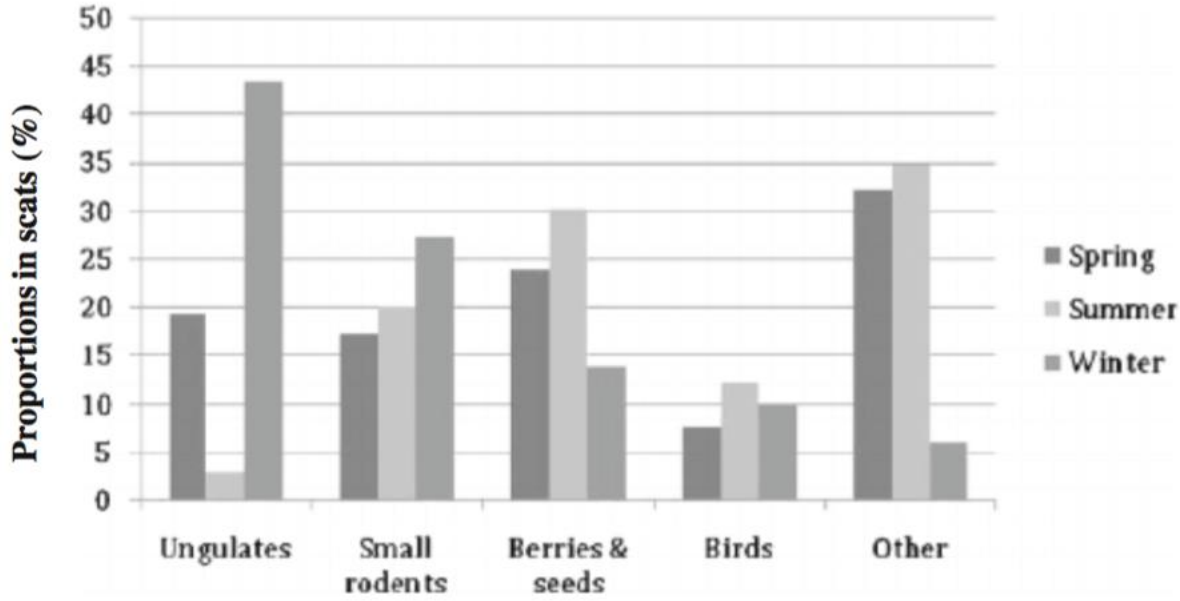
Species	Hunting attempts (%)	Scavenging (%)
Rodent	64 (90)	
Frog	2 (3)	
Black grouse	3 (4)	
Capercaillie	2 (3)	
Moose		15 (60)
Roe deer[a]		8 (32)
Grouse		2 (8)

(Robert Needham, 2014)
Hunting attempts (71 times) and scavenging (25 times) recorded
This diagram represents hunting attempts (71 times) and scavenging (25 times) recorded along 62 different red fox tracks followed in a total of 71 km during winter 2009 at Varaldskogen, SE Norway.

From this diagram we can identify that red foxes utilize rodent hunting in a significant level throughout the wither seasons. Out of 71 hunting attempts the red fox was hunting for rodents 64 times. This could also show how effective their hunting technique is special in the winter when they listen for rodent movement under the snow. Their method of catching live prey under the snow consists of sharp listening to identify the exact location of the prey and after a large jump up into the air and then sweet down head first into the snow to catch the live prey. The rest of their hunting was made up of frog, black grouse and capercaillie but these hunts were very low compared to rodent hunting. From this diagram we can also learn that the red foxes like to scavenge during winter seasons since they are opportunistic hunter. Ungulate scavenging played the larger part with an overall percentage of 92. Only 8% made up their bird (grouse) scavenging. This could be because ungulate road kills and ungulate death ration is higher than in the case of bird species.

https://www.researchgate.net/publication/263280789_Seasonal_diets_of_red_foxes_in_a_boreal_forest_with_a_dense_population_of_moose_The_importance_of_winter_scavenging

Figure 4

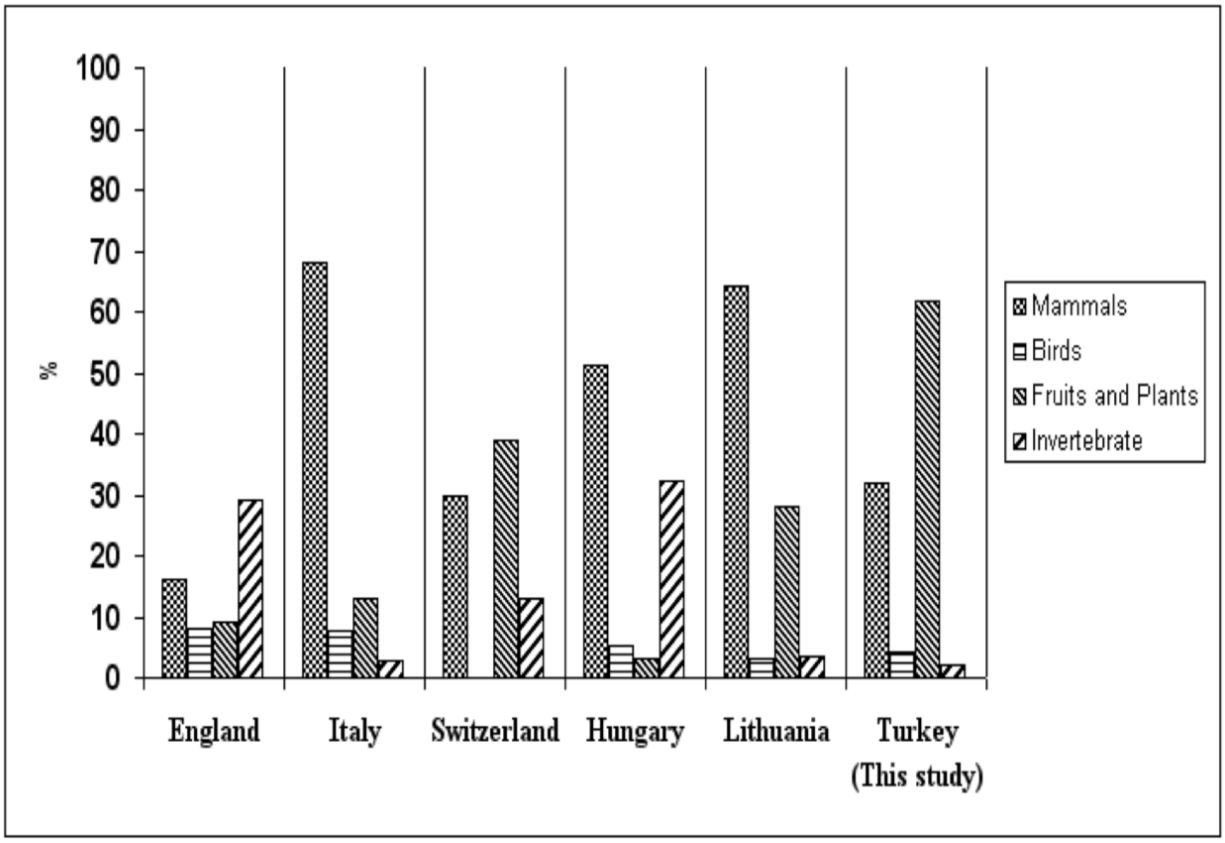


"Seasonal changes in the major food groups in the diet of the red fox in the Varaldskogen study area in 2005–2009, expressed as proportions of recognized material in scats. Ungulates mainly moose, Small rodents field voles and bank voles, Birds mainly capercaillie and black grouse." (Robert Needham, Research Gate, 2014)

From this diagram we can see that during spring the percentage of ungulate remains found in the red fox scats were high with a percentage of 44. This could be because the newly born fawns can be a potential prey for the red fox especially in the case of the roe deer. Summer period was law with a percentage of less than 5% and winter months were medium with around 19%. This could be the outcome of ungulate carrion scavenging. In the case of small rodents the proportion in the scats was relatively similar with an average of roughly 21%. This shows that rodent predation is constant in the case of the red fox all year around. Barriers were utilized mainly in the spring and summer season when the amount of these fruits are high in the winter. This represents that the red fox is a omnivores specie and ears plant based materials as well. Bird predation was also similar throughout the season but with a lower average compared to the rodent proportion. The other items found in the scats were relatively high special during spring and summer. During spring and summer the amount of edible material in the forest is high and red foxes have many opportunist the fill their bellies. These items could include insects, eggs and amphibians which are all abundant throughout the spring and summer months. This also shows that red foxes are very opportunistic feeders and they eat technique anything.

https://www.researchgate.net/publication/263280789_Seasonal_diets_of_red_foxes_in_a_boreal_forest_with_a_dense_population_of_moose_The_importance_of_winter_scavenging

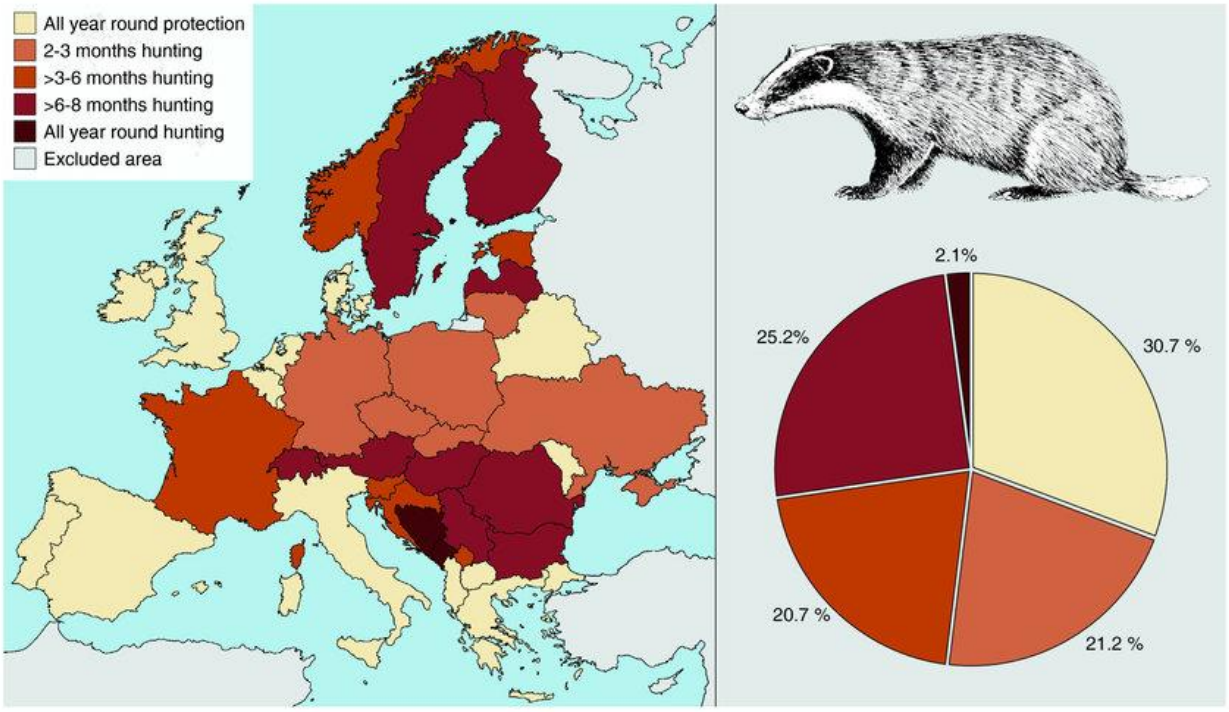
Figure 5



"Comparison of diet components frequency data of red foxes in England, Italy, Switzerland, Hungary, Lithuania and Turkey" (Derg, 2009)

With the exception of England mammal predation and consumption was the main food source in the case of the red fox from the selected European countries. In the case of Switzerland there were virtually no bird predation among the red fox and in England the main food source consisted of invertebrates. In turkey the fruit consumption was the highest. This shows the caried diet composition of the red fox based on the habitat and the amount and type of food than can be found there.
https://dergipark.org.tr/en/download/article-file/341815

Figure 6

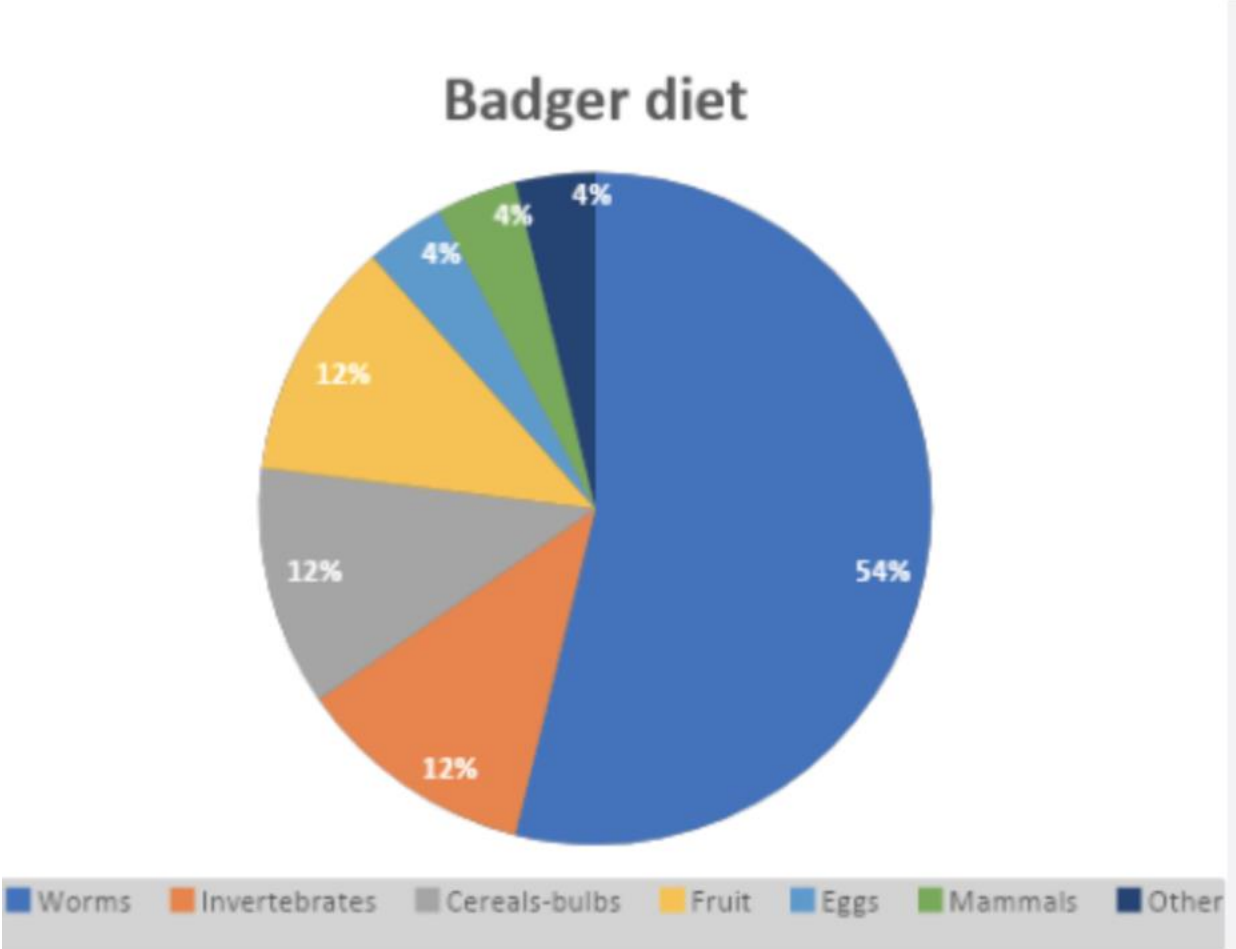


“General hunting season of the European Badger in Europe”. (Przemysław Kurek, 2022)

This diagram represents the European badger occurrence in Europe. From this diagram we can also learn that in European countries like Span, Portugal, Ireland, Netherlands, Belgium, Luxemburg, Italy, Greece, Belarus and Moldova the European badger is considered a protective mammalian specie and hunting of this species is prohibited by law. This makes up 30.7% of the countries protecting the European badger in Europe. In the rest of the countries European badger hunting is allowed with specific hunting seasons that must be followed except in Montenegro and Bosnia where European badger can be hu ted all year round.

https://www.google.com/imgres?imgurl=https://www.lancashirebadgergroup.org.uk/wp-content/uploads/2022/02/badger-diet-pie-chart.png?x94974&tbnid=xCk3zFWO9OpTgM&vet=1&imgrefurl=https://www.lancashirebadgergroup.org.uk/about-badgers/&docid=NWIJwWrchq_R0M&w=461&h=356&itg=1&hl=hu-hu&source=sh/x/im/m1/3&kgs=e984ee7581cb4cc8&shem=abme,trie#imgrc=xCk3zFWO9OpTgM&imgdii=KlCDqCG_WFfREM

Figure 7



"General diagram about the diet composition of the European Badger". (Group)

This diagram shows a general outline of the European badger diet on a pie chart. Since the badger is a omnivores mammalian specie they utilize large amounts of feeding material that can be found in nature. Seasonal changes can occur but the consistency stays relatively even. From this diagram we can clearly see that the main type of food source in the case of the European badger is worms with estimates put it as high as 50%. Their large claws are made for digging which helps them to move large amounts of earth when searching for worms.

https://www.google.com/imgres?imgurl=https://www.lancashirebadgergroup.org.uk/wp-content/uploads/2022/02/badger-diet-pie-chart.png?x94974&tbnid=xCk3zFWO9OpTgM&vet=1&imgrefurl=https://www.lancashirebadgergroup.org.uk/about-badgers/&docid=NWIJwWrchq_R0M&w=461&h=356&itg=1&hl=hu-hu&source=sh/x/im/m1/3&kgs=e984ee7581cb4cc8&shem=abme,trie

Figure 8

Food items	F% winter (83)	F% spring (79)	F% summer (19)	F% autumn (18)	χ^2	P
Fruits	8.4	22.8	52.6	22.2	20.3	0.0001
Maize	44.6	38.0	21.0	27.8	4.6	n.s.
Molluscs	8.4	11.4	5.3	0.0	2.8	n.s.
Earthworms	81.9	88.6	52.6	88.9	14.2	0.0002
Insects	27.7	45.6	31.6	11.1	10.5	n.s.
Amphibians	22.9	24.0	5.3	11.1	4.6	n.s.
Reptiles	1.2	0.0	0.0	0.0	1.4	n.s.
Birds	3.6	5.1	15.8	5.6	4.4	n.s.
Mammals	12.0	10.1	10.5	22.2	2.1	n.s.
Rodents	7.2	3.8	5.3	22.2	7.7	n.s.
Lagomorphs	3.6	3.8	5.3	0.0	0.8	n.s.
Carrion	1.2	6.3	0.0	0.0	5.0	n.s.

“Seasonal variation in badger diet. Pooled data of the study period are expressed in percentage of frequency (F%); number of feces samples in bracket” (Remonti, 2005)

From this figure we can identify the seasonal diet composition of the European badger based on scat analysis. It is visible that fruits were consumed by badgers in the summer months when the amount of wild frits are high in the nature. It is very clear to see that the most amount of prey that was consumed was earthworms with a frequency of more than 80% during winter, spring and autumn. During the summer period there was a declaim but this could be answered with more food supplies during summer periods and less earthworm number due to high temperature. Rodent and mammal predation was relatively law. Carrion scavenging was very law with only a slight frequency in winter and spring. We can clearly see that the main food option for the European badger is earthworm.

https://www.researchgate.net/publication/50889615_Diet_of_the_Eurasian_badger_*Meles_meles*_in_an_agricultural_riverine_habitat_NW_Italy

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DECLARATION

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Date: Gödöllő, 14 November 2024

Mihály Márton PhD
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